EE120 section 2, Spring 1991
Final
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Problem #1 (15%)

The input to an LTI is the sequence *x*[*n*], and the system's impulse response is *h*[*n*].

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                +n
Let  x[n] = a     u[n],  |a| < 1
                +n
and  h[n] = b     u[n],  |b| < 1 .
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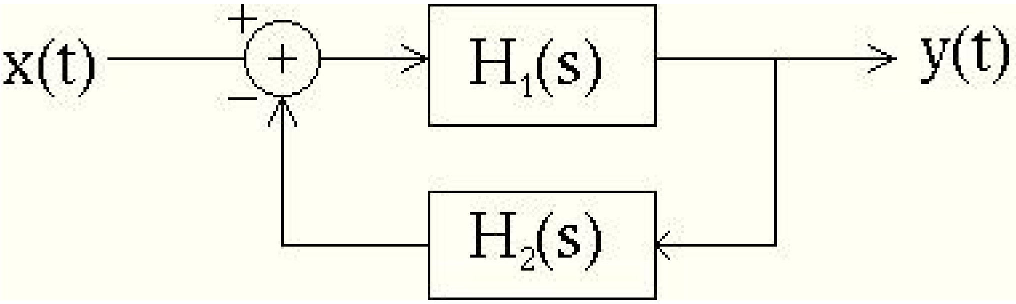
Compute the ouput *y*[*n*] directly in the time domain and then verify your result by computing *y*[*n*] using Fourier transform techniques.

Problem #2 (20%)

Consider the feedback system as described below.



a. Derive the closed-loop transfer function $H(s)$.

b. Let $H1(s) = K$ and $H2(s) = 1/(s+1)$. For what real values of K (positive or negative) is the system stable?

c. Calcualate the impulse response $h(t)$ for $K = 2$.

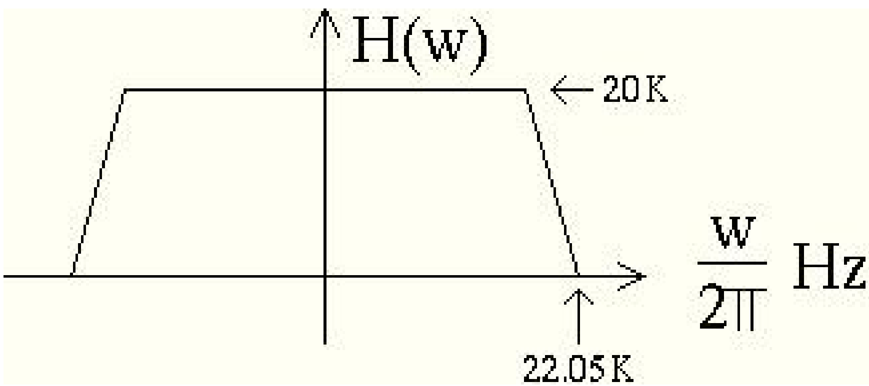
d. Calculate the step response for $K = 2$.

Problem #3 (20%)

A manufacturer of consumer electronics praises its CD player and claims that "...The higher the frequency used to resample a CD's digital signal, the smoother and more natural the recreated analog waveform will be. With 16 times oversampling ... a gently sloping analog filter can then be used in the final output stage, avoiding harsh phase distortion..."

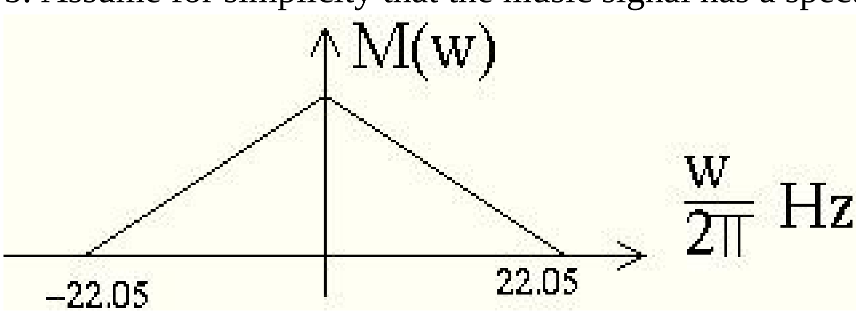
To check this claim:

a. Assume that the overall audio system of the CD should have a flat frequency response between 2 and 20k Hz. Additional bandwidth of 2.05 kHz is required as a transition band between the passband and the stopband.



What is the standard (minimum) sampling frequency that is required for successful reproduction of any signal within that frequency band?

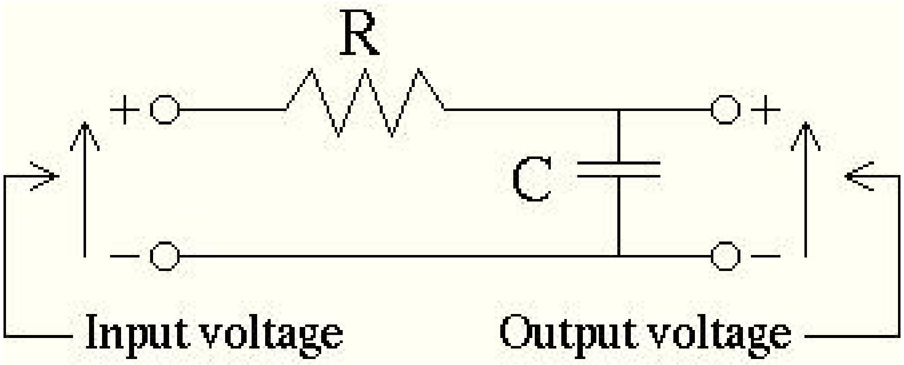
b. Assume for simplicity that the music signal has a spectral density as shown below:



Sketch the spectral density of the sampled waveform. Mark all the relevant parameters.

c. Now assume that the music signal is 16-times oversampled. Sketch the spectral density of the sampled waveform. Mark all relevant parameters.

d. Assume that a simple RC low-pass filter is used to recover the analog music signal from its samples.



(1) Derive the frequency response *H-RC*(omega) of this filter.

(2) How much phase-shift is introduced by this filter at omega/2Pi = 20 kHz when it is designed to have a 3dB attenuation at:

(a) Half the standard sampling frequency?
(b) Twice the standard sampling frequency?
(c) Eight times the standard sampling frequency? By how much does this filter attenuate signals at the actual sampling frequency?

Problem #4 (25%)

The signal *x*(*t*) is passed through systems *A* and *B* as shown below. The Fourier transform of *x*(*t*) is real and is also shown below. *H*(omega) is an ideal filter

