EC 415: Homework 3

Due by Friday 03/19/2021 6:00PM

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Exercise 3.18

Mimic the code in speccos.m with sampling interval $T_s=1/100$ to find the spectrum of a square wave with fundamental f=10, 20, 30, 33, 43 Hz. Can you predict where the spikes will occur in each case? Which of the square waves show aliasing?
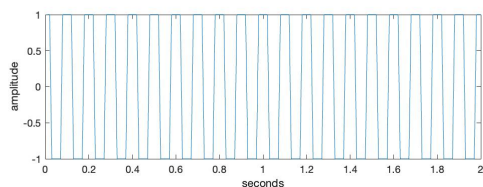
Solution
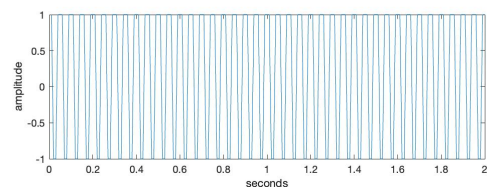TODO - Answer questions
This was confirmed by using the following code and changing the value of f appropriately

Listing 1: MATLAB code for Exercise 3.18

```
f=10; phi=0;                    % specify frequency and phase
time=2;                         % length of time
Ts=1/100;                       % time interval between samples
t=Ts:Ts:time;                   % create a time vector
x=sign(cos(2*pi*f*t+phi));      % create cos wave
plotspec(x,Ts)                  % draw waveform and spectrum
```
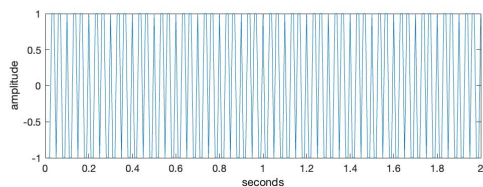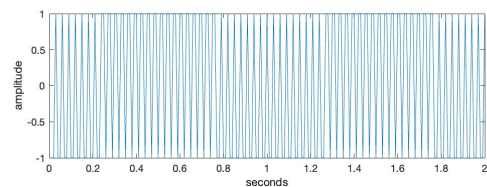

(a) f=10Hz

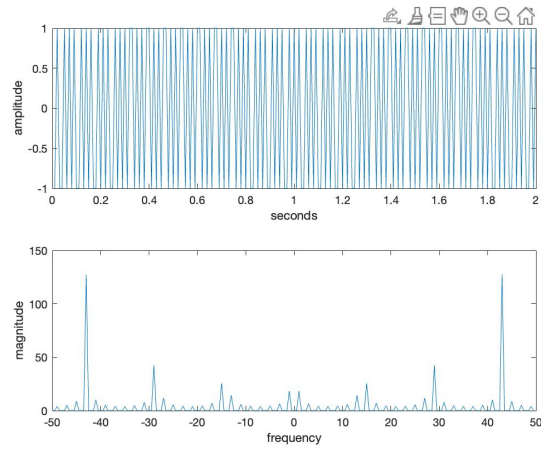(b) f=20Hz

(a) f=30Hz

(b) f=33Hz

Figure 2

Figure 3: f=43Hz

Exercise 3.19

Mimic the code in speccos.m with T_s=1/1000 to find the spectrum of the output y(t) of a squaring block when the input is $x(t) = cos(2\pi f_1 t) + cos(2\pi f_2 t)$ for f_1=100 and f_2=150Hz

Solution
TODO i don't think this is right, what's a squarring block?
Using this code

Listing 2: MATLAB code for Exercise 3.19

```
% speccos.m plot the spectrum of a cosine wave
f1=100; f2=150;                         % specify frequency
time=2;                                 % length of time
Ts=1/1000;                              % time interval between samples
t=Ts:Ts:time;                           % create a time vector
x=cos(2*pi*f1*t) + cos(2*pi*f2*t);      % create cos wave
plotspec(x,Ts)                          % draw waveform and spectrum
```
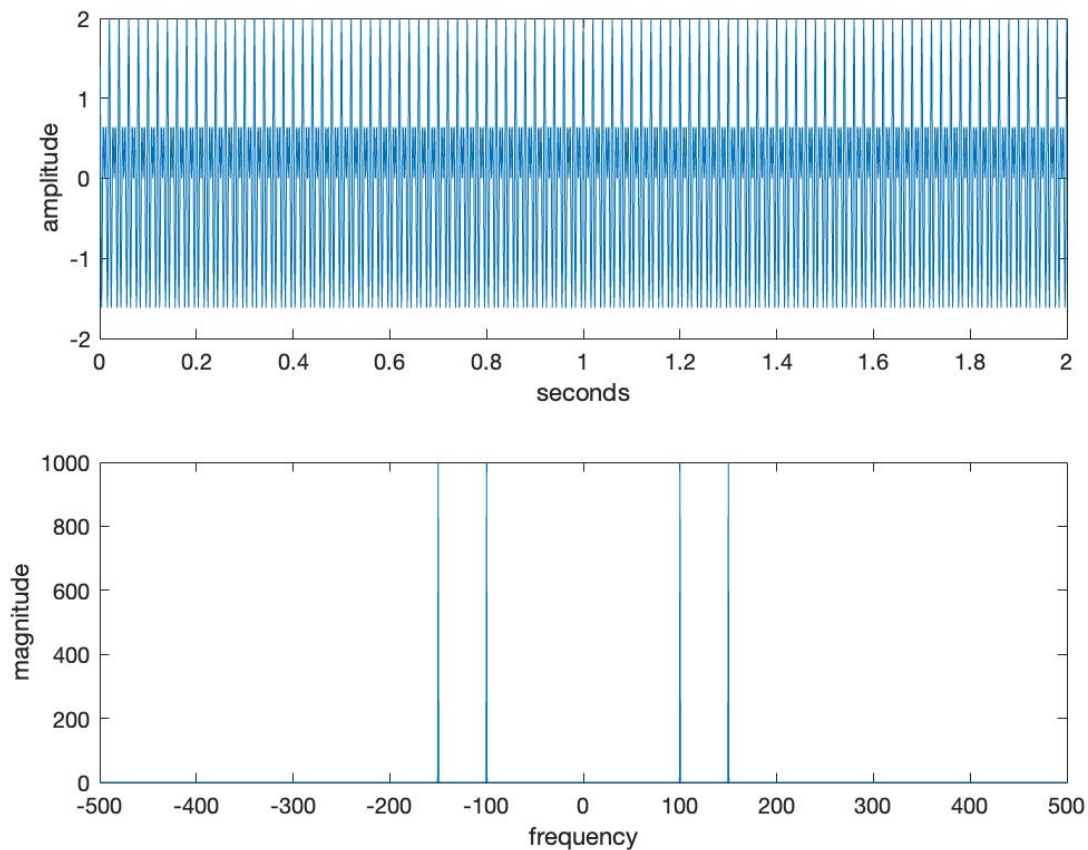
This output was generated

Figure 4: TODO

Exercise 3.20

TRUE or FALSE: The bandwidth of x^4(t) cannot be greater than that of x(t). Explain.

Solution
FALSE: for any given signal, $Bandwidth(x^n(t)) = n * Bandwidth(x^($t).

Exercise 3.23

Suppose that the output of a nonlinear block is the rectification (absolute value) of the input $y(t) = |x(t)|$. Find the spectrum of the output when the input is $x(t) = cos(2\pi f1t) + cos(2\pi f2t)$ for $f_1 = 100$ and $f_2 = 125$ Hz

