ECEN 220
Lab Report 3
Signals and LTI Systems

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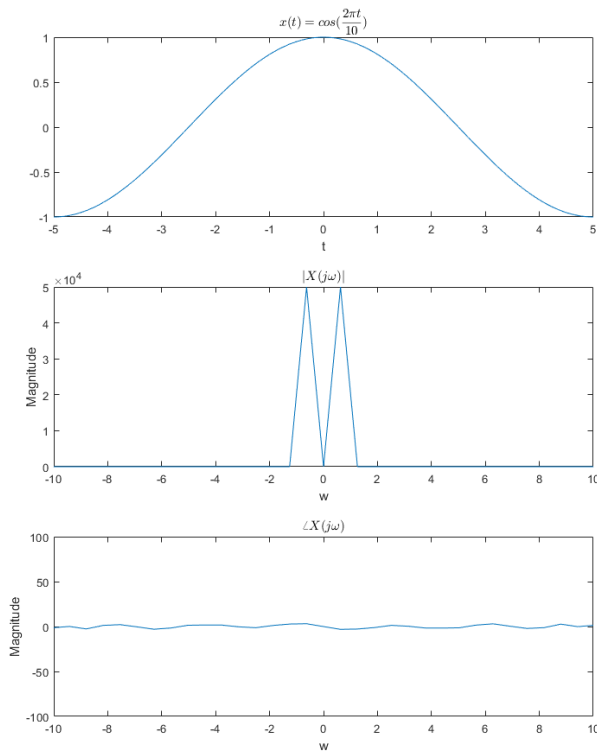300447549

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1   Cosine FS

Figure 1: (1.a) & (1.b) Signal and Mag/Phase plots of $cos(\dfrac{2\pi t}{10})$

1.c)   The plotted magnitudes in the frequency domain are as expected, with 2 deltas at the positive and negative natural frequency of the cosine. However, due to limit of machine precision and floating point errors around zero, the phase plotting is inaccurate. Ie should be a flat zero for all ω
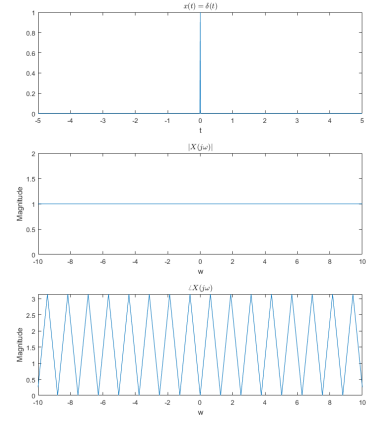
1.d)   As the t resolution increases this doesn't effect the mag plotting due to the fact that it is just 2 deltas and those delta sample value do not change. But as ω space is a transformed t space it to increases in resolution, The 'discreteness' of the transforms increases. Ie the deltas sharpening etc.
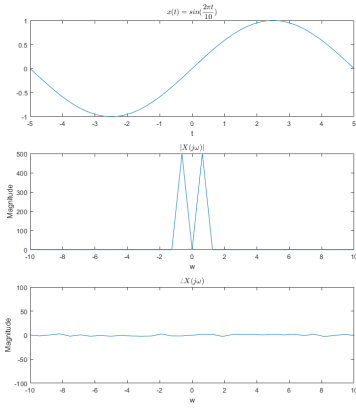
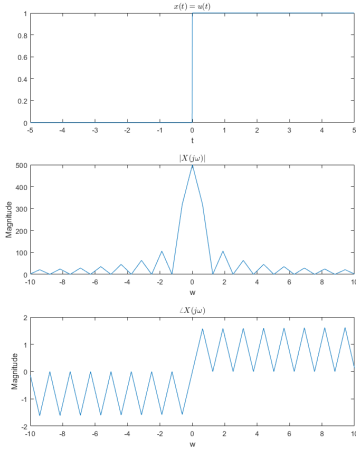(a) $= sin(\omega_0 t)$
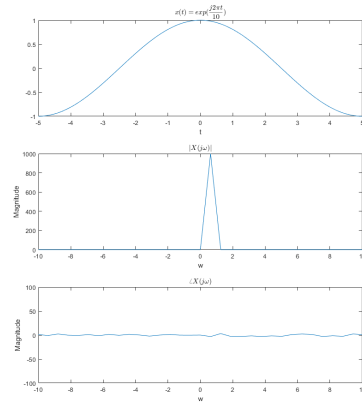
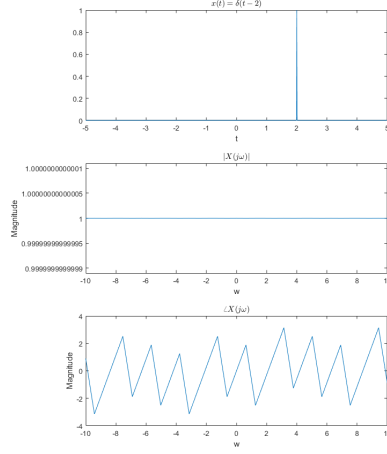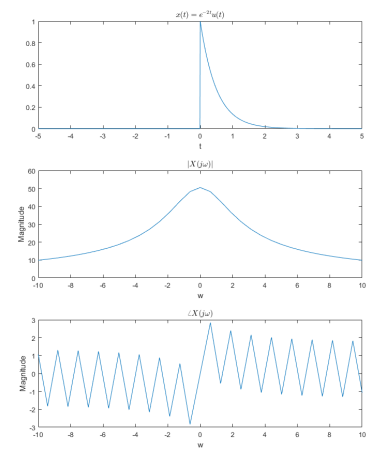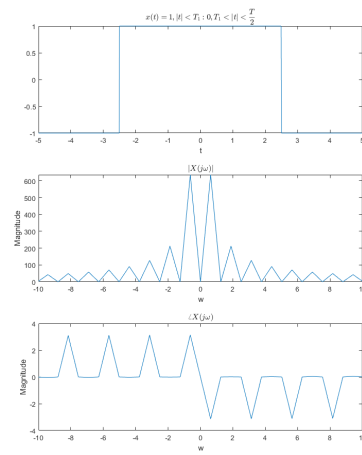(b) $= e^{j\omega_0 t}$

(c) $= \delta(t)$

(d) $= u(t)$

(e) $= \delta(t - t_0) : t_0 = 2$

(f) $= e^{-at}u(t) : a = 2$

$$(g) = \begin{cases} 1, & |t| < T_1 \\ 0, & T_1 < |t| < \frac{T}{2} \end{cases}$$

Figure 2: (2.a)

2   Other Fs's (Ref: Figure 2)

2.b)

   a. $|X(j\omega)| = \delta(-\omega_0 + \delta(\omega_0)$

   b. $|X(j\omega)| = \delta(\omega_0$

   c. $|X(j\omega)| = 1$

   d. $|X(j\omega)| = \delta(0)$

   e. $|X(j\omega)| = 1$

   f. $|X(j\omega)| = |\dfrac{1}{j\omega + \alpha}|$

   g. $|X(j\omega)| = sinc(\omega)$

2.c)   Anomalies in the phase of the first 2 are the same as previously discussed in 1.c, ie machine precision etc.

fig 2c   The ideal Magnitude function for a zero centred delta is correctly plotted as a constant, but due to Matlab treating the delta as not perfectly zero centred the phase plot is not a constant, but instead in slightly modulated.

fig 2d   The ideal Mag/Phase for the unit step should be a delta and a linear phase shift but as plotted in Matlab, it was treated as periodic, ie a squared pulse, so the plotted transform is that for a zero starting square pulse.

fig 2e   The ideal Magnitude function for a shifted delta is correctly plotted as a constant, but due to Matlab treating the delta as not perfectly centred on its ideal. It should be a Sawtooth wave, which is a visible component but there is still some modulation.

fig 2f   The magnitude is correctly plotted, but again the phase should be a smooth transition $\pm$ 180 degrees, but Matlab plots oscillations of amplitude π.

fig 2e   For this zero centred square phase correctly plots oscillations between 0 and $-\pi$ for $\omega > 0$ and oscillations between 0 and $+\pi$ for $\omega < 0$. Although I am not sure abount the zero magnitude at $\omega = 0$

3   Appendix

Figure 1:

```
clear;
clc;

%% A
Fs = 10000000; %samples per second
T = 10;
Ts = 1/Fs; %seconds per sample
t = -T/2:Ts:T/2-Ts;

%signal
w0 = (2.*pi)./10;
x = cos(w0.*t);

figure()
sig = subplot(3,1,1);
plot(t,x)
title('$$x(t) = cos(\frac{2\pi t}{10})$$','interpreter','latex')
xlabel(sig,'t');


%% B

%FT
X = fft(x);

f = (0:length(X)-1)*Fs/length(X);
N = length(f);
w = (-N/2:N/2-1)*(Fs/N)*2*pi;
Xshift = fftshift(X);

mag = subplot(3,1,2);
plot(w,abs(Xshift))
title('$$|X(j\omega)|$$','interpreter','latex')
xlabel(mag,'w');
ylabel(mag,'Magnitude');
xlim(mag, [-10,10])

phs = subplot(3,1,3);
plot(w,angle(Xshift))
title('$$\angle X(j\omega)$$','interpreter','latex')
xlabel(phs,'w');
ylabel(phs,'Magnitude');
xlim(phs, [-10,10])
```

Figures 2:

```matlab
clear;
clc;

%% A
Fs = 100;
T = 10;
Ts = 1/Fs;
t = -T/2:Ts:T/2-Ts;
w0 = (2.*pi)./10;


u = t>=0;


x_vec = [sin(w0.*t); exp(1j.*w0.*t); (t==0); u; (t==2); exp(-2.*t).*u; square(w0*(t+2.5))];


%signal
sig = 5; %changes occording to whic function from the vector i'm plotting
figure(sig)
x = x_vec(sig,:);
sig = subplot(3,1,1);
plot(t,x)
%changes occording to whic function from the vector i'm plotting
title('$$x(t) = \delta (t-2)$$','interpreter','latex')
xlabel(sig,'t');


%FT
X = fftshift(fft(x));
N = length(x);
w = (-N/2:N/2-1)*(Fs/N)*2*pi;


%spectrum.
mag=subplot(3,1,2);
plot(w,abs(X));
title('$$|X(j\omega)|$$','interpreter','latex')
xlabel(mag,'w');
ylabel(mag,'Magnitude');
xlim(mag, [-10,10]);


phs=subplot(3,1,3);
plot(w,angle(X));
title('$$\angle X(j\omega)$$','interpreter','latex')
xlabel(phs,'w');
ylabel(phs,'Magnitude');
xlim(phs, [-10,10]);
```