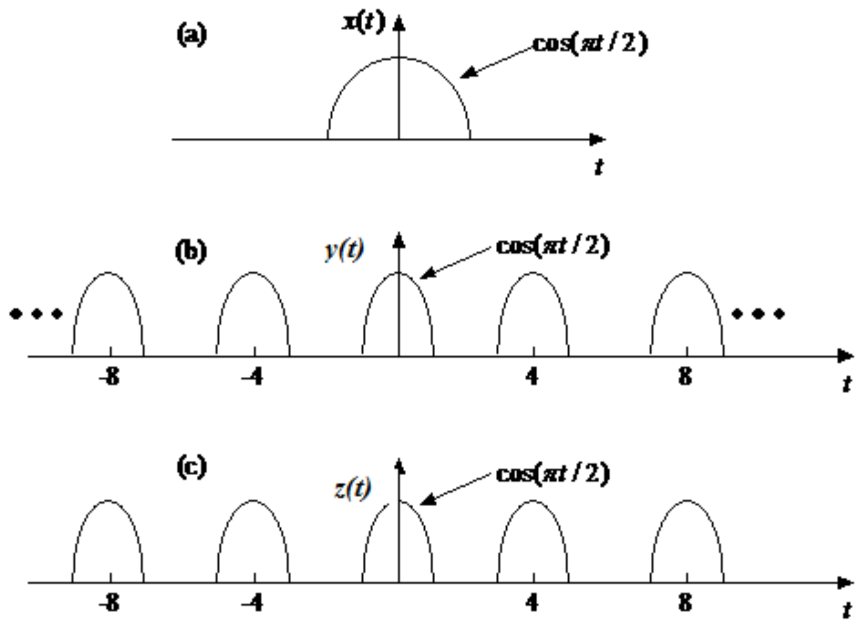
Due February 11 2008 at 5:00 PM

ECE 438 — Assignment No. 3 — Spring 2009

1. For each signal $x(t), y(t)$, and $z(t)$ given in parts a - c below, do the following:

   i. Find an expression for its CTFT. (Use transform relations including comb function and the results of previous parts of the problem wherever possible. In particular, for part (a), you should use the product theorem and known transform pairs, rather than evaluating the Fourier integral directly.)

   ii. Carefully sketch the CTFT.



2. The signal $x(t) = \cos(2\pi(50)t)\mathrm{sinc}(50t)$ is sampled with period T = 0.005 sec. to generate a discrete-time signal $x[n]$.

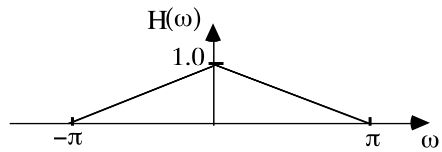
   a. Sketch $x(t)$ and $x[n]$.

   b. Derive and sketch the CTFT $X(f)$ for $x(t)$.

   c. Derive and sketch the CTFT $X_s(f)$ for $x_s(t) = \mathrm{comb}_T[x(t)]$

   d. Using your results from part c. above, find the DTFT $X(\omega)$ for $x[n]$

3. A non-negative unit amplitude square wave with period P sec. and 50% duty cycle is filtered with an ideal low pass analog filter with cutoff at f_c kHz, and then sampled with an ideal sampler at a rate of 20 kHz, filtered with a digital filter having the frequency response $H(\omega)$ shown below, and then reconstructed as an analog signal $y(t)$ with an ideal D/A convertor with a cutoff frequency of 10 kHz.



Find the output $y(t)$ for the following values of T and f_c

a. P = 0.2 msec, f_c = 10 kHz

b. P = 0.2 msec, f_c = 20 kHz

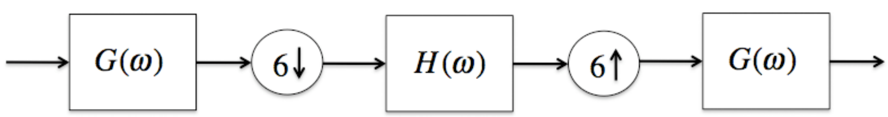
4. Consider the digital filter described by the following difference equation

$$y[n] = \left(x[n] + x[n-1] + x[n-2]\right)/3$$

a. Find a simple expression for the frequency response $H(\omega)$ of this filter.

b. Sketch the magnitude of $H(\omega)$.

Now consider the following digital system,



where $H(\omega)$ is the filter from parts a and b and $G(\omega)$ is an ideal low-pass filter with a cutoff frequency of $\pi/6$ rad/sample and unity gain in the passband.

c. Find the overall frequency response $F(\omega)$ for this system.

d. Sketch the magnitude of $F(\omega)$.

e. Discuss the possible advantages of a system like that shown above compared to directly implementing a digital filter with frequency response $F(\omega)$ as a single stage.

5. Conversion between analog and digital frequencies

a. Electrocardiogram signals are very susceptible to interference from the 60 Hz power present in the room where the patient is being monitored. You are going to design a high-pass digital filter to eliminate the 60 Hz interference and everything at frequencies below 60 Hz. Assume that the highest frequencies of interest in the electrocardiogram signal are at 2500 Hz. Choose an appropriate sampling frequency for your A/D convertor, and sketch the desired frequency response of the digital filter. Be sure to show how you calculated the cutoff frequency for the digital filter.

b. Long term climate change is a topic of great interest at this time. To see if there has been a significant long-term trend in temperatures in Lafayette, IN, you have downloaded temperature data from the U.S. Weather Service. The file contains the average monthly temperature at the Purdue airport for the past 100 years. Thus it consists of 1200 samples. In order to see if there is a long-term trend, you will need to remove the annual cycle from the data. Sketch the desired frequency response of an ideal low-pass digital filter that will accomplish this. Be sure to show how you calculated the cutoff frequency of the digital filter.