Solution
Using this code

Listing 3: MATLAB code for Exercise 3.23

```
f1=100;  f2=125;                    % specify frequency
time=2;                             % length of time
Ts=1/100;                           % time interval between samples
t=Ts:Ts:time;                       % create a time vector
x=cos(2*pi*f1*t) + cos(2*pi*f2*t);  % create cos wave
y = abs(x);                         % Take abs value
plotspec(y,Ts)                      % draw waveform and spectrum
```
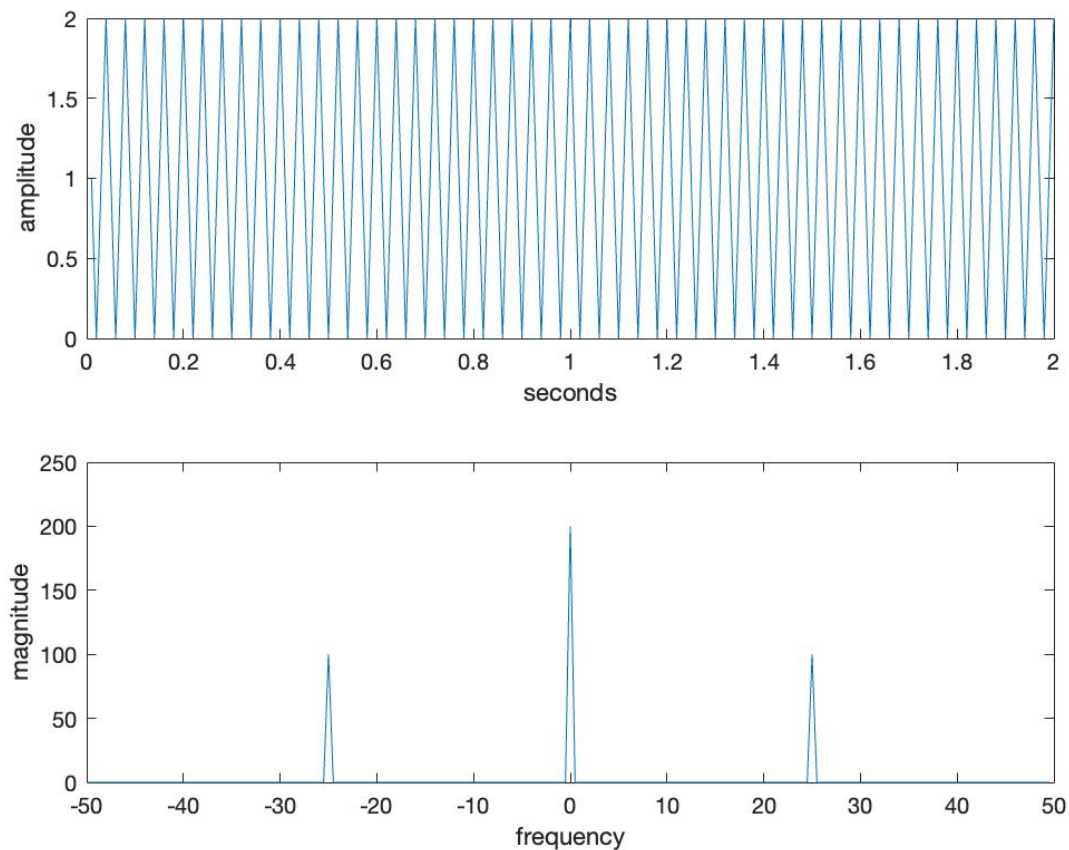
This output was generated

Figure 5: TODO

Exercise 3.25

Quantization of an input is another kind of common nonlinearity. The Matlab function quantalph.m (available on the website) quantizes a signal to the nearest element of a desired set. Its help file reads
% y=quantalph (x , alphabet)
% quantize the input signal x to the alphabet
% using nearest neighbor method
% input x - vector to be quantized
% alphabet vector of discrete values
% that y can assume
% sorted in ascending order
% output y quantized vector
Let x be a random vector x=randn(1,n) of length n. Quantize x to the nearest [3, 1, 1, 3].

  a. What percentage of the outputs are 1s? 3s?

  b. Plot the magnitude spectrum of x and the magnitude spectrum of the output.

  c. Now let x=3*randn(1,n) and answer the same questions.

  d. Explain what the randn(1,n) function does.

Solution
This code was used to get the following answers

Listing 4: MATLAB code for Exercise 3.25

```
% Set UP
n = 100;
alphabet = [3, 1, 1, 3];

% For A and B
x = randn(1,n);
y = quantalph (x , alphabet );

% Get percentages of 1 & 3
num1=0; num3=0;
for i=1:n

    if y(i) == 1
        num1 = num1 + 1;
    elseif y(i) == 3
        fprintf('trig\n')
        num3 = num3 + 1;
    end
end
fprintf(' 1 appered %d percent of the time\n', num1/n*100)
fprintf(' 3 appered %d percent of the time\n', num3/n*100)

% Plot
plotspec(x,1)

% For c
```

```
x = 3*randn(1, n);
y = quantalph (x , alphabet );

% Get percentages of 1 & 3
num1=0; num3=0;
for i=1:n
    if y(i) == 1
        num1 = num1 + 1;
    elseif y(i) == 3
        num3 = num3 + 1;
    end
end
fprintf('_1_appered_%d_percent_of_the_time\n', num1/n*100)
fprintf('_3_appered_%d_percent_of_the_time\n', num3/n*100)

% Plot
```

