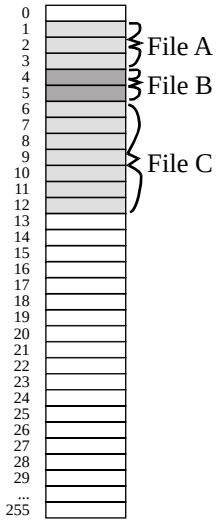
Jonathan W. Valvano First Name: _____ Last Name:_____
February 27, 2009, 10:00 to 10:50am

Open book, open notes, calculator (no laptops, phones, devices with screens larger than a TI-89 calculator, devices with wireless communication). You may put answers on the backs of the pages, but please don't turn in any extra sheets.

(30) Question 1. Consider a file system that uses **contiguous allocation** to define the set of blocks allocated to each file. There are 8192 bytes on this disk, made up of 256 blocks, where each block is 32 bytes. This file system is used to record important "black box" information. Therefore, the file system is initialized to empty when the device is manufactured. Each time the system is turned on a new file is created. While running important data are stored into that file (open file, append data at the end, close file). Files are never deleted. Block 0 contains the directory and not available for data. Each directory entry has three fields: name, block number of the first block, and total number of bytes stored. The example in the figure shows file A with 3 allocated blocks (1,2,3 containing 32,32,8 bytes), file B with 2 blocks (4,5 containing 32,32 bytes) and file C with 7 blocks (6,7,8,9,10,11,12 containing 32,32,32,32,32,32,8). All 32 bytes of each data block can contain data for the file.

Directory

A,1,72
B,4,64
C,6,200



(10) Part a) Does this file system have any external fragmentation? Justify your answer.

(5) Part b) Assume a file has **n** data blocks. It takes one *block read* to fetch the **directory**. On **average** how many more *block reads* does it take to read a single byte at a random position in the file? What is the **maximum** number of additional *block reads* that it takes to read a single byte in the file (worst case)?

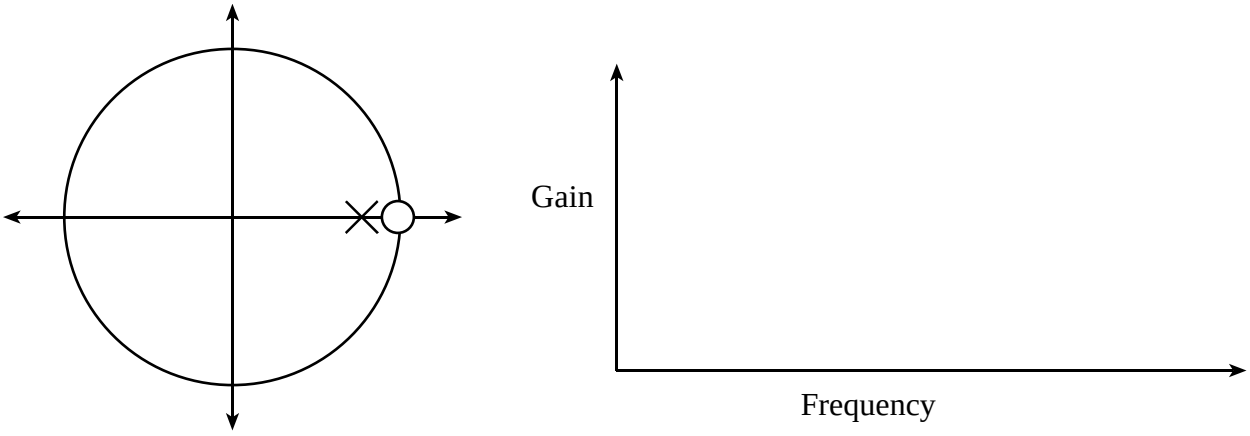
(5) Part c) Describe a simple mechanism to manage free blocks in this system. Be as explicit as possible, describing how many bytes in the directory are needed to manage the free space. Describe what the free space looks like after the disk is erased/formatted. Describe what the free space looks like when the disk is full.

(5) Part d) File names are a single character. How many files can be stored? Justify your answer.

(5) Part e) Assume you have **n** files each with of random size. Quantify the number of wasted bytes due to internal fragmentation. You may assume **n** is less than the number determined in part d).

(20) Question 2. The sampling rate of a real-time data acquisition system is 100 Hz. There is a zero at $\mathbf{z} = 1$, and a pole at $\mathbf{z} = ¾$.

