Lab Assignment - 07 - Spring 2020

Signals and systems
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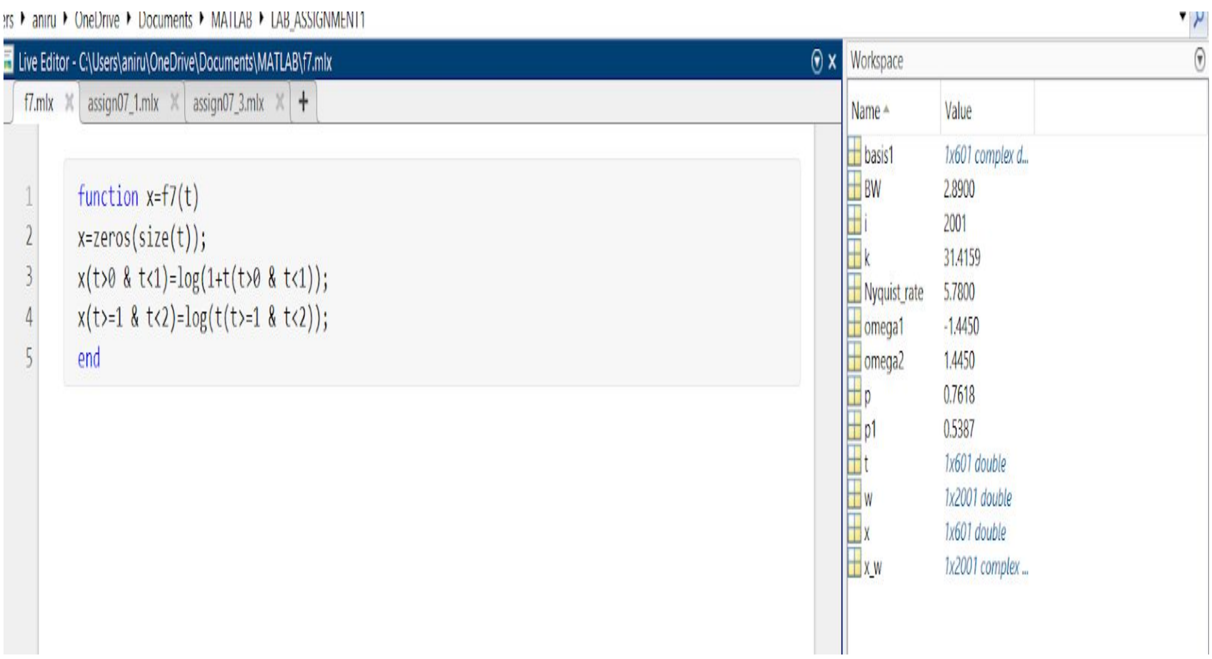
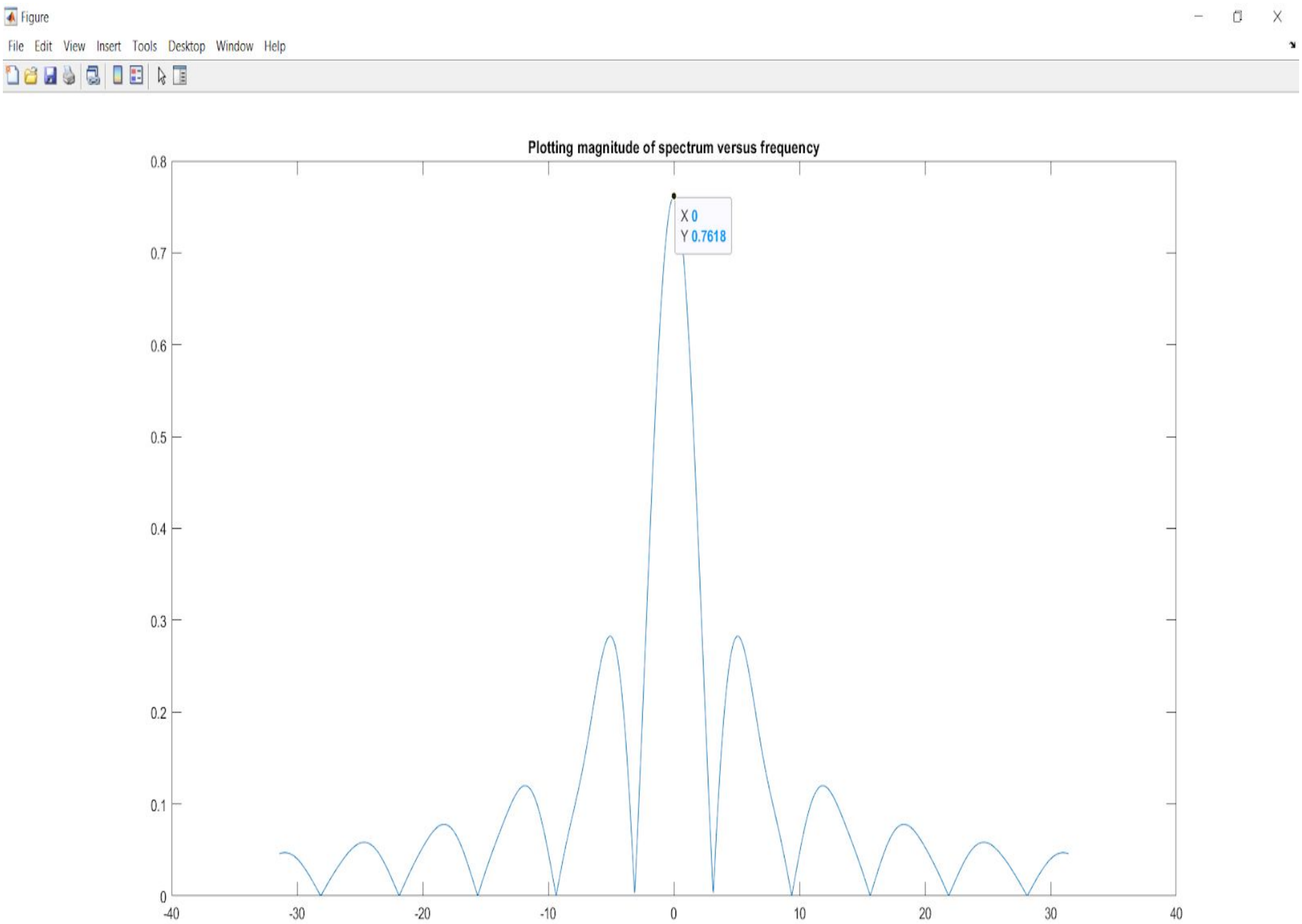
Q1) Given the following signal, determine and plot the fourier transform and then determine the Nyquist sampling rate.

$$x(t) = \begin{cases} \ln(1+t) & 0 < t < 1 \\ \ln(t) & 1 \le t < 2 \\ 0 & \text{elsewhere} \end{cases}$$

- We first write a function named as f7(t) to plot x(t) and use it in our program to compute its fourier transform.
- Here's the code :



- After computing the fourier transform, we plot the magnitude of the spectrum vs the frequency.
- Then, we find the highest magnitude of frequency from the graph and name the point as p.