a. 98% of the outputs are 1 and the other 2% of outputs are 3

b. TODO

c. 71% of the outputs are 1 and the other 29% of outputs are 3

d. TODO

Exercise 4.1

Calculate the Fourier transform of $\delta(t - t_0)$ from the definition. Now calculate it using the time-shift property (A.37). Are they the same?
Hint: they had better be.

Solution
TODO

Exercise 4.10

Suppose that a system has an impulse response that is an exponential pulse. Mimic the code in convolex.m to find its output when the input is a white noise (recall specnoise.m on page 42).

Solution
Using this code

Listing 5: MATLAB code for Exercise 4.10

```matlab
% Create Noise signal
time=1;                            % length of time
Ts=1/10000;                        % time interval between samples
t=Ts:Ts:time;                      % create time vector
x=randn(1,time/Ts);               % Ts points of noise for time seconds
h=exp(-t);                         % define impulse response
y=conv(h,x);                       % Do convolution
subplot(3,1,1), plot(t,x)     % Plot
subplot(3,1,2), plot(t,h)
subplot(3,1,3), plot(t,y(1:length(t)))
% actual commands used to draw figure:
subplot(3,1,1), plot(t,x)
ylabel('input')
subplot(3,1,2), plot(t,h)
ylabel('impulse response')
subplot(3,1,3), plot(t,y(1:length(t)))
ylabel('output')
xlabel('time in seconds')
```
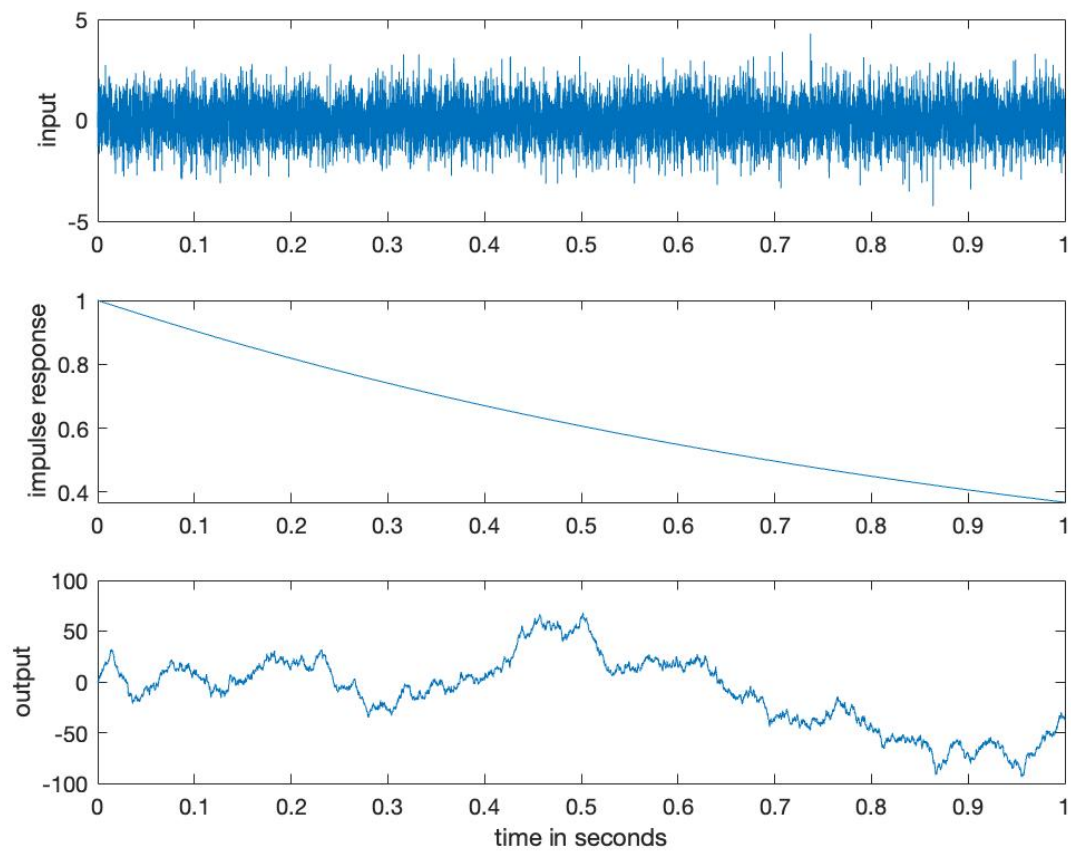
This output was generated

Figure 6: output of exponential pulse response to noisy input

Exercise 4.17

Suppose a system has an impulse response that is a sinc function. Using freqresp.m, find the frequency response of the system. What kind of filter does this represent?

Hint: center the sinc in time; for instance, use $h = sinc(10 * (t - time/2))$.

Solution
Using this code

Listing 6: MATLAB code for Exercise 4.17

```
Ts=1/100;  time=10;              % sampling interval and total time
t=0:Ts:time;                     % create time vector
h=sinc(10 * (t - time/2));       % define impulse response
plotspec(h,Ts)                   % find and plot frequency response
```
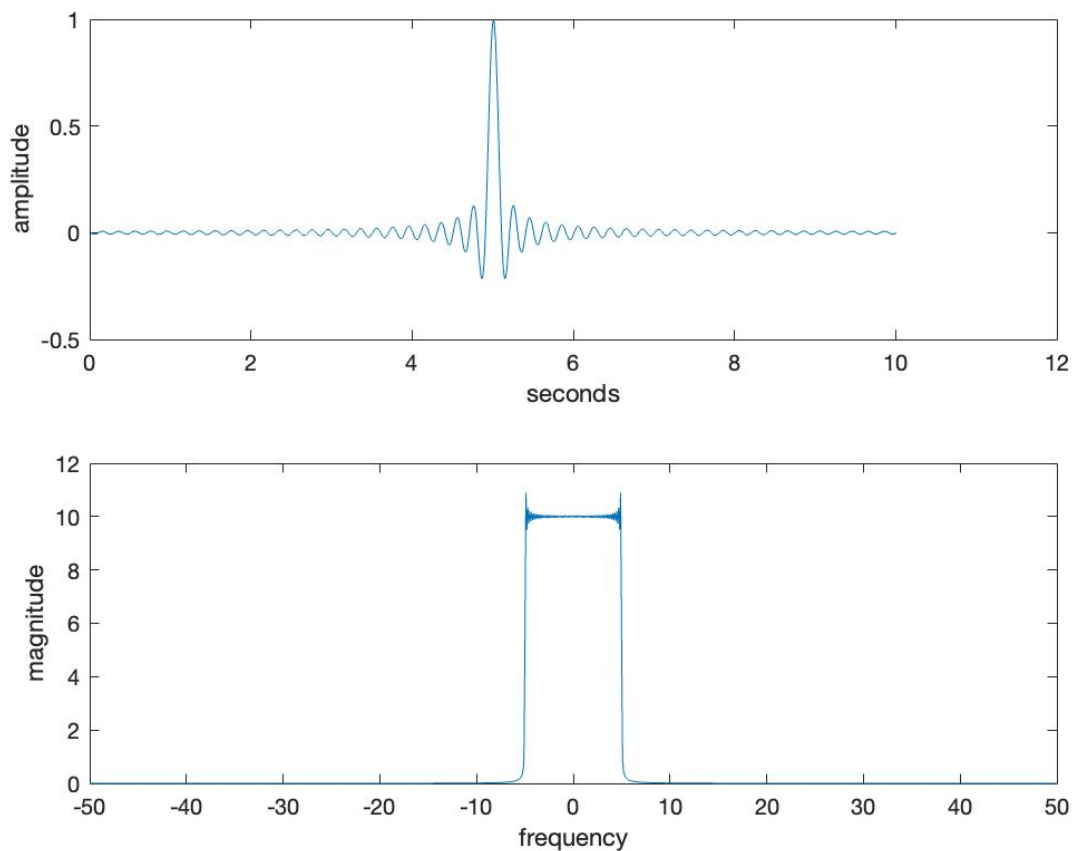
This output was generated

Figure 7: frequency response of system with sinc impulse response

This figure represents a low pass filter.

