Homework #9
EECS 360

1.

Let $x_a(t) = \sum_{k=-\infty}^{\infty} tri(\frac{t - T_o k}{w})$ where w=0.2ms and T_o=0.5ms

a) $x_a(t)$ is input to an ideal lowpass filter with a bandwidth of 4.5 kHz that produces an output signal $y_a(t)$. Find $y_a(t)$ and $Y_a(f)$.
b) $x_a(t)$ is input to an ideal bandpass filter with a bandwidth of 0.5 kHz centered at 2 kHz. that produces an output signal $y_b(t)$. Find $y_b(t)$ and $Y_b(f)$.
c) What is the total power in the in the frequency range $|f| \leq 5000$?

2.

a) $x(t) = 10000\text{sinc}^2(10000t)$, x(t) is input to an ideal lowpass filter with a bandwidth of B kHz find the smallest B such that the filter introduces no distortion.
b) Find the % energy in the frequency range $|f| \leq 5000$?
c) What are the barriers to building the filter described in part a)

3. Let $x(t) = \sum_{k=-\infty}^{\infty} rect(\frac{t - T_o k}{w})$ where w=.1μs and T_o=2μs

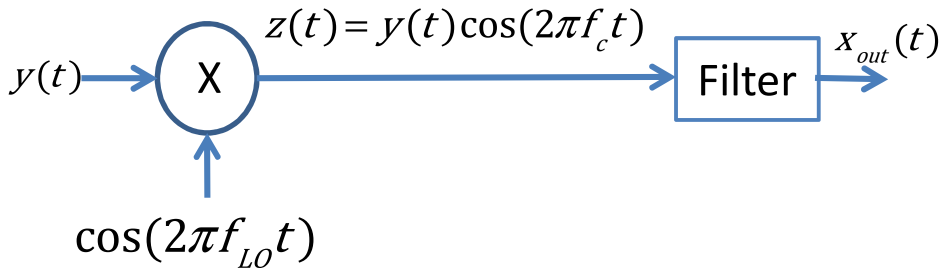
Design (specify) a system (filter) to convert x(t) to $y(t) = \cos(2\pi f_a t)$ where f_a=1.5 MHz.

4. A system transfer function is $H(f) = tri(\frac{f}{40000})e^{-j2\pi\alpha f}$ where α= 1/80000. The input to H(f) is $x(t) = \cos(2\pi 20000t)$. Find the system output in the time and frequency domains, i.e., y(t) and Y(f).

5. A multipath communications channel can be modeled as a filter in the time domain using an impulse response, $h_c(t)$. Let $h_c(t) = a_0\delta(t) + a_1\delta(t - 0.1\mu s)$. The received signal is the filter output given an input signal of x(t).

a) Find the model for the multipath communications channel in the frequency domain, i.e., $H_c(f)$.
b) For a_0=1 and a_1=-1 and a transmitted signal of $x(t) = \cos(2\pi f_c t)$ where f_c=10Mhz find the received signal.

6. Let x(t) and g(t) be voice signals with a bandwidth of 3kHz, assume X(f)=tri(f/3000) and G(f)=rect(f/6000). Let $y(t)=x(t)\cos(2\pi f_c t)+g(t)\cos(2\pi(f_c+20{,}000)t)$ be a transmitted signal where f_c=1500kHz. The received signal y(t) is processed as shown below.



a) Plot Y(f)
b) Plot Z(f)
c) Design (specify) the Local Oscillator frequency f_{LO} and the filter such that $x_{out}(t)=Cx(t)$, where the constant $C\neq 0$.

7. A series R, L, C circuit is modeled by the following differential equation with x(t)=input voltage and y(t)=output voltage=voltage across the capacitor.

$$LC\frac{d^2y(t)}{dt^2}+RC\frac{dy(t)}{dt}+y(t)=x(t)$$

a) Find H(f).
b) Plot $20Log_{10}(|H(f)|)$ with R=100 Ohm, L=0.001 Henry, C=0.000001 Farad. (You are encouraged to use Matlab to do this plot.)
c) For R=100 Ohm, L=0.001 Henry, C=0.000001 Farad, given x(t)=cos(2π1760t) find A in y(t)=Acos(2π1760t+ϕ)
d) Is 1760 Hz close to the 3 dB bandwidth for this system?
   Confirm your results with:
   http://www.ittc.ku.edu/~frost/EECS_360/Mathematica-360/Series-RLC-Transfer-Functions.cdf

8. A series R, L, C circuit is modeled by the following differential equation with x(t)=input voltage and y(t)=output voltage=voltage across the resistor.

$$LC\frac{d^2y(t)}{dt^2}+RC\frac{dy(t)}{dt}+y(t)=RC\frac{dx}{dt}$$

a) Find H(f).
b) Plot $20Log_{10}(|H(f)|)$ with R=500 Ohm, L=0.4 Henry, C=0.0000007 Farad. (You are encouraged to use Matlab to do this plot.)
c) For R=500 Ohm, L=0.4 Henry, C=0.0000007 Farad, given x(t)=cos(2π217t) find A in y(t)=Acos(2π217t+ϕ) and given x(t)=cos(2π417t) find B in y(t)=Bcos(2π417t+ϕ), i.e., find the amplitudes of the output cosine. What is the 3 dB bandwidth for this system?
   Confirm your results with:

http://www.ittc.ku.edu/~frost/EECS_360/Mathematica-360/Series-RLC-Transfer-Functions.cdf

d) Use http://www.ittc.ku.edu/~frost/EECS_360/Mathematica-360/Series-RLC-Transfer-Functions.cdf and find the impact of keeping L and R fixed and changing C.
e) Use http://www.ittc.ku.edu/~frost/EECS_360/Mathematica-360/Series-RLC-Transfer-Functions.cdf and find the impact of keeping L and C fixed and changing R.