- From the figure, we can observe that the value of p is 0.7618.
- Now, as per 3dB Bandwidth theory, we plot p/sqrt(2) points i.e., 0.5386 points on both sides of the graph.
- The following are the two graphs :

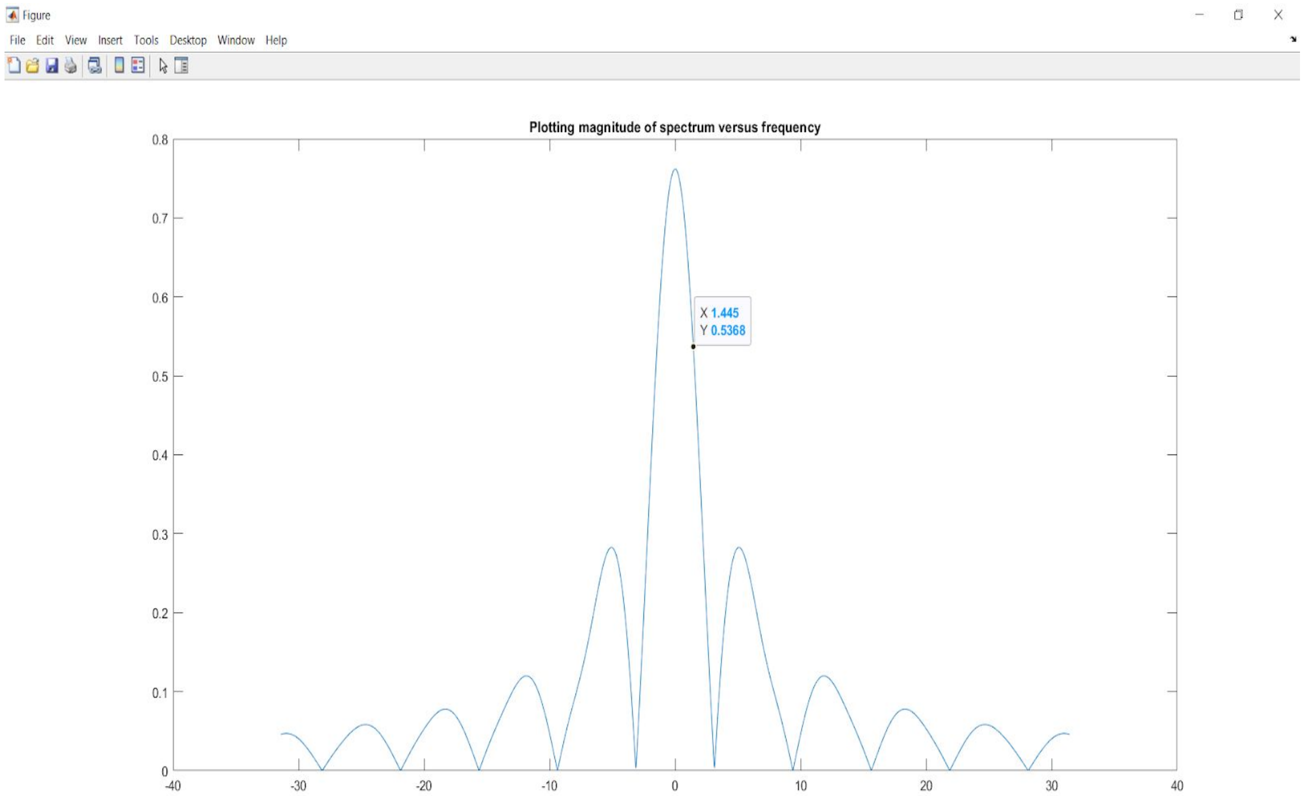


Figure
File Edit View Insert Tools Desktop Window Help
Plotting magnitude of spectrum versus frequency
X 1.445
Y 0.5368
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-40
-30
-20
-10
0
10
20
30
40

