Today, we will:

- Do some review example problems – digital data acquisition, aliasing, FFTs
- Discuss the concept of **leakage** in more detail.

Example: DFTs and FFTs

Given: Vibrations are observed in a computer hard drive. Preliminary measurements with an accelerometer indicate that the strongest vibrations occur at a fundamental frequency of about 7200 rpm (120 Hz), and the engineers expect that significant harmonics may be present up to the 4th harmonic. Data are acquired with a digital data acquisition system.

To do:

(*a*) What is the minimum sampling frequency they should use to avoid aliasing?

(*b*) They decide to sample data at $f_s = 4000$ Hz. They take 1024 data points ($N = 1024$ pts) and plug the data into a computer program to calculate a DFT (or FFT). How many *useful* data points (frequencies) will appear on their frequency spectrum?

(*c*) The results are good, but the frequency resolution is not as good as they had hoped. Bob and Ted argue about what they should do to improve the frequency resolution:

- Bob suggests using the same N, but increasing the sampling frequency f_s.
- Ted suggests using the same f_s, but increasing the number of data points N.

Which of these suggestions would improve the frequency resolution and why?

Solution:

Given: A voltage signal has a 1.50 V DC component and two periodic components:

- Frequency $f_1 = 115$ Hz, amplitude $A_1 = 2.00$ V
- Frequency $f_2 = 540$ Hz, amplitude $A_2 = 0.500$ V

There is also some noise. We sample the signal digitally at 1000 Hz, taking 256 data points.

(*a*) **To do**: Is there any aliasing? If so, calculate f_a.

(*b*) **To do**: Calculate the frequency resolution and sketch the frequency spectrum.

Solution:

Given: Brian samples a voltage signal digitally at a sampling frequency of 400 Hz. He plugs the data into Excel, calculates an FFT, and plots the frequency spectrum.

(*a*) **To do**: If Brian samples data for 5.12 seconds, how many *useful* frequencies are plotted on the frequency spectrum?

(*b*) **To do**: If Brian samples data for 5.00 seconds, how many *useful* frequencies are plotted on the frequency spectrum?

(*c*) **To do**: For the situation of Part (*b*), what is the frequency resolution of the resulting frequency spectrum produced by Excel? *Give your answer to three significant digits.*

Solution: