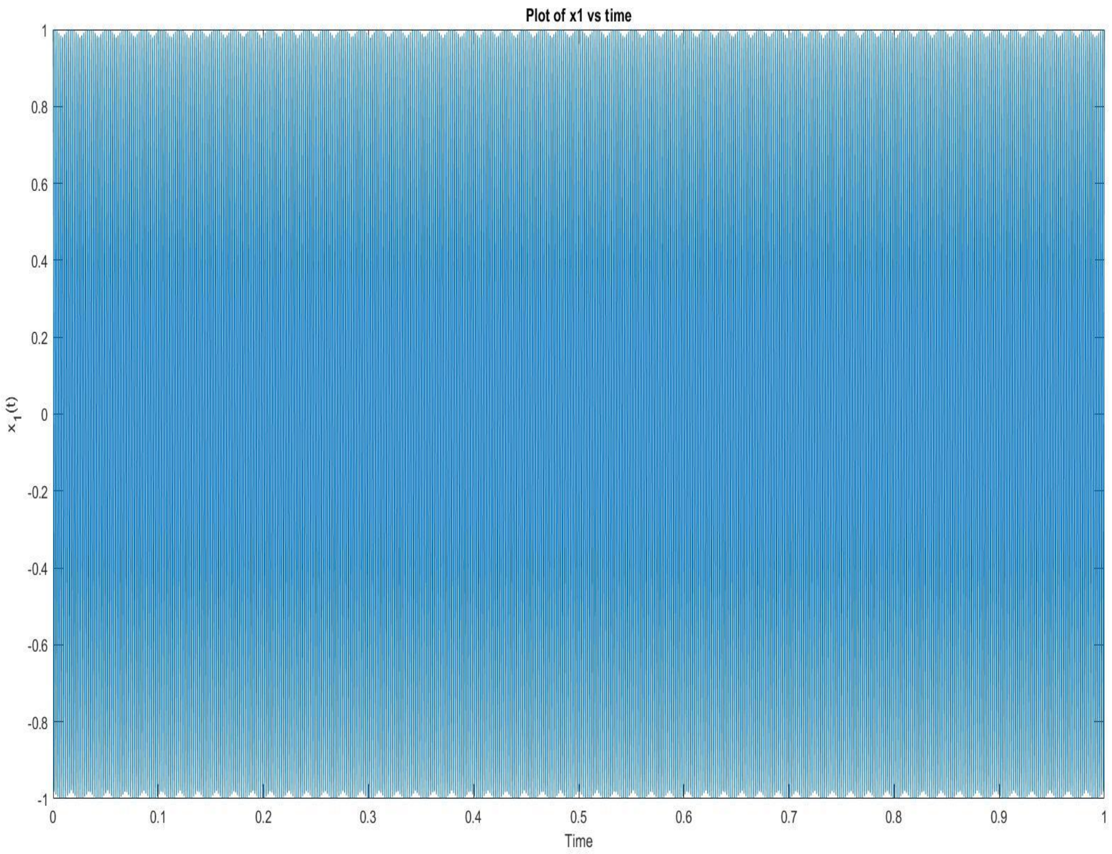
Solutions to A.1

Comments and plot for A.1 1-3:

As frequency increases, pitch increases.



Comments for A.1 4-5:

Let ID = 21803061

f_1 = 306 f_2 = 180;

y = 2cos(2*306*pi*t) + 3 sin(2*180*pi*t);

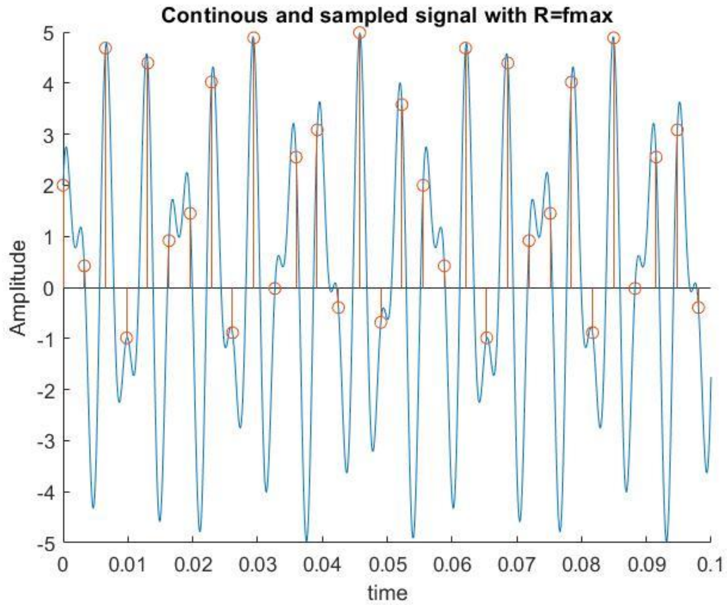
With sampling rate = fmax, we cannot recover original signal, its very different from original.