Exercise 4.18

Suppose a system has an impulse response that is a sin function. Using freqresp.m, find the frequency response of the system. What kind of filter does this represent? Can you predict the relationship between the frequency of the sine wave and the location of the peaks in the spectrum?
Hint: try $h = sin(25 * t)$.
Solution
Using this code

Listing 7: MATLAB code for Exercise 4.18

```
Ts=1/100; time=10;          % sampling interval and total time
t=0:Ts:time;                % create time vector
h=sin(25*t);                % define impulse response
plotspec(h,Ts)              % find and plot frequency response
```
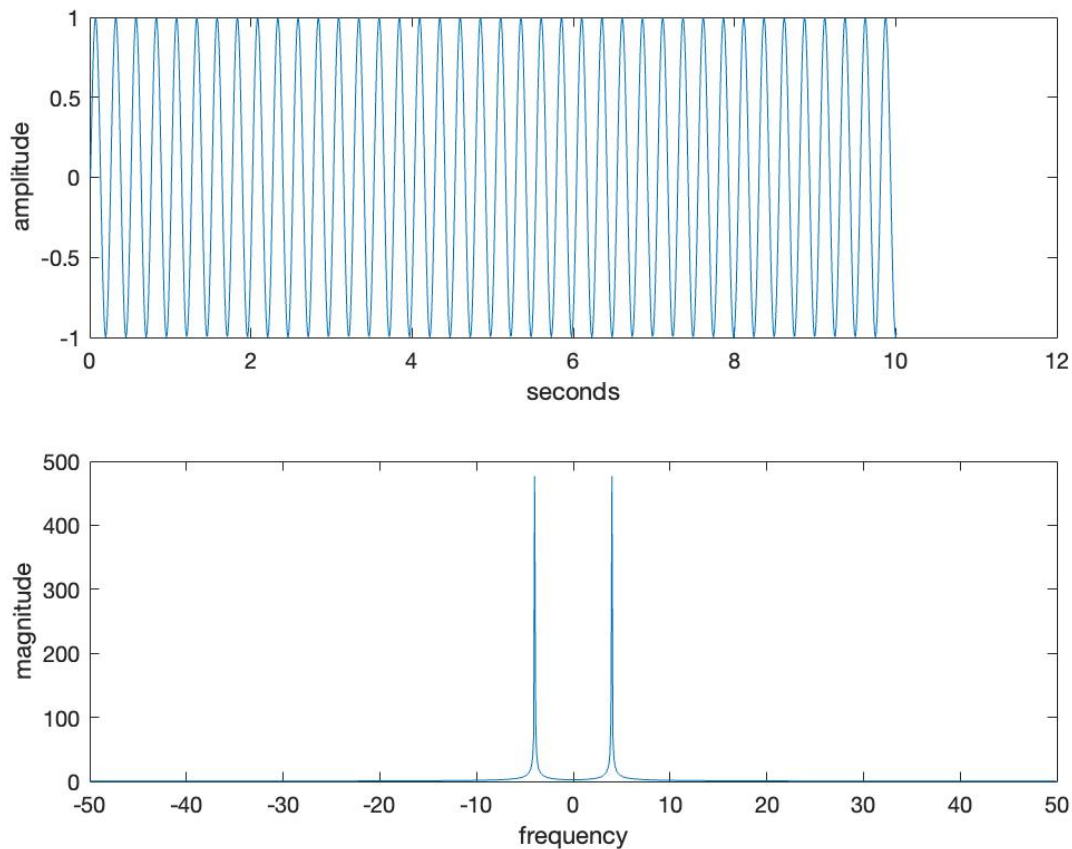
This output was generated

Figure 8: frequency response of system with sinc impulse response

This figure represents a narrow band pass filter.

