EECS 120, Midterm 1, 3/04/02

Do your calculations on the sheets and put a box around your answer where this makes sense. Print your name and your TA's name here:

Last Name __________________ First ____________________ TA's name ___________________

1. **20 points** The following statements are either TRUE or FALSE. If you believe a statement is true, outline a BRIEF PROOF. If you believe it is false, provide a BRIEF COUNTEREXAMPLE.

   a. If x(t), t is in the set of real numbers, is a real-valued signal, its Fourier transform X(f), f is in the set of real numbers, is also real-valued.

   b. If x(t), y(t), t is in the set of real numbers, are real-valued signals and (x * y)(t) = 0, for all t contained in the set of real numbers, then either x or y is identically zero.

   c. If x(t), t is in the set of real numbers, is a real-valued, baseband signal with bandwidth W Hz, then the signal y, $y(t) = x^4(t)$, t is in the set of real numbers, has bandwidth at most 4W Hz.

   d. If x(t), t is in the set of real numbers, is a real-valued, band-limited signal with bandwidth W Hz, then the signal y(t) = x(2t), t is in the set of real numbers, has bandwidth W^2 Hz.

   e. If x,y are real-valued signals with bandwidth W_x, W_y Hz, respectively, the signal x + y has bandwidth $W_x + W_y$ Hz.

2. **20 points** m_1, m_2 are two signals both with bandwidth B Hz. A modulated signal x with carrier frequency $f_c >> B$ is constructed as

$$\text{For every value } t,\ x(t) = m_1(t)\cos 2\pi f_c t + m_2(t)\sin 2\pi f_c t$$

   a. Find a coherent demodulation scheme that recovers m_1. Briefly explain using a mathematical or graphical argument why your scheme works.

   b. Find a coherent demodulation scheme that recovers m_2. Briefly explain using a mathematical or graphical argument why your scheme works.

3. **20 points** A pure tone $m(t) = \cos 2\pi f_m t$ amplitude-modulates the carrier $\cos 2\pi f_c t$ ($f_c >> f_m$) using three schemes: (1) AM without carrier, (2) AM with large carrier, (3) AM-USB. The resulting signal is called x.

For each scheme write down the algebraic expression for x, the algebraic expression for its Fourier transform, X, and sketch X(f), for f greater than or equal to zero. Carefully mark the magnitudes and frequencies on your sketch.

4. **20 points** A signal m phase-modulates a carrier of frequency f_c Hz to produce the signal

$$\text{For every value } t,\ x(t) = \cos(2\pi f_c t + m(t))$$

Suppose $|m(t)| << 1$, so this is narrow-band PM.

a. Find a coherent demodulation scheme to recover the signal m from x. Explain why your scheme works. You may give an algebraic or block diagram description of your scheme.

b. Suppose the modulated signal suffers amplitude distortion so that the received signal is y instead of x,

For every value t, $y(t) = A(t)x(t) = A(t)\cos(2\pi f_c t + m(t))$

Where $1 <= A(t) <= 2$ is the distortion. What signal does your demodulater generate and how is it related to m?

c. Modify the design of your demodulater so that the effect of the distortion A is eliminated. Remember you don't know A. [Hint: First send y through a hard delimiter. A hard delimiter is a memoryless device g whose output is sgn(y(t)) when its input is y(t).]