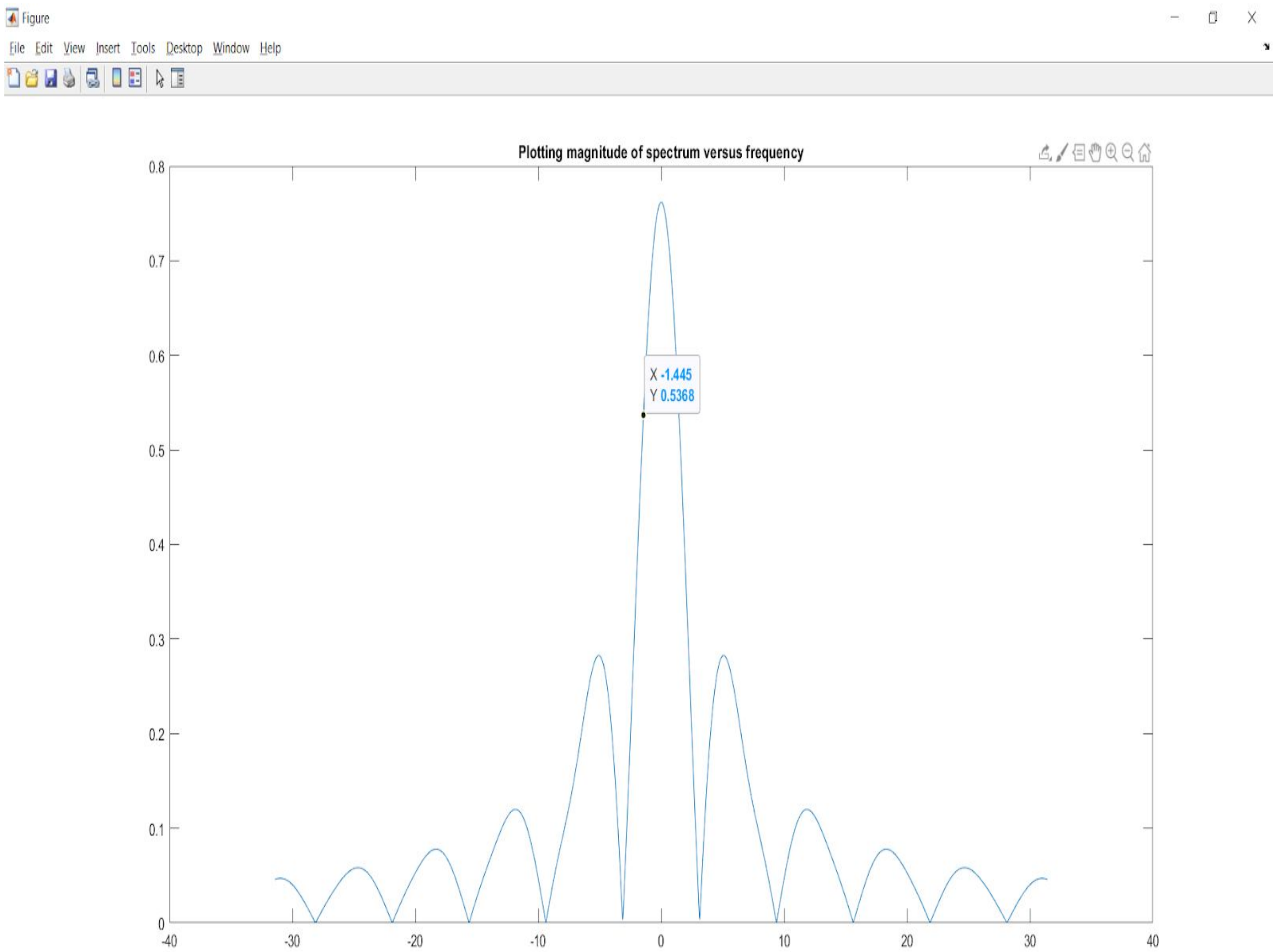
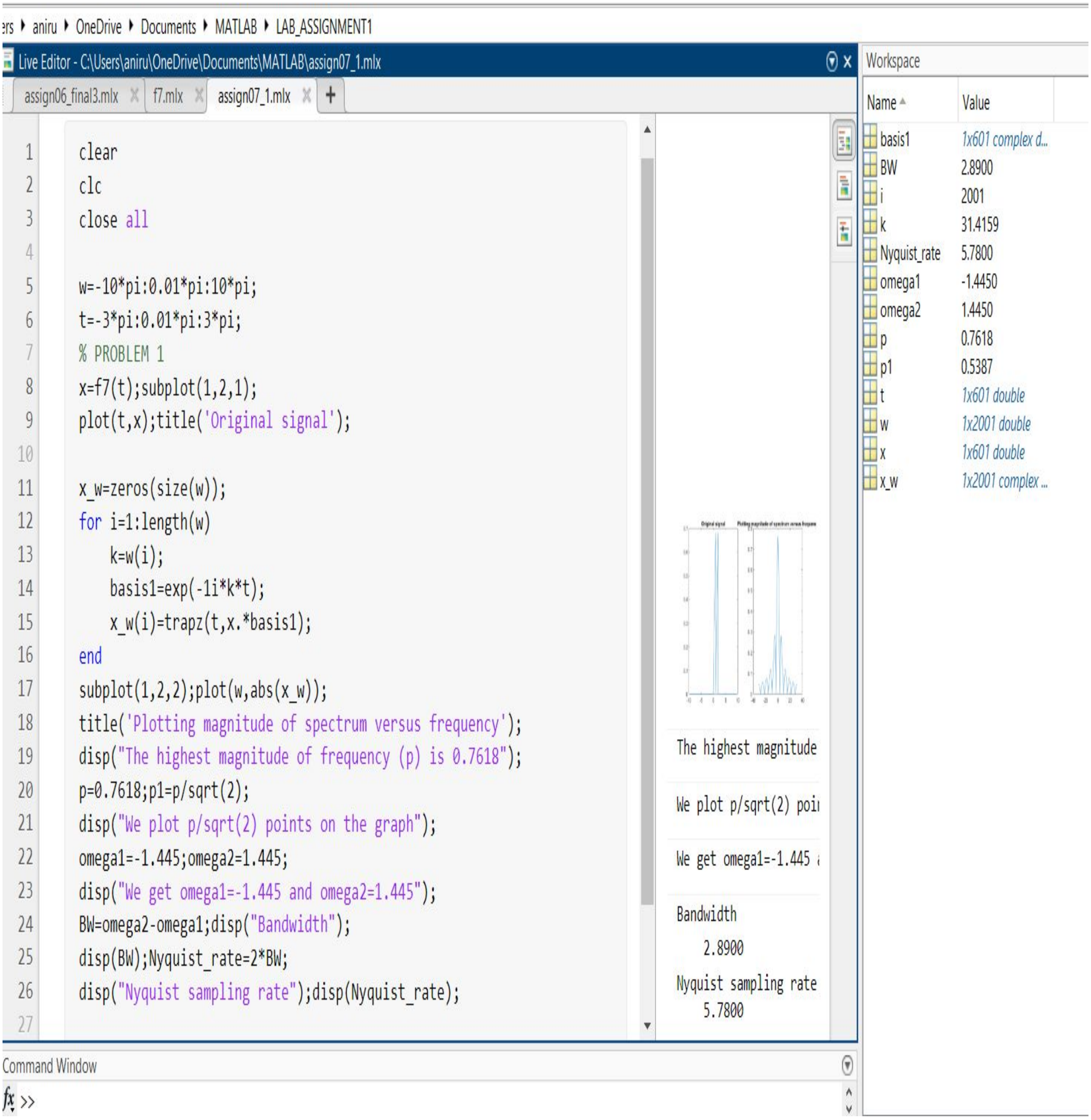


