PC Digital Data Acquisition
A general computer data acquisition configuration is shown below.
The computer consists of several key components

**CPU** - central processing unit

**RAM** - random access memory

**ROM** - read only memory

**DISK** - permanent storage device

**OUTPUT** - printers, plotters, etc
The Data Acquisition Board is used for the collection and digitization of data from measuring devices. Analog signals are collected and digitized using the Analog to Digital Converter (ADC). These converters come in a variety of different resolutions usually referred to in terms of the number of bits. 10 bit, 12 bit, 16 bit and even 24 bit are common.
Binary numbers are used to represent the “flip-flop” bistable state of a system - ON = 1 and OFF = 0

1001 - is the number 9

MSB - most significant bit

LSB - least significant bit

Example 4.1, 4.2 and 4.3 from the reference text book for the course are good examples of the representation of numbers in different forms
Acquisition using either Multiplexer or Simultaneous Sample/Hold

Characteristics are specified in terms of samples/sec of acquisition - 25 kHