Bilkent University

Department of Computer Engineering

EEE 391- Basics of Signals and Systems
MATLAB Assignment 1

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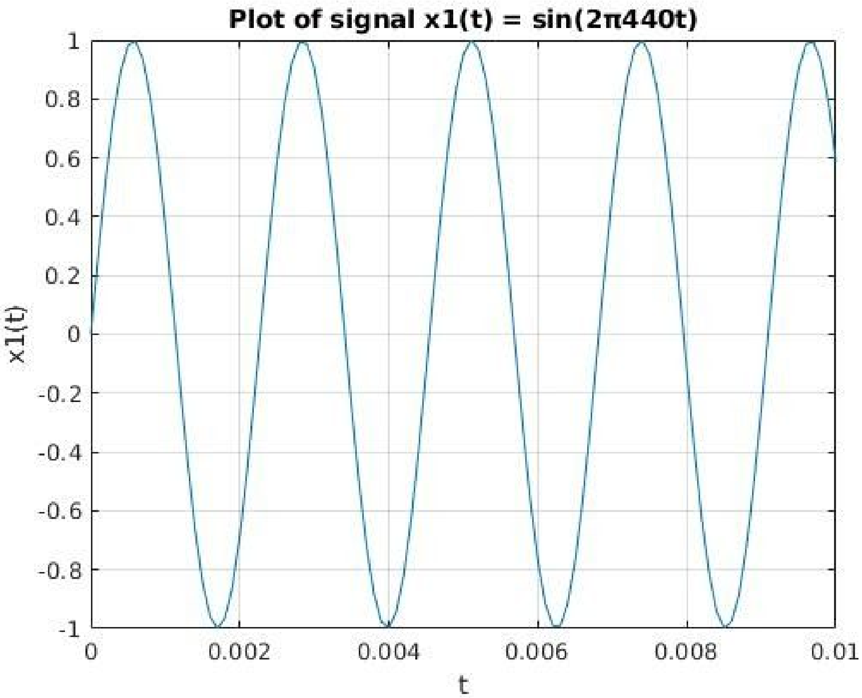
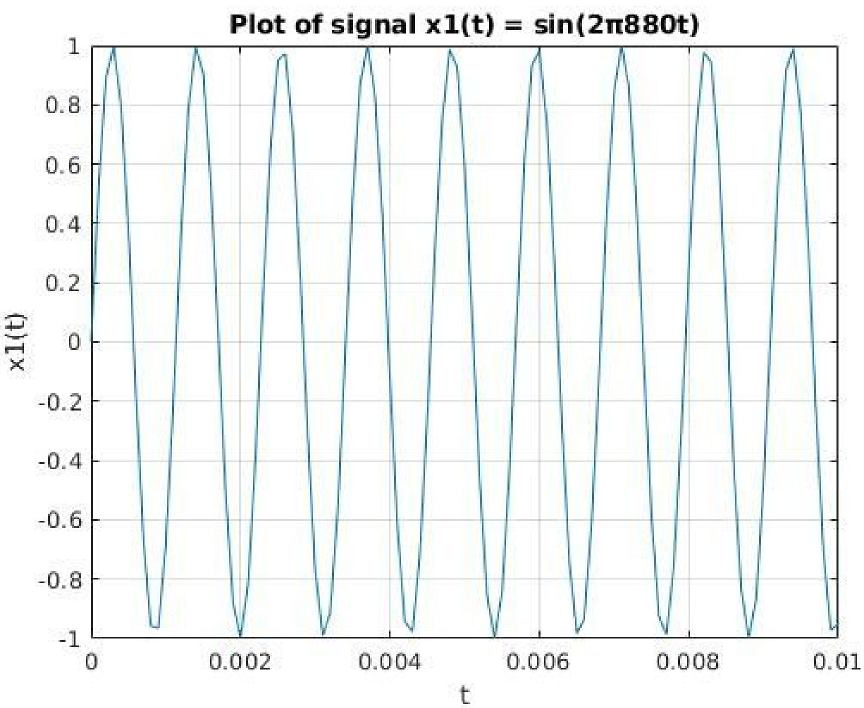
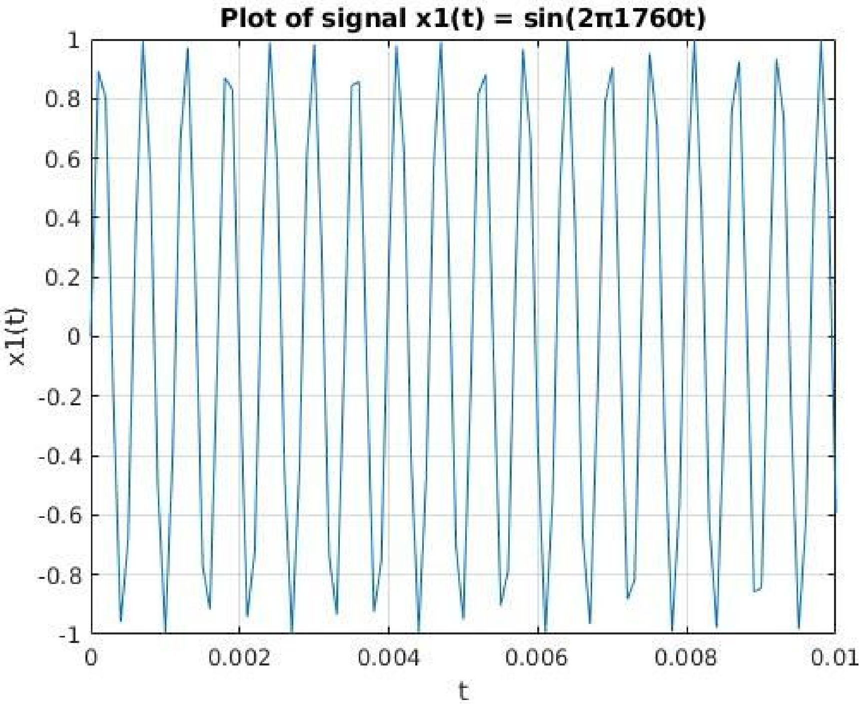
Section: 2

