ECE-486 Test 1, March 18, 2004
Two Hours, Closed Book, No Calculators

1. Evaluate the inverse z-transform of the following:

$$X(z) = 3z^3 + \frac{5}{z(z-10)} - \frac{2}{z-1/2} + \frac{4z}{z+2} \qquad 1/2 < |z| < 2.$$

2. A continuous-time system is tested by exciting the system with a pure 10 kHz sinusoidal test signal and sampling the (distorted) system output using a sample rate of 41 ksps. A DFT is calculated using a block of 410 samples collected from the system output. Identify all DFT indexes associated with the input signal, and the 2^{nd}, 3^{rd}, and 4^{th} harmonics of the input signal. Give your indexes in the range $0 \leq k < 410$.

3. Determine the zero-state response of the system

$$y(n) = \frac{1}{2}y(n-1) + 4x(n) + 3x(n-1).$$

to the following input signals

(a) $x(n) = e^{j\omega_0 n}u(n)$

(b) $x(n) = \{\ldots, -1,\ 1, -1,\ \underset{\uparrow}{1}, -1,\ 1, -1, \ldots\}$

4. Many discrete-time systems require the generation of sinusoidal functions (often to drive an input of a mixer). For convenient values of ω_0, values of functions like $\cos(\omega_0 n)$ can be calculated and stored in a finite length table for later access in real time. However, for an arbitrary value of ω_0, the values must be generated as they are needed. A simple time-invariant linear system can be constructed with the desired sinusoidal output...

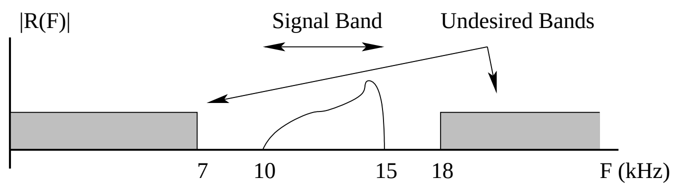
   (a) Find a difference equation for a system *with no input* which (for some initial condition, and no input) has system output given by $y(n) = \cos(\omega_0 n)$ for $n \geq 0$.

   (b) Indicate the initial condition required for your system to produce $y(n) = \cos(\omega_0 n)$ for $n \geq 0$.

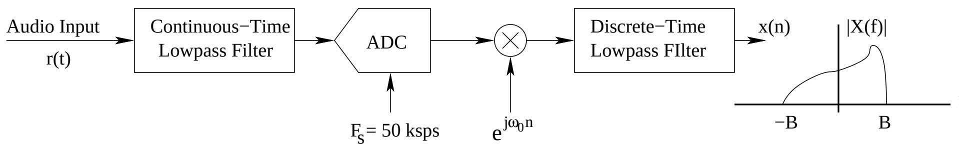
   (c) Draw a block diagram showing how your system could be implemented (Direct-form I or Direct-form II).

   (d) Is your system BIBO stable? (Justify your answer).

5. This problem deals with the design of an underwater acoustic data modem receiver. To transmit digital data underwater, information is modulated to the band of frequencies 10 kHz $< F < 15$ kHz for acoustic transmission. The acoustic environment introduces undesired signals below 7 kHz and above 18 kHz which must be removed prior to demodulation of the data. The (positive frequency) spectrum of the signal at the input to the receiver is illustrated below.



The demodulator is implemented by sampling the signal at 50 ksps, translating the desired signal band, and lowpass filtering as illustrated below. The system is required to remove all "undesired signals" identified in the input spectrum, and should not introduce any spurious signals into signal band.



(a) Specify the required passband and stopband for the continuous-time filter. Make the transition band (between the passband and stopband edges) as large as possible.

(b) Specify the required value for ω_0.

(c) Give the value of "B" as shown in the plot of $|X(f)|$.

(d) Specify the required passband and stopband edges for the discrete-time filter.