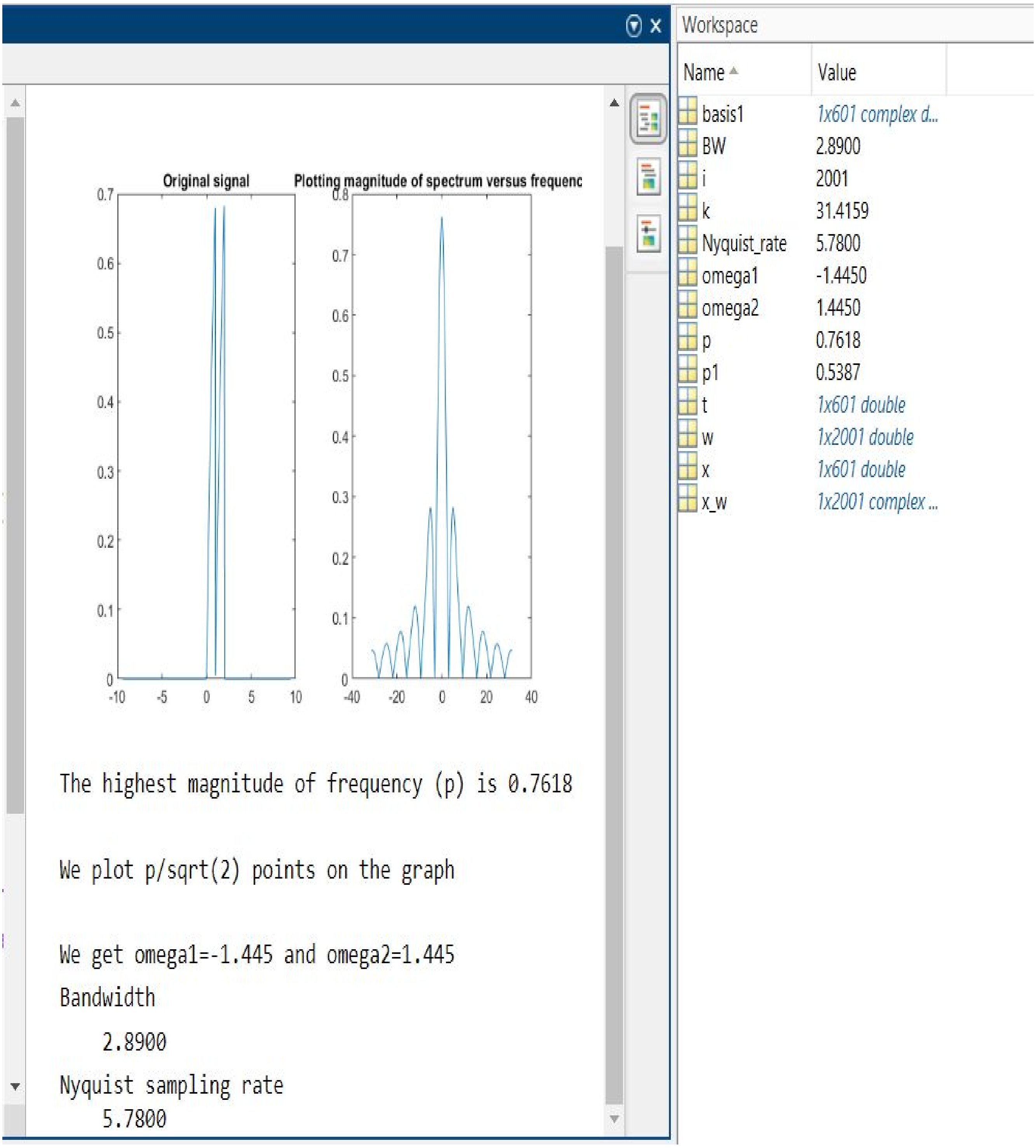
Figure
File Edit View Insert Tools Desktop Window Help
Plotting magnitude of spectrum versus frequency
X -1.445
Y 0.5368
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-40
-30
-20
-10
0
10
20
30
40

- The closer to 0.5386 we get on the graph is 0.5368, whose frequency values are omega1 as -1.445 and omega2 as 1.445 on each side of the point that are observed from the graph.
- Now, we calculate Bandwidth of the spectrum that is given by BW=omega2 - omega1 i.e., 1.445- (-1.445) = 2.890.
- Also, Nyquist rate = 2 * BW = 2 * 2.890