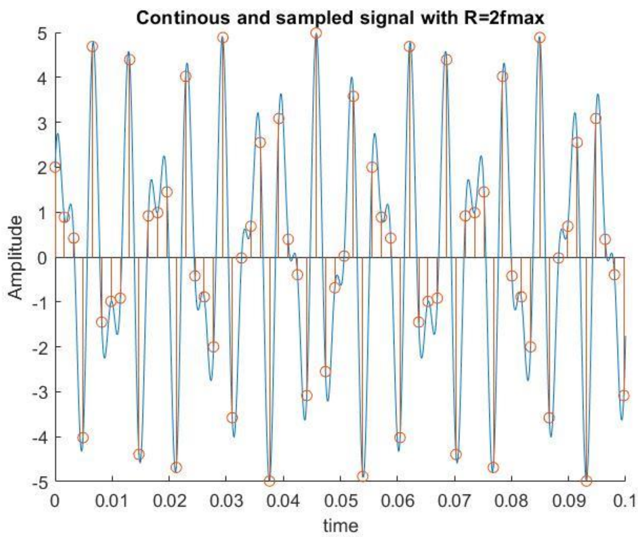
R = 2fmax is better but it is in the boundary, so we still can not get a perfectly recovered signal.

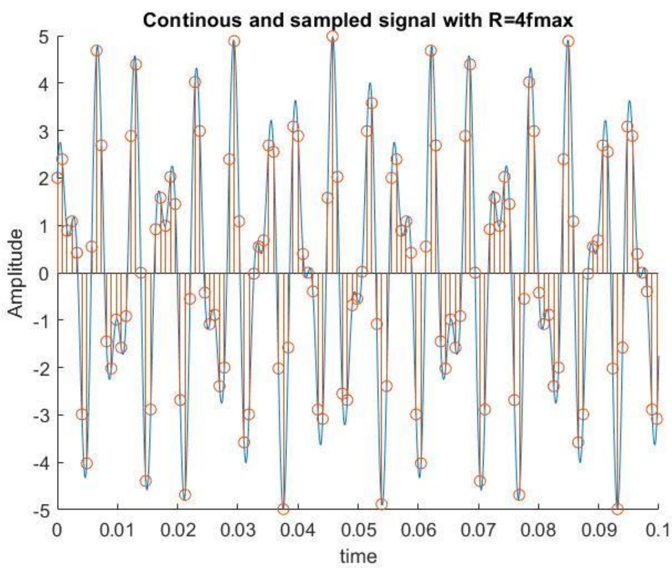
With R = 4fmax, we get the same signal with continuous one.

Sinc Interpolation should be used.

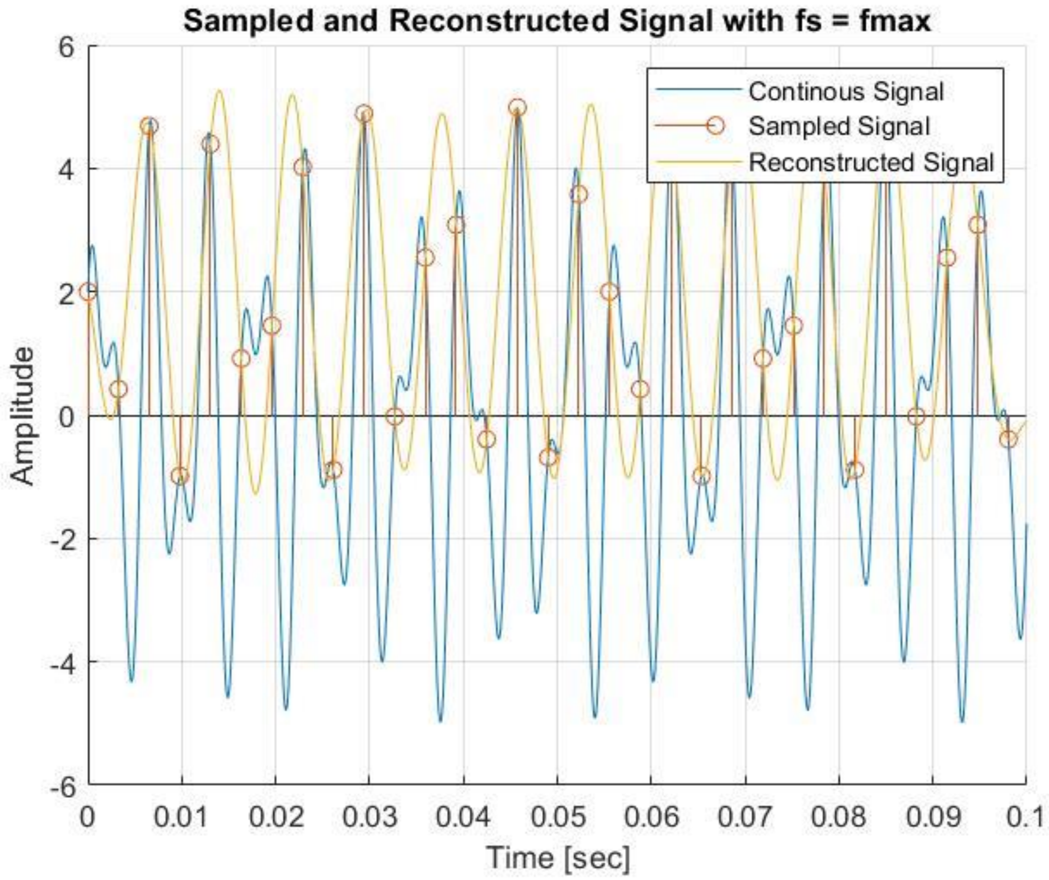
Plots for A.1-4

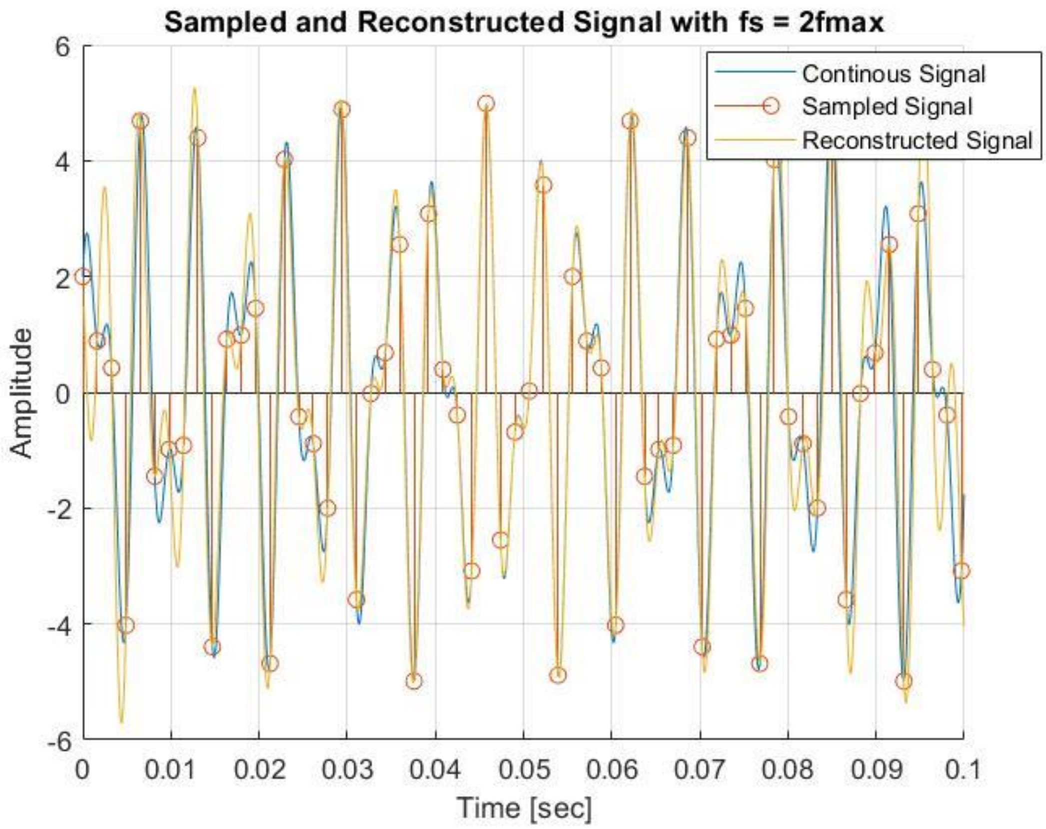


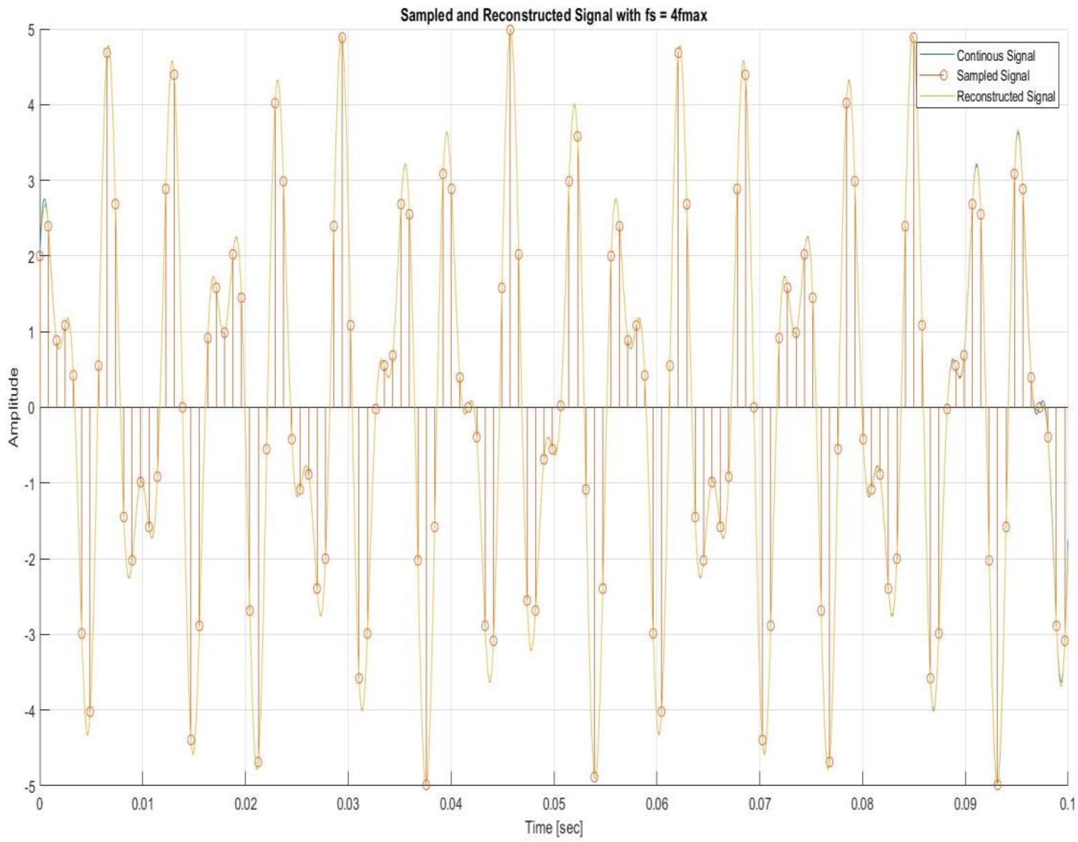




Plots for A.1-5







Code for Part A.1

```
%% A.1 1-3
f_0 = 550;
t = [0:1/8192:1];
x1 = cos(2*pi*f_0*t);
soundsc(x1)
plot(t,x1);
title('Plot of x1 vs time')
xlabel('Time')
ylabel('x_1(t)')
f_0 = 430;
x1 = cos(2*pi*f_0*t);
soundsc(x1)
f_0 = 750;
x1 = cos(2*pi*f_0*t);
soundsc(x1)
%% Sampling and reconstruction demo
clear,clc,close all;

%% Parameters
F1 = 306;       % frequency of signal [Hz]
F2 = 180;
```

```
Fs_low = F1;
Fs_mid = 2*F1;
Fs_high =4*F1;
Ts_low = 1/Fs_low;
Ts_mid = 1/Fs_mid;
Ts_high =1/Fs_high;
%% Generate "continuous time" signal and discrete time
signal
tc = 0:1/8192:0.1;          % CT axis
xc = 2*cos(2*pi*F1*tc)+3*sin(2*pi*F2*tc);
td_0 = 0:Ts_low:0.1;          % DT axis
td_1 = 0:Ts_mid:0.1;
td_2 = 0:Ts_high:0.1;
xd_0 = 2*cos(2*pi*F1*td_0)+3*sin(2*pi*F2*td_0);
xd_1 = 2*cos(2*pi*F1*td_1)+3*sin(2*pi*F2*td_1);
xd_2 = 2*cos(2*pi*F1*td_2)+3*sin(2*pi*F2*td_2);