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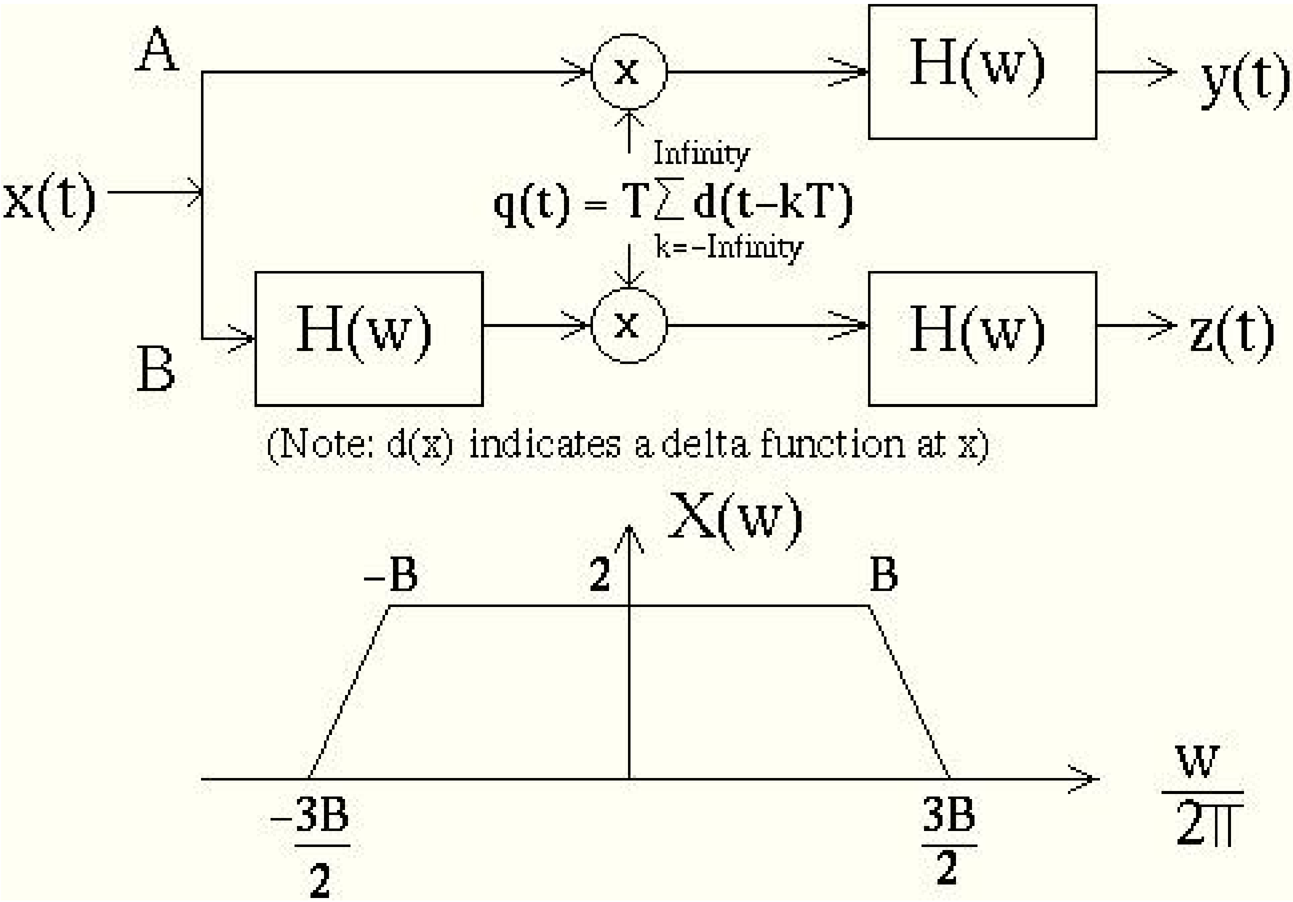
H(omega) = {1,   |omega| <= 2 Pi B
           {0,   |omega| > 2 Pi B
```

and 2*B* = 1/T.



a. Sketch and mark all the relevant parameters of the Fourier transforms of *y*(*t*) and *z*(*t*).

Calculate:

$$\text{b. epsilon-B} = \int_{-\infty}^{\infty} |x(t) - z(t)|^2 \, dt$$

$$\text{c. epsilon-A} = \int_{-\infty}^{\infty} |x(t) - y(t)|^2 \, dt$$

d. Explain the difference (if any) between epsilon-B and epsilon-A.

Problem #5 (20%)

Let an unmodulated carrier be cos(*omega-c*t*) and let the message signal *m*(*t*) be restricted to the frequency band |*omega*| <= 2 Pi *B*.

Write an expression for the modulated wave *x*(*t*) for each of the folllowing modulation methods:

a. DSB-LC (conventional AM)
b. DSB-SC
c. SSB-LC
d. SSB-SC
e. PM
f. FM

Explain and add definitions (if necessary) for the terms that are used in your expressions.

Each of the following statements may apply to one or more of the above-mentioned modulation methods.

1. Requires sychronous demodulation for detection.
2. High quality detection can be obtained with envelope demodulation.
3. Is wasteful of power.
4. Is wasteful of bandwidth.
5. Requires nonlinear demodulation for proper detection.
6. Useful where both power and bandwidth are at a premium.
7. Modulated signal bandwidth is independent of the message magnitude.
8. Allows an inexpensive receiver.
9. Modulated signal bandwidth can be greater than 4B.
10. Is a nonlinear modulation method.

Make a table as shown below and mark the corresponding squares where a statement applies to a modulation method.

\	a	b	c	d	e	f
1	_	_	_	_	_	_
2	_	_	_	_	_	_
3	_	_	_	_	_	_
4	_	_	_	_	_	_
5	_	_	_	_	_	_
6	_	_	_	_	_	_

7	_	_	_	_	_	_
8	_	_	_	_	_	_
9	_	_	_	_	_	_
10	_	_	_	_	_	_

Note: a phrase like "epsilon-B" or "H-RC" indicates that "B" and "RC", for example, are subscripts.