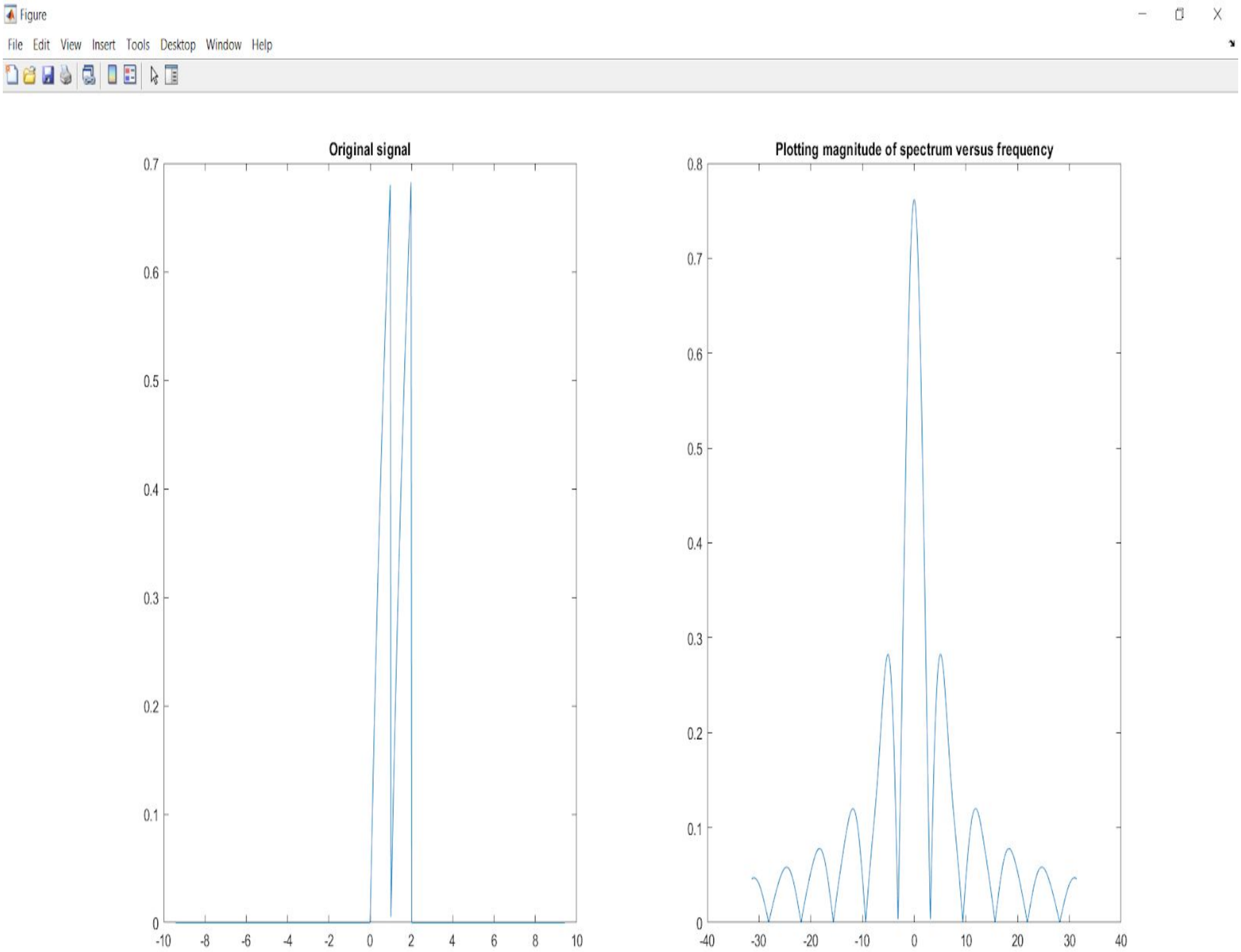
  = 5.7800
- Here’s the code :



```
clear
clc
close all

w=-10*pi:0.01*pi:10*pi;
t=-3*pi:0.01*pi:3*pi;
% PROBLEM 1
x=f7(t);subplot(1,2,1);
plot(t,x);title('Original signal');

x_w=zeros(size(w));
for i=1:length(w)
    k=w(i);
    basis1=exp(-1i*k*t);
    x_w(i)=trapz(t,x.*basis1);
end
subplot(1,2,2);plot(w,abs(x_w));
title('Plotting magnitude of spectrum versus frequency');
disp("The highest magnitude of frequency (p) is 0.7618");
p=0.7618;p1=p/sqrt(2);
disp("We plot p/sqrt(2) points on the graph");
omega1=-1.445;omega2=1.445;
disp("We get omega1=-1.445 and omega2=1.445");
BW=omega2-omega1;disp("Bandwidth");
disp(BW);Nyquist_rate=2*BW;
disp("Nyquist sampling rate");disp(Nyquist_rate);
```



Here’s the output :



Q2) For the given signal with f0 = 4

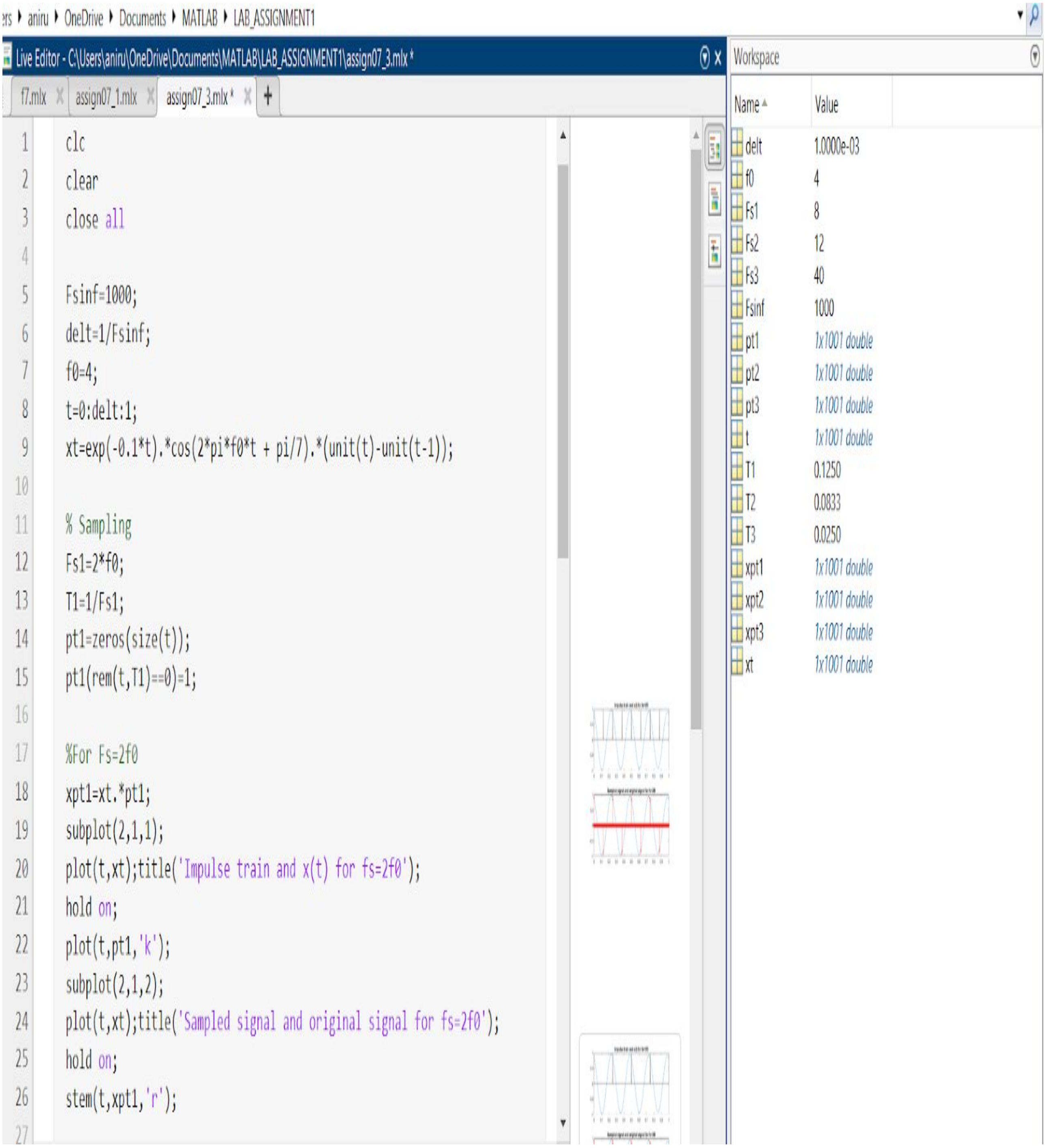
$$x(t) = \exp(-0.1t)\cos(2\pi f0t + \pi/7)(u(t) - u(t-1))$$

To simulate and plot the sampled discrete signals at the following sampling rates

a) fs = 2f0, b) fs = 3f0 and c) fs = 10f0

- Firstly, we write the code for x(t) and then write for impulse train p(t). Then, we multiply x(t) and p(t) to get xp(t).
- We name it as a sampled signal and plot it against the original signal.

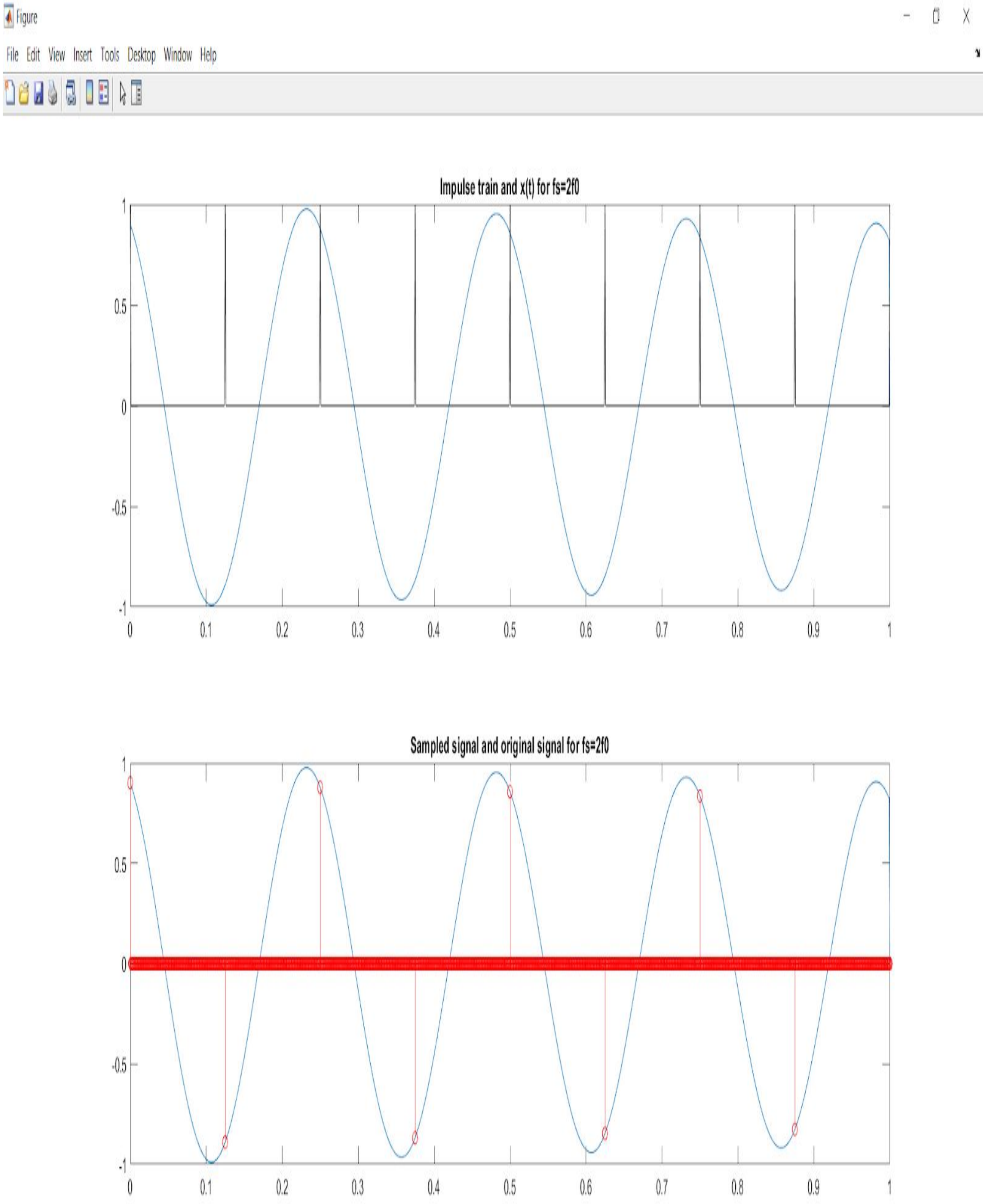
- We also plot the impulse train Vs Original signal x(t).
- Repeat these steps for each value of Fs. It is also given that F0=4 which will be constant.
- A) Fs = 2F0
- Here’s the code :