N_0 = length(td_0);% number of samples
N_1 = length(td_1);
N_2 = length(td_2);
%% Plot sampled and continous signals;
figure;
hold on;
plot(tc,xc);
stem(td_0,xd_0);
xlabel('time')
ylabel('Amplitude')
title('Continous and sampled signal with R=fmax')
figure;
hold on;
plot(tc,xc);
stem(td_1,xd_1);
xlabel('time')
ylabel('Amplitude')
title('Continous and sampled signal with R=2fmax')
figure;
hold on;
plot(tc,xc);
stem(td_2,xd_2);
xlabel('time')
ylabel('Amplitude')
title('Continous and sampled signal with R=4fmax')
%% Reconstruction by using the formula:
% xr(t) = sum over n=0,...,N-1: x(nT)*sin(pi*(t-
nT)/T)/(pi*(t-nT)/T)
% Note that sin(pi*(t-nT)/T)/(pi*(t-nT)/T) = sinc((t-
nT)/T)
% sinc(x) = sin(pi*x)/(pi*x) according to MATLAB
```

```
xr_0 = zeros(size(tc));
xr_1 = zeros(size(tc));
xr_2 = zeros(size(tc));
for t = 1:length(tc)
    for n = 0:N_0-1
        xr_0(t) = xr_0(t) + xd_0(n+1)*sin(pi*(tc(t)-
n*Ts_low)/Ts_low)/(pi*(tc(t)-n*Ts_low)/Ts_low);
    end
end

for t = 1:length(tc)