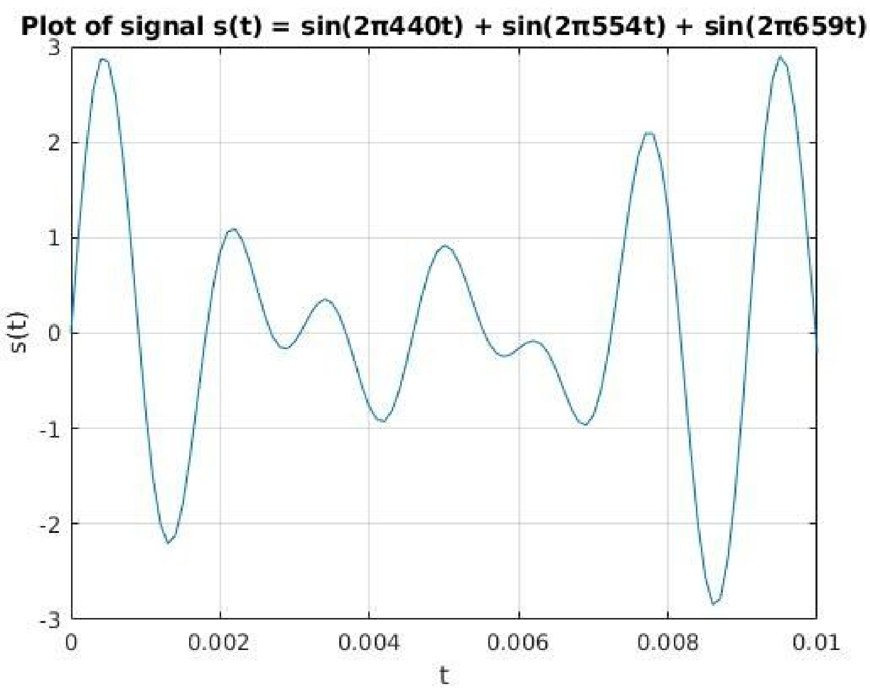
Part 1:


Plot of signal x1(t) = sin(2π440t)
x1(t)
t
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0
0.002
0.004
0.006
0.008
0.01


Plot of signal x1(t) = sin(2π880t)
x1(t)
t
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0
0.002
0.004
0.006
0.008
0.01

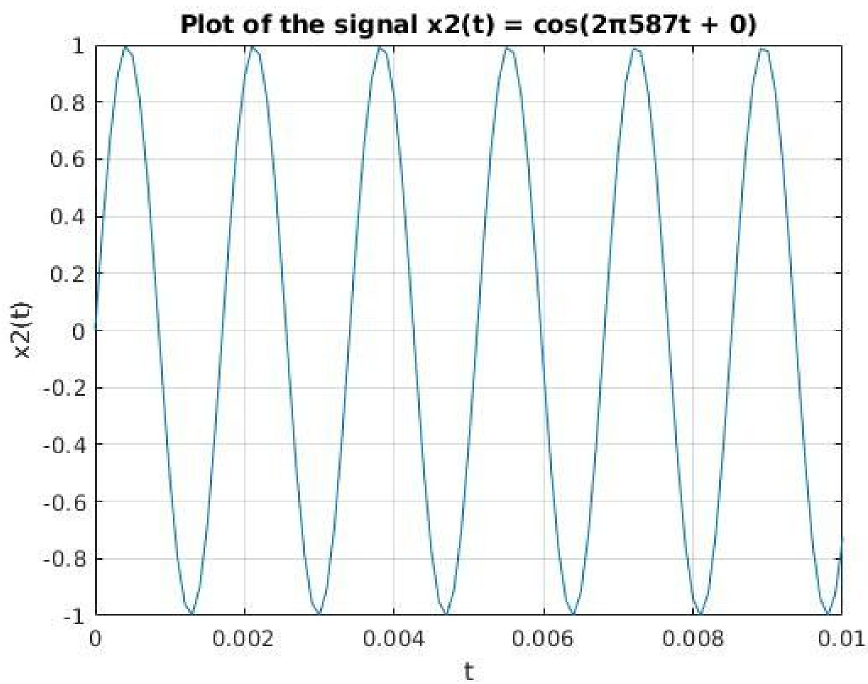


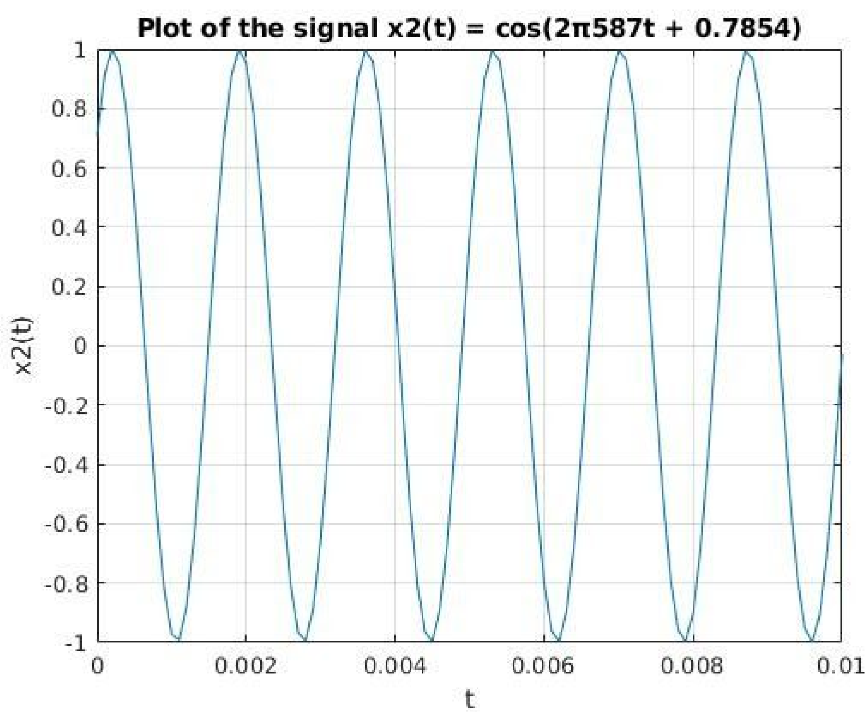
As the frequency increases, the pitch of the sound also increases.

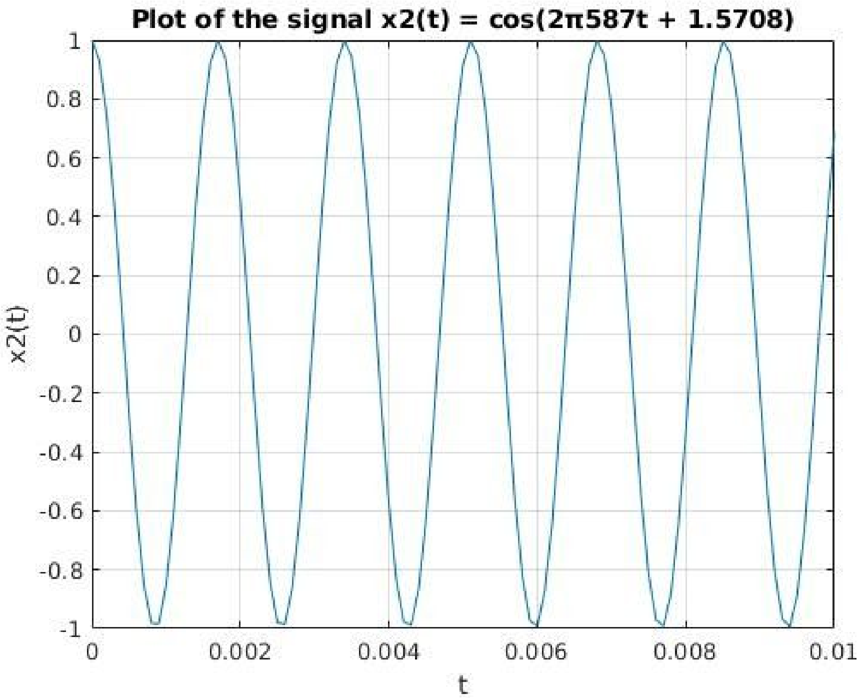


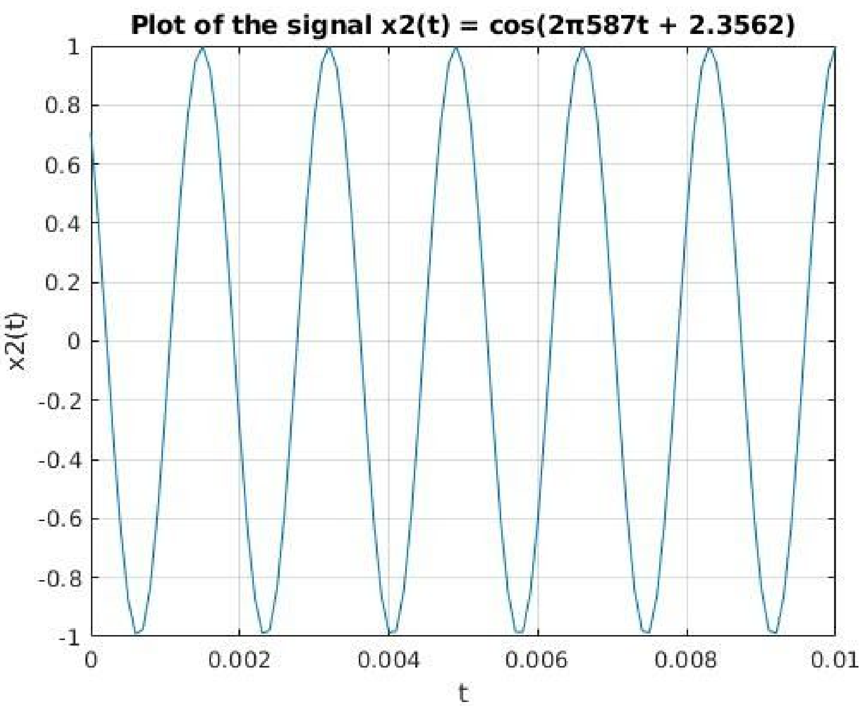
The combination of the A, C sharp, and E sounds good because they are harmonically related to each other.

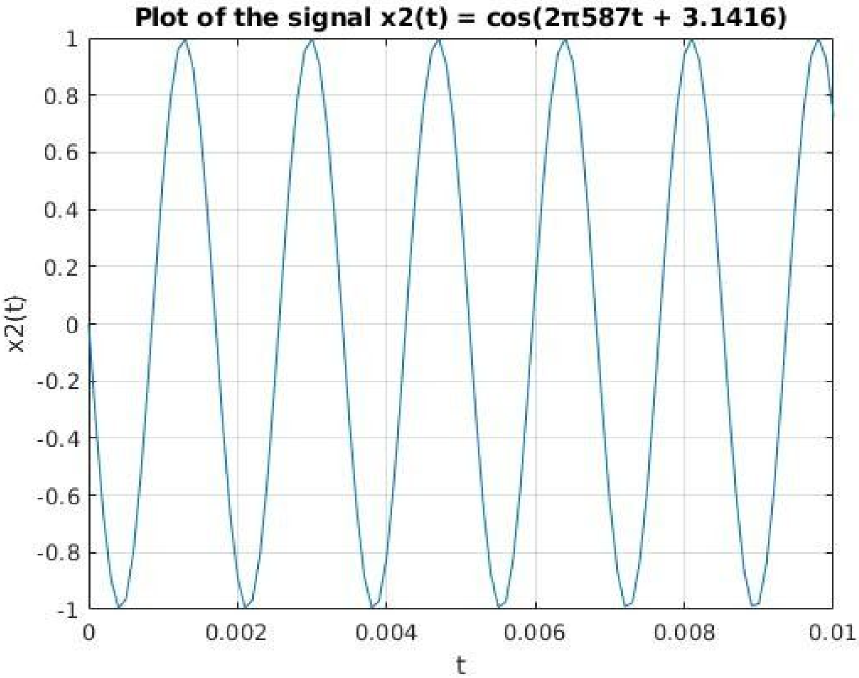
Part 2:


Plot of the signal x2(t) = cos(2π587t + 0)
x2(t)
t
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0
0.002
0.004
0.006
0.008
0.01


Plot of the signal x2(t) = cos(2π587t + 0.7854)
x2(t)
t
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0
0.002
0.004
0.006
0.008
0.01

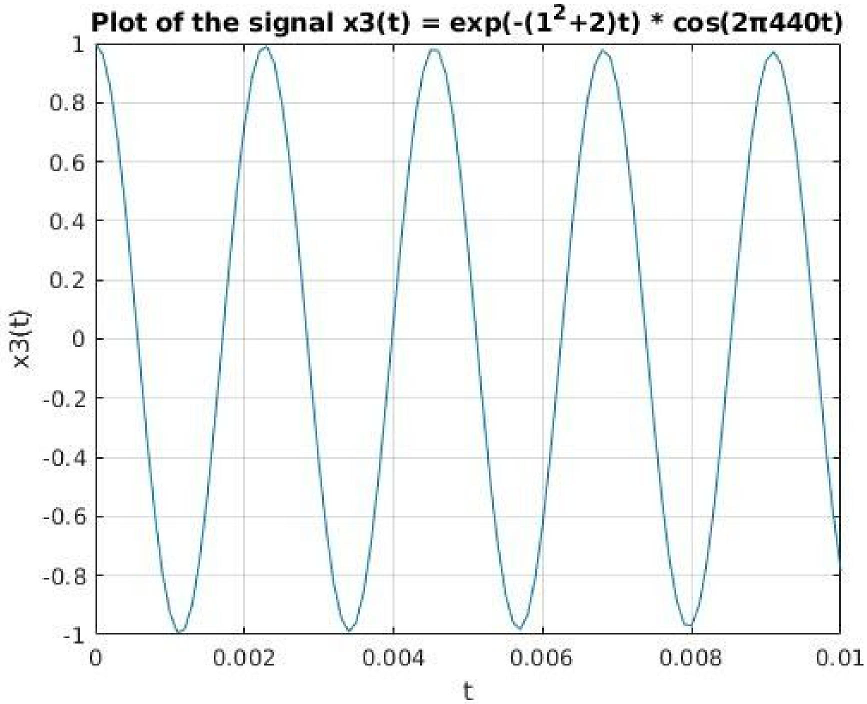

Plot of the signal x2(t) = cos(2π587t + 1.5708)
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
x2(t)
0
0.002
0.004
0.006
0.008
0.01
t

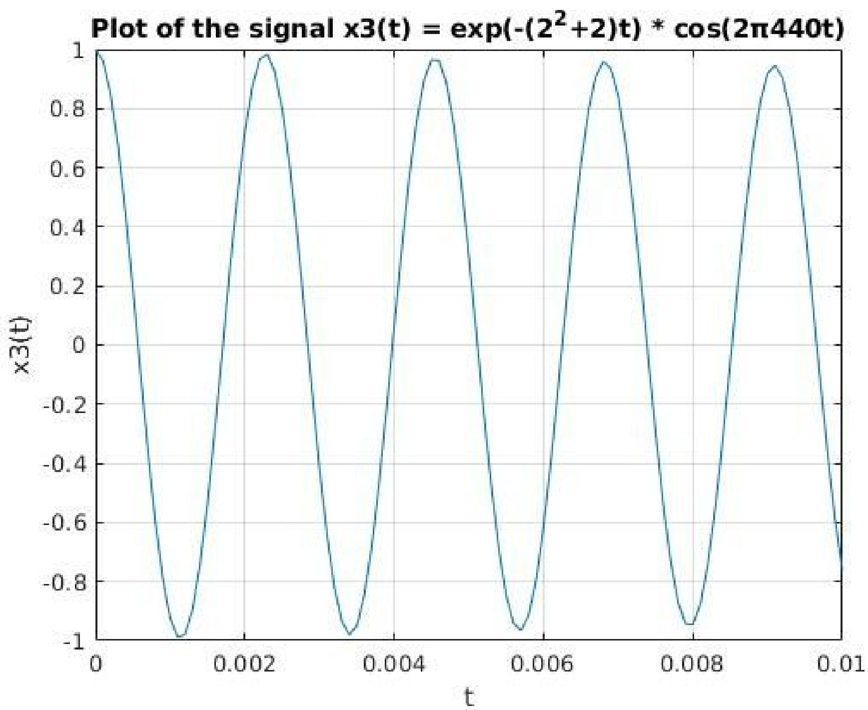

Plot of the signal x2(t) = cos(2π587t + 2.3562)
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
x2(t)
0
0.002
0.004
0.006
0.008
0.01
t

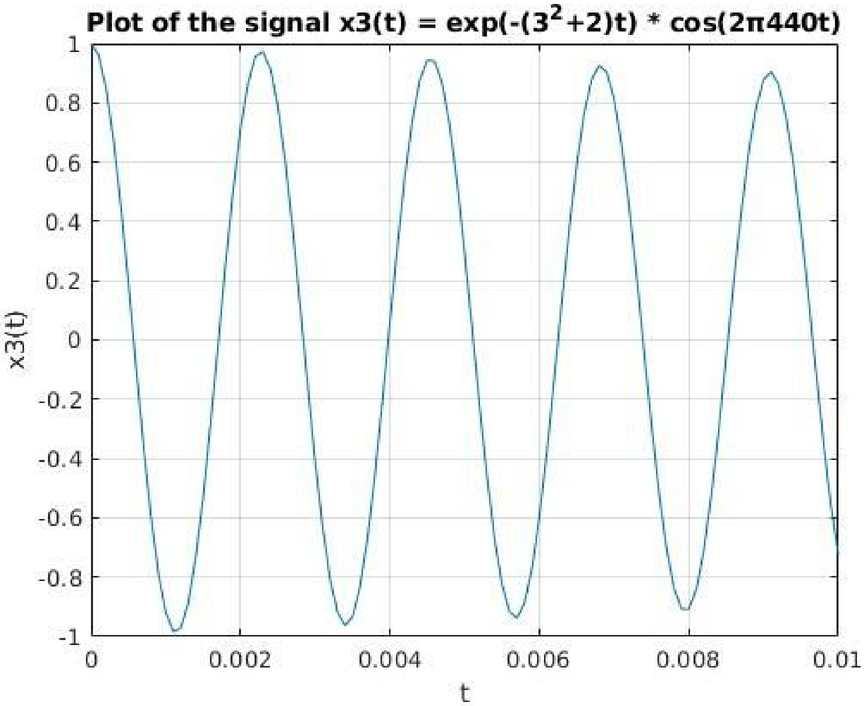


With the change of ɸ, the pitch and the volume of the sound is not affected because the frequency of the signal has not been changed.

Part 3:

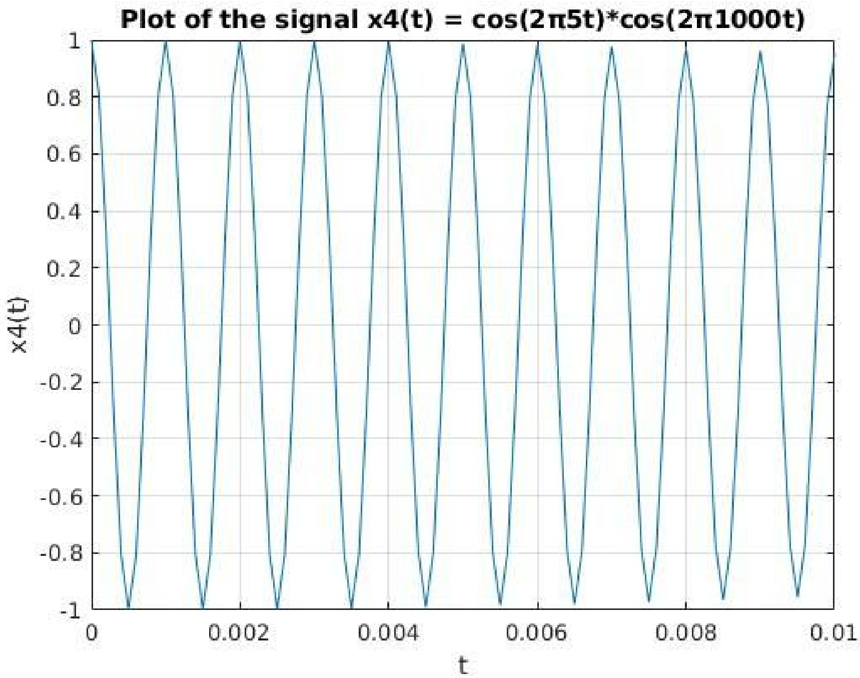

Plot of the signal x3(t) = exp(-(1^2+2)t) * cos(2π440t)
x3(t)
t
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0
0.002
0.004
0.006
0.008
0.01


Plot of the signal x3(t) = exp(-(2^2+2)t) * cos(2π440t)
x3(t)
t
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0
0.002
0.004
0.006
0.008
0.01

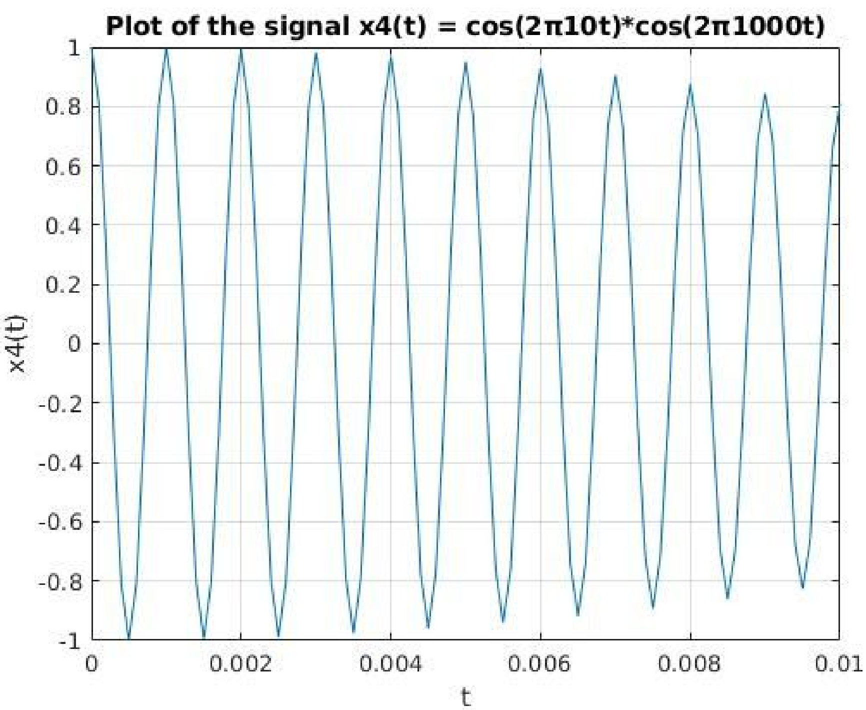


The effect of the exponential term is to decrease the amplitude of the signal by time. The sound $x_3(t)$ in Part 3 is more close to the sound produced by the piano. On the other hand, sound $x_1(t)$ in Part 1 is more close to the sound of the flute. As a is increased in the signal function, the decreasing rate of the amplitude is increased. Therefore, the duration of the sound decreases as a increases.

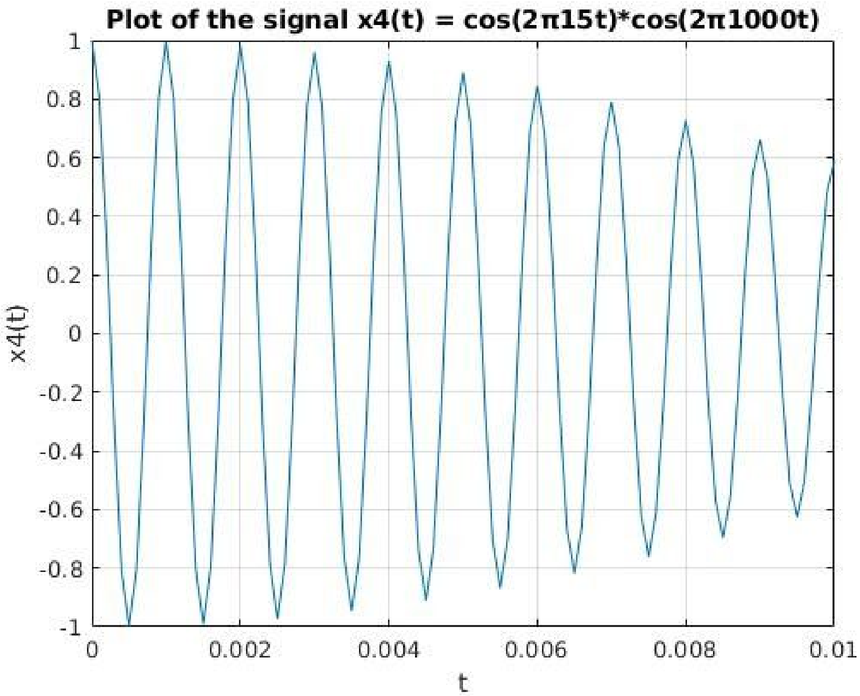
Part 4:



Plot of the signal x4(t) = cos(2π5t)*cos(2π1000t)
x4(t)
t
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0
0.002
0.004
0.006
0.008
0.01



Plot of the signal x4(t) = cos(2π10t)*cos(2π1000t)
x4(t)
t
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0
0.002
0.004
0.006
0.008
0.01



The low-frequency cosine term makes us hear the superposition of two frequencies which are very close to each other. By the trigonometric identity of the multiplication of two cosines, we get the sum of two different signals with different but very close frequencies. The sum of these signals causes a periodic variation in the volume of the sound.

Part 5:

In the first chirp that has starting frequency 2500 Hz and ending frequency 500 Hz, the frequency of the signal is decreasing in time. On the other hand, in the second chirp that has starting frequency 500 Hz and ending frequency 2500 Hz, the frequency increases in time. If we increase the μ, then the decreasing or increasing rate of the frequency increases. As opposed to that, if we decrease the μ, the decreasing or increasing rate of the frequency decreases. If we double the μ coefficient and apply it to the first chirp, the frequency of the signal decreased to zero and also it gets negative values. However, the negative frequency is equal to its absolute value. Therefore, the frequency decreases to zero and after that, it begins to increase. If we halve the μ coefficient, then the frequency doesn't reach to 500 Hz.

In the Chirp Puzzle part, the signal first chirp down and reaches to zero. After the zero frequency, it begins to chirp up because the negative frequencies are equal to their absolute value. The negative frequencies don't exist in nature, but they make the math to describe the spectral content of a signal.

Codes:

```
clc; clear all; close all;
pause on;

% Part 1
t = 0:0.0001:3;
f = 440;
quot = [1, 2, 4];
for i = 1:length(quot)
   x1 = sin(2 * pi * quot(i) * f .* t);
   figure;
   plot(t, x1);
   xlim([0 0.01]);
   grid();
   tit = ['Plot of signal x1(t) = sin(2π', num2str(quot(i) * f), 't)'];
   title(tit);
   ylabel('x1(t)');
   xlabel('t');
   sound(x1(1:10000));
   pause(1.05);
end

t = 0:0.0001:3;
f = [440, 554, 659];
s = sin(2 * pi * f(1) * t) + sin(2 * pi * f(2) * t)+ sin(2 * pi * f(3) * t);
plot(t, s);
xlim([0 0.01]);
grid();
tit = ['Plot of signal s(t) = sin(2π', num2str(f(1)), 't) + sin(2π', num2str(f(2)), 't) + sin(2π',
num2str(f(3)), 't)'];
title(tit);
ylabel('s(t)');
xlabel('t');
soundsc(s(1:10000));

% Part 2
t = 0:0.0001:3;
f = 587;
phi = [0, pi/4, pi/2, 3*pi/4, pi];

for i = 1:length(phi)
```

```
    x2 = sin(2 * pi * f .* t + phi(i));
    figure;
    plot(t, x2);
    xlim([0 0.01]);
    grid();
    tit = ['Plot of the signal x2(t) = cos(2π', num2str(f), 't + ', num2str(phi(i)), ')'];
    title(tit);
    xlabel('t');
    ylabel('x2(t)');
    sound(x2(1:10000));
    pause(1.05);
end

% Part 3
a = [1, 2, 3];
t = 0:0.0001:3;

for i = 1:length(a)
    x3 = exp(-(a(i)^2+2).*t).*cos(2 * pi * 440 .* t);
    figure;
    plot(t, x3);
    xlim([0 0.01]);
    grid();
    tit = ['Plot of the signal x3(t) = exp(-(', num2str(a(i)),'^2+2)t) * cos(2π440t)'];
    title(tit);
    xlabel('t');
    ylabel('x3(t)');
    sound(x3);
    pause(3.05);
end

% Part 4
t = 0:0.0001:3;
f1 = [5, 10, 15];
f2 =  1000;

for i = 1:length(f1)
    x4 = cos(2 * pi * f1(i) .* t).*cos(2 * pi * f2 .* t);
    figure;
    plot(t, x4);
    xlim([0 0.01]);
    grid();
    tit = ['Plot of the signal x4(t) = cos(2π', num2str(f1(i)), 't)*cos(2π', num2str(f2), 't)'];
```

```
    title(tit);
    xlabel('t');
    ylabel('x4(t)');
    sound(x4);
    pause(3.05);
end

% Part 5
t = 0:0.0001:2;
fl = [500, 2500];
f0 = [2500, 500];
quot = [1/2, 1, 2];
for i = 1:length(fl)
    td = 2;
    phi = 0;
    mu = (fl(i) - f0(i)) / (2*td);
    for j = 1:length(quot)
        x5 = cos(2 * pi * quot(j) * mu .* t.^2 + 2 * pi * f0(i) .* t + phi);
        soundsc(x5);
        pause(2.05)
    end
end

% A Chirp Puzzle
t = 0:0.0001:3;
fl = -2000;
f0 = 3000;
td = 3;
phi = 0;
mu = (fl - f0) / (2*td);
cp = cos(2 * pi * mu .* t.^2 + 2 * pi * f0 .* t + phi);
soundsc(cp, 10000);

% Part 6
notename = ["A", "A#", "B", "C", "C#", "D", "D#", "E", "F", "F#", "G", "G#"];
song = ["A", "E", "E", "E", "F", "E", "F", "G", "E", "E", "D", "D", "D", "C", "D", "E"];

for k1 = 1:length(song)
    idx = strcmp(song(k1), notename);
    songidx(k1) = find(idx);
end
dur = 0.3*8192;
songnote = [ ];
```

```
for k1 = 1:length(songidx)
    songnote = [songnote; [notecreate(songidx(k1),dur) zeros(1,75)]'];
end
soundsc(songnote, 8192)
```