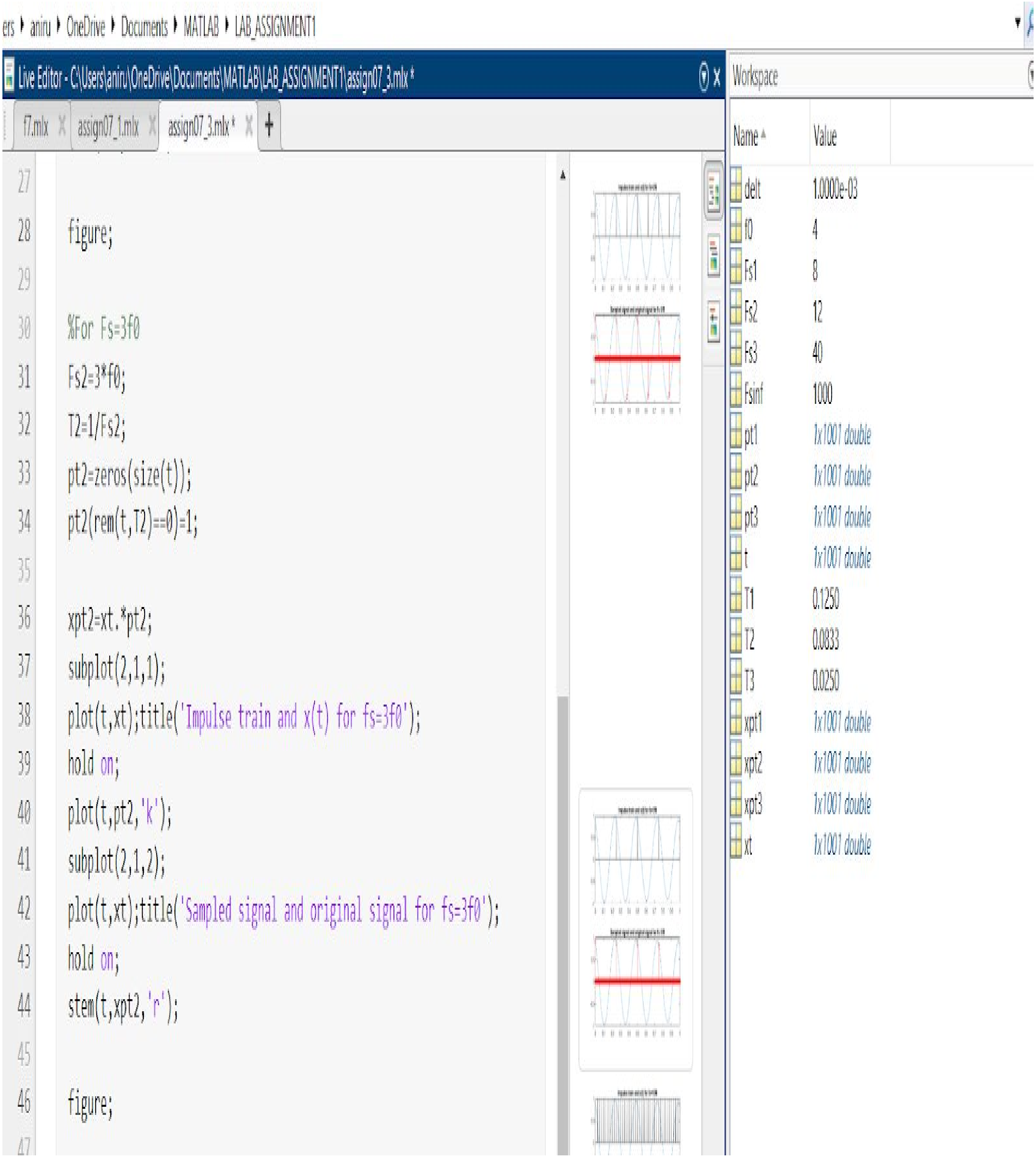
```
clc
clear
close all

Fsinf=1000;
delt=1/Fsinf;
f0=4;
t=0:delt:1;
xt=exp(-0.1*t).*cos(2*pi*f0*t + pi/7).*(unit(t)-unit(t-1));

% Sampling
Fs1=2*f0;
T1=1/Fs1;
pt1=zeros(size(t));
pt1(rem(t,T1)==0)=1;

%For Fs=2f0
xpt1=xt.*pt1;
subplot(2,1,1);
plot(t,xt);title('Impulse train and x(t) for fs=2f0');
hold on;
plot(t,pt1,'k');
subplot(2,1,2);
plot(t,xt);title('Sampled signal and original signal for fs=2f0');
hold on;
stem(t,xpt1,'r');
```

Name	Value
delt	1.0000e-03
f0	4
Fs1	8
Fs2	12
Fs3	40
Fsinf	1000
pt1	1x1001 double
pt2	1x1001 double
pt3	1x1001 double
t	1x1001 double
T1	0.1250
T2	0.0833
T3	0.0250
xpt1	1x1001 double
xpt2	1x1001 double
xpt3	1x1001 double
xt	1x1001 double

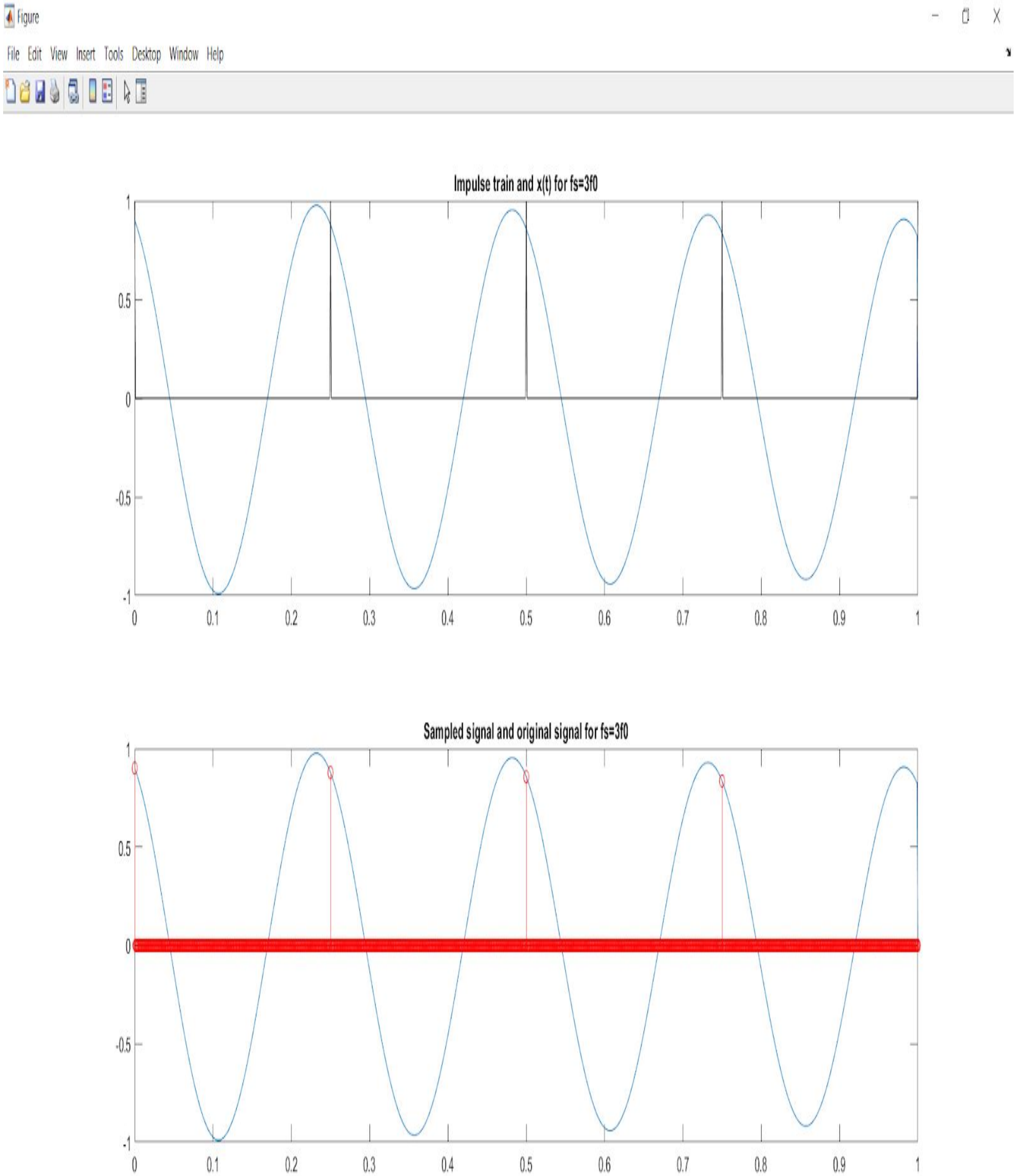
- Here’s the output :



