Introduction: In this lab, we understood the concept of a more complicated signals by frequency modulation, and amplitude modulation.

Problem 3.4 in text

5. $x(t) = A\cos[2\pi(f_c - f_\Delta)t] + B\cos[2\pi(f_c + f_\Delta)t]$

$A = B = 1.$

(a) $A\cos[2\pi(f_c - f_\Delta)t] \rightarrow Re\{A.e^{j0}.e^{j2\pi(f_c - f_\Delta)t}\}$

$B\cos[2\pi(f_c + f_\Delta)t] \rightarrow Re\{B.e^{j0}.e^{j2\pi(f_c + f_\Delta)t}\}$

$$x(t) = Re\{A.e^{j2\pi(f_c - f_\Delta)t}\} + Re\{B.e^{j2\pi(f_c + f_\Delta)t}\}$$

$$= Re\{(Ae^{-j2\pi f_\Delta t} + Be^{j2\pi f_\Delta t}).e^{j2\pi f_c t}\}$$

$\Rightarrow x(t) = Re\{z(t)\}.$

$\Rightarrow z(t) = (Ae^{-j2\pi f_\Delta t} + Be^{j2\pi f_\Delta t}).e^{j2\pi f_c t}$

(b) $z(t) = (Ae^{-j2\pi f_\Delta t} + Be^{j2\pi f_\Delta t}).e^{j2\pi f_c t}$

$\Rightarrow Re\{z(t)\} = ((B+A)\cos(2\pi f_\Delta t)\cos(2\pi f_c t)) - ((B-A)\sin(2\pi f_\Delta t).\sin(2\pi f_c t))$

Thus, $x(t) = C\cos(2\pi f_\Delta t)\cos(2\pi f_c t) + D\sin(2\pi f_\Delta t).\sin(2\pi f_c t))$

where, $C = B + A$,

& $D = -(B - A) = A - B$.

When, $A = B = 1$.

$x(t) = 2\cos(2\pi f_\Delta t)\cos(2\pi f_c t)$.

(c) For $x(t)$ to be $2\sin(2\pi f_\Delta t).\sin(2\pi f_c t)$,

C has to be zero, and D to be 2.

Thus, $A + B = 0$, & — ①

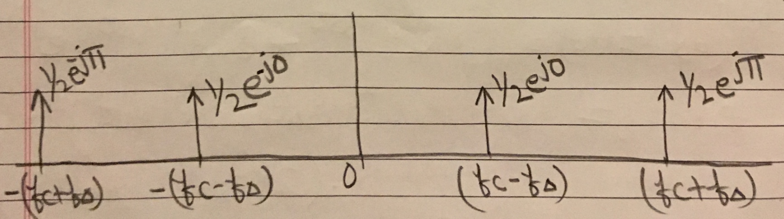
$A - B = 2$. — ②

Adding ① & ② –

$\Rightarrow 2A = 2 \Rightarrow A = 1$,

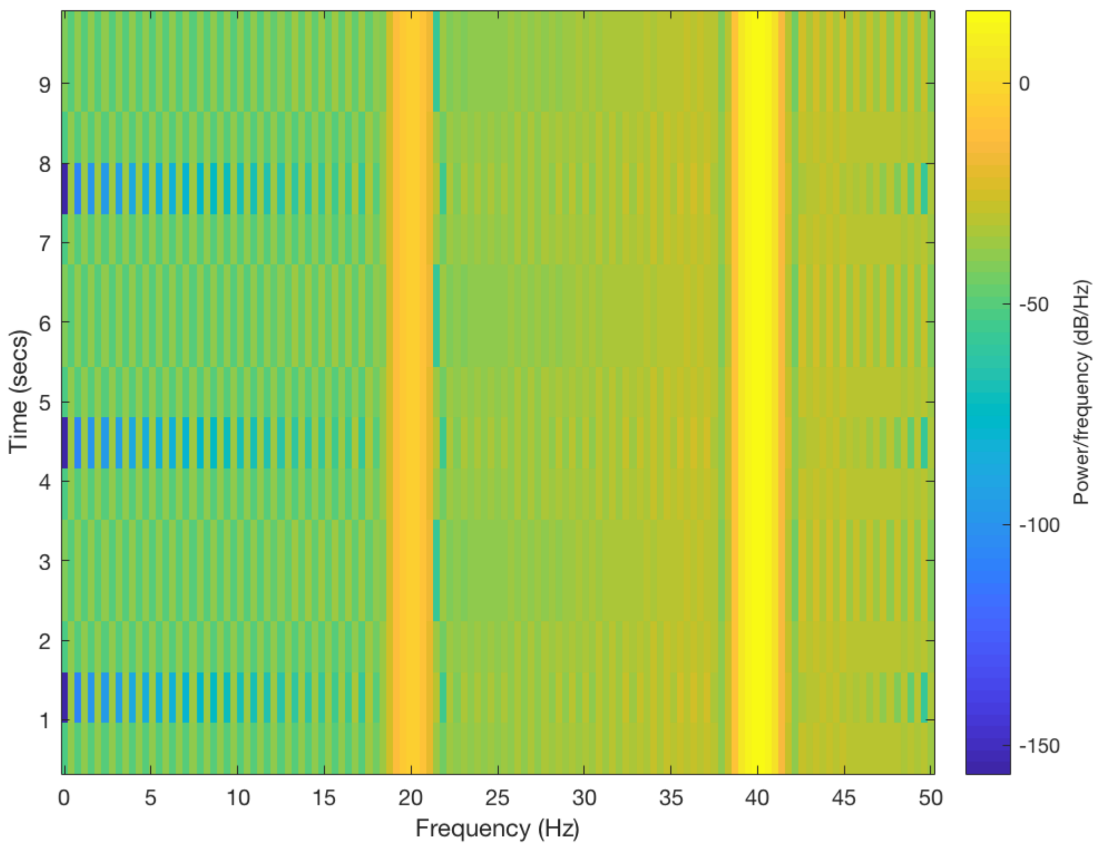
$\Rightarrow B = -1$.