Part a) Make a rough sketch of the gain versus frequency response of a digital filter with this pole-zero plot. You should label the **Frequency** axis with specific values like 0, 25, 50, but you need not label the **Gain** axis.



Part b) Show the **H(z)** transfer function for this digital filter. Express **H(z)** in terms of constants and terms like $\mathbf{z^{-1}}$ $\mathbf{z^{-2}}$ $\mathbf{z^{-3}}$ etc.

(10) Question 3. You are given a digital filter with the following transfer function:

$$H(z) = \frac{z^2 - 2}{z^3 + \frac{1}{2}}$$

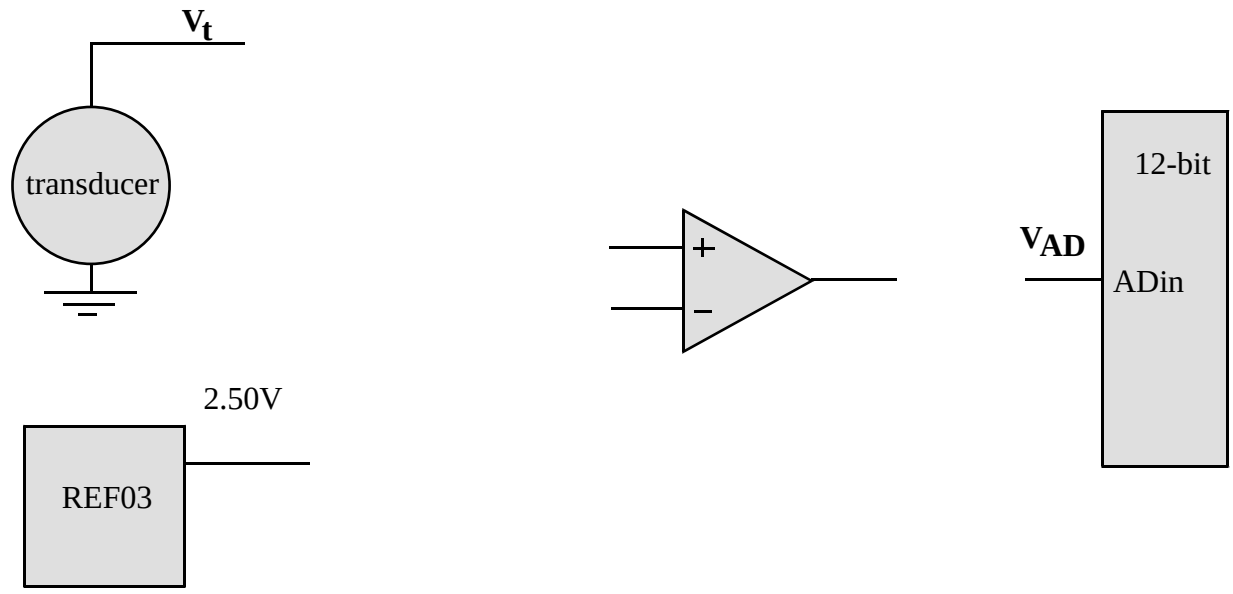
Show the digital filter equation, calculating y(n) as a function of terms like y(n-1), y(n-2),… x(n), x(n-1), etc. Express the result using integer operations using integer coefficients. No software is required.

(15) Question 4. Describe two experimental techniques that could be used to determine if a noise were due to 60 Hz EM field pickup. Describe the tool used and what the output of the total looks like if there is or if there is not 60 Hz EM field noise.

(25) Question 5. The objective of this question is to design the analog electronics to interface a transducer to the 0 to +5V 12-bit ADC. The transducer output, $\mathbf{V_t}$, is a single voltage (relative to ground, not differential), with a range of 0 to 1 volts.

$$\mathbf{V_{AD} = 5.0 - 5V_t}$$

Part a) Build this interface with one op amp and a REF03 2.50V analog reference. You do not need to show the power connections. You do not need to include an analog low pass filter. $\mathbf{V_t}$ =0 should map to $\mathbf{V_{AD}}$ =5V and $\mathbf{V_t}$ =1 should map to $\mathbf{V_{AD}}$ =0V.



Part b) What is the voltage resolution, referred to input $\mathbf{V_t}$, of the system if the ADC has 12 bits? Please include units.