- B) Fs = 3F0
- Here's the code :

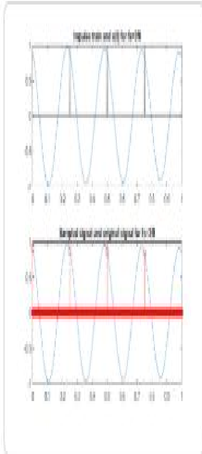


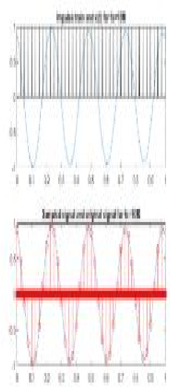
- Here’s the output :



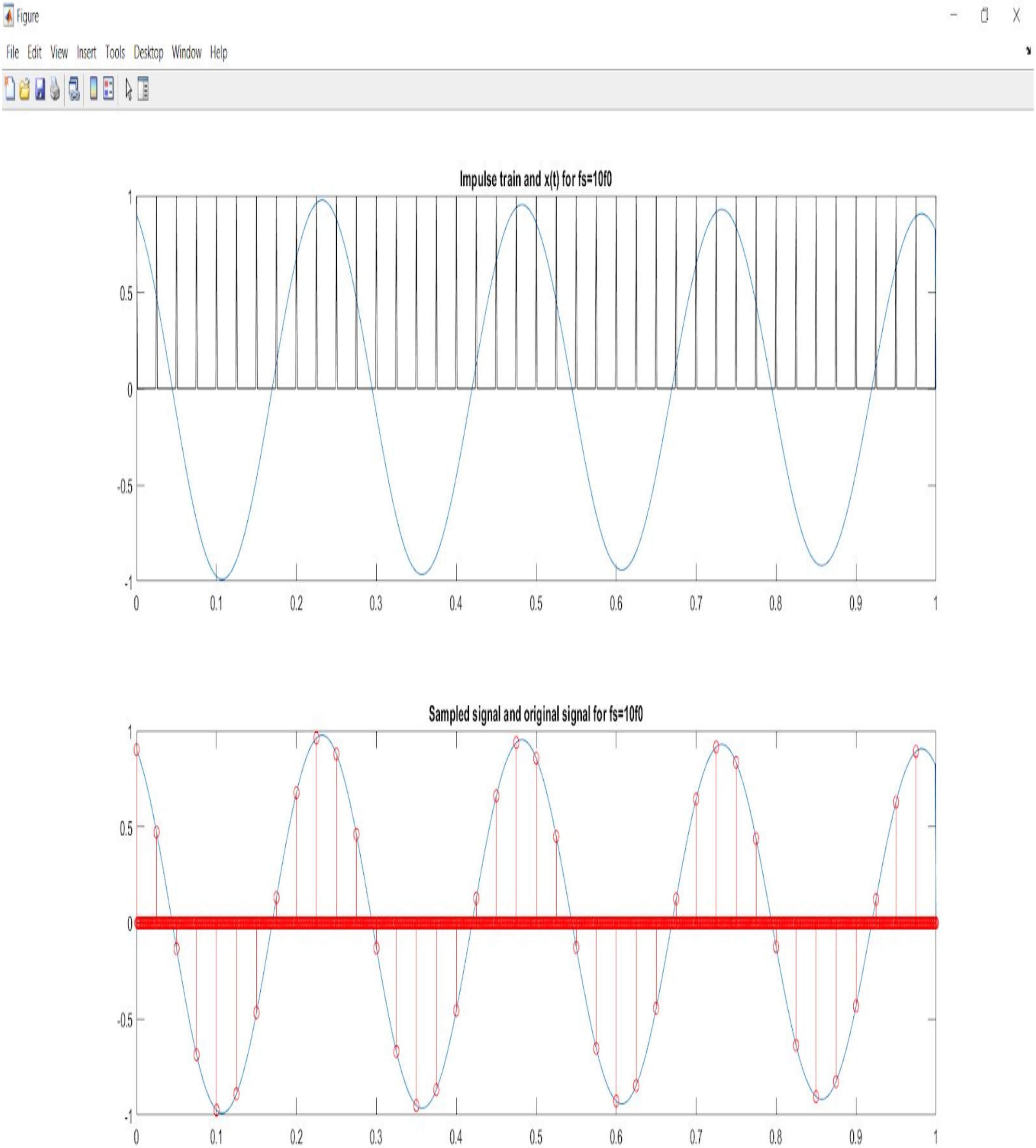
- C) Fs = 10F0
- Here’s the code :

```
figure;

%For Fs=10f0
Fs3=10*f0;
T3=1/Fs3;
pt3=zeros(size(t));
pt3(rem(t,T3)==0)=1;

xpt3=xt.*pt3;
subplot(2,1,1);
plot(t,xt);title('Impulse train and x(t) for fs=10f0');
hold on;
plot(t,pt3,'k');
subplot(2,1,2);
plot(t,xt);title('Sampled signal and original signal for fs=10f0');
hold on;
stem(t,xpt3,'r');
```





- Here’s the output :



Figure
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Impulse train and x(t) for fs=10f0
Sampled signal and original signal for fs=10f0

--------------------THE END---------------------