Plotting by hand

Plot by hand the magnitude and argument of the spectrum of:

a. $cos(40\pi t) + sin(20\pi t)$.
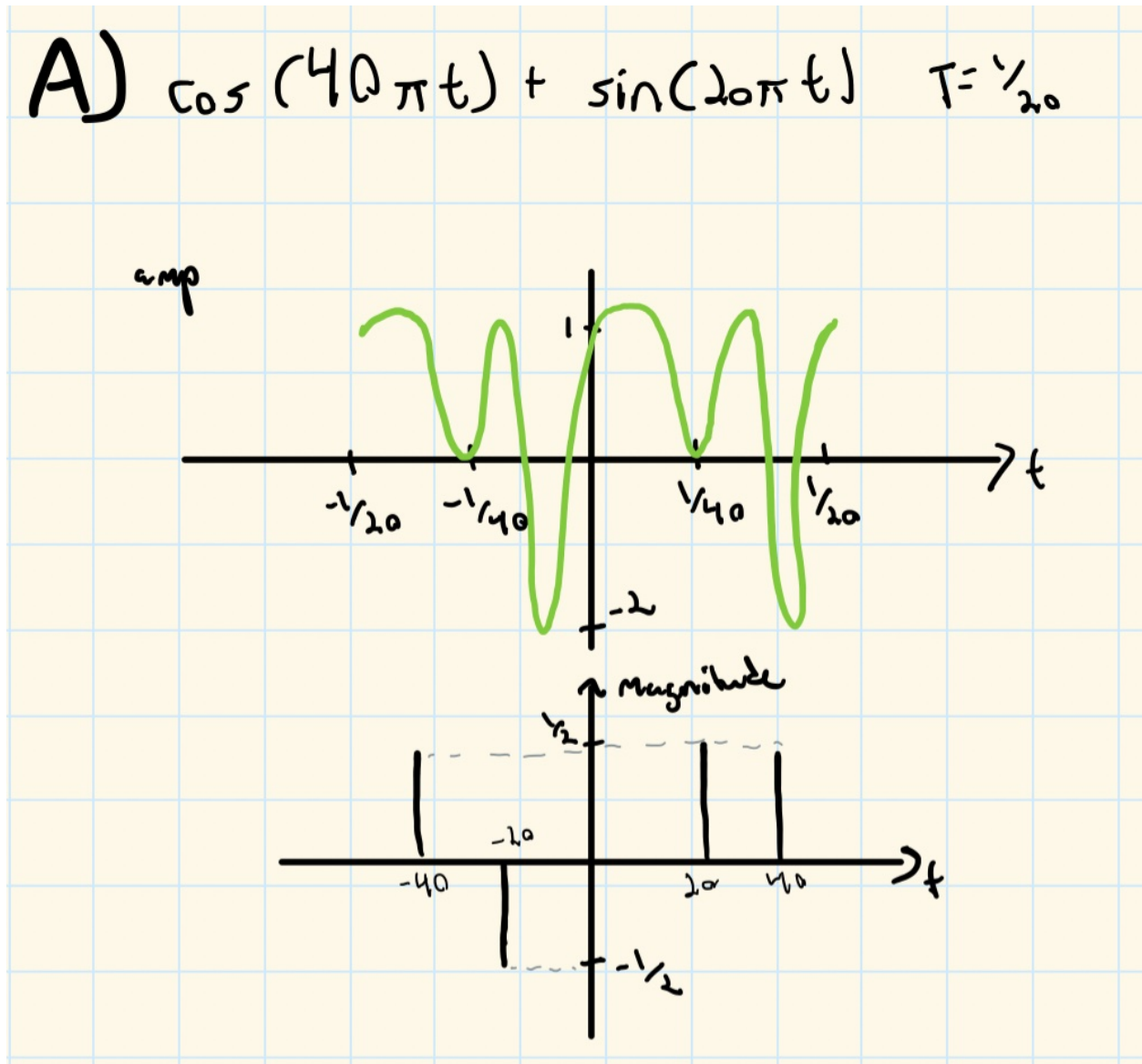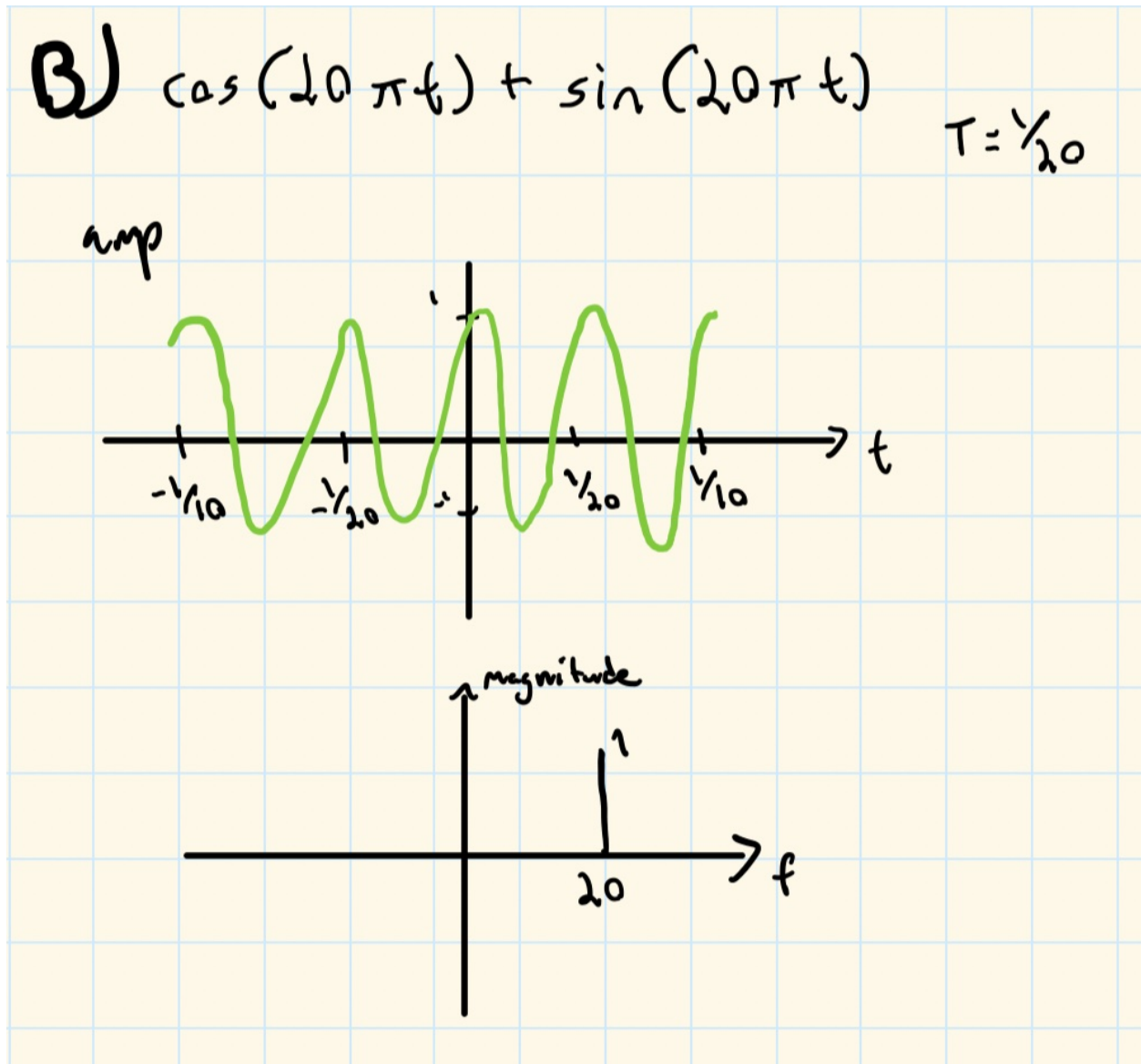
b. $cos(20\pi t) + sin(20\pi t)$.

Solution

Figure 9: spectrum plot of $cos(40\pi t) + sin(20\pi t)$

B) $cos(20\pi t) + sin(20\pi t)$

$T = \frac{1}{20}$

amp

magnitude

Figure 10: spectrum plot of $cos(20\pi t) + sin(20\pi t)$