    for n = 0:N_1-1
        xr_1(t) = xr_1(t) + xd_1(n+1)*sin(pi*(tc(t)-
n*Ts_mid)/Ts_mid)/(pi*(tc(t)-n*Ts_mid)/Ts_mid);
    end
end

for t = 1:length(tc)
    for n = 0:N_2-1
        xr_2(t) = xr_2(t) + xd_2(n+1)*sin(pi*(tc(t)-
n*Ts_high)/Ts_high)/(pi*(tc(t)-n*Ts_high)/Ts_high);
    end
end

%% Plot the results
figure
hold on
grid on
plot(tc,xc)
stem(td_0,xd_0)
plot(tc,xr_0)
xlabel('Time [sec]')
ylabel('Amplitude')
title('Sampled and Reconstructed Signal with fs = fmax')
legend('Continous Signal','Sampled Signal','Reconstructed
Signal');

figure
hold on
grid on
plot(tc,xc)
stem(td_1,xd_1)
plot(tc,xr_1)
xlabel('Time [sec]')
ylabel('Amplitude')
title('Sampled and Reconstructed Signal with fs = 2fmax')
```

```
legend('Continous Signal','Sampled Signal','Reconstructed
Signal');

figure
hold on
grid on
plot(tc,xc)
stem(td_2,xd_2)
plot(tc,xr_2)
xlabel('Time [sec]')
ylabel('Amplitude')
title('Sampled and Reconstructed Signal with fs = 4fmax')
legend('Continous Signal','Sampled Signal','Reconstructed
Signal');
```