So, $x(t) = \cos[2\pi(f_c - f_\Delta t) - \cos[2\pi(f_c + f_\Delta)t]$



2.3

```
N = 1024;

n = (0:N-1);

w0 = 2*pi/5;

x = sin(w0*n)+10*sin(2*w0*n);

spectrogram(x,128,64,[],100);
```

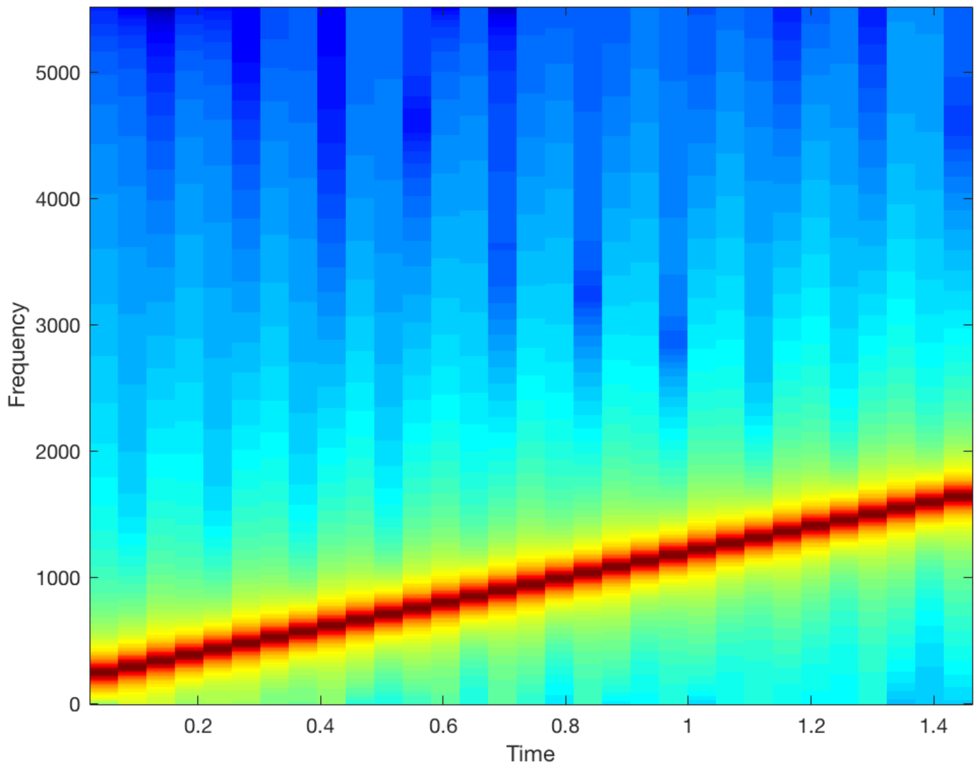


a. I hear a sharp chirping sound, similar to the one's used in building alarm.
b. I see a different color plot at different sample interval.

```
fsamp =11025; % set sampling frequency

dt =1/fsamp; % set sampling interval in seconds

dur = 1.5;%set signal duration in seconds

tt=0:dt:dur; % create vector of time samples spaced at dt seconds

psi =2*pi* (500*tt.^2+200*tt +100); % set argument for chirp function

xx=10*cos(psi); % modulate signal with cosine and amplitude cos

soundsc(xx,fsamp);% play signal
```

specgram(xx,1024,fsamp);% plot spectrogram

This sound is linear chirping sound, and is somewhat similar to the one's used in building alarm.



b. From the matlab code, the values are:

t_n =1.5 sec
A= 10
μ=2*pi* (500*tt.^2+200*tt +100);
f_0=200 Hz
ϕ=100

c. The range in the hertz would be from 0 to 2000 Hz.

d. The signal's frequency is linearly increasing.

fsamp =11025; % set sampling frequency

dt =1/fsamp; % set sampling interval in seconds

```
dur = 1.5;%set signal duration in seconds

tt=0:dt:dur; % create vector of time samples spaced at dt seconds

psi =2*pi* (500*tt.^2+200*tt +100); % set argument for chirp function

xx=10*cos(psi); % modulate signal with cosine and amplitude cos

soundsc(xx,fsamp);% play signal

specgram(xx,1024,fsamp);% plot spectrogram
```

e. function [xx,tt] = mychirp (f1, f2, dur, fsamp)

```
%MYCHIRP   generate a linear-FM chirp signal

        xx= mychirp (f1, f2, dur, fsamp )

        f1= 400

        f2=4000

        dur=7

        fsamp= 11025

        tt=0:7

if (nargin<4)

fsamp = 11025

end
```

f. function [xx,tt] = mychirp (f1, f2, dur, fsamp)

```
%MYCHIRP   generate a linear-FM chirp signal

        xx= mychirp (f1, f2, dur, fsamp )

        f1= 5000

        f2=500
```

```
    dur=3

    fsamp= 11025

    tt=0:3

if (nargin<4)

fsamp = 11025

end
```

Yes, the frequency movement is linear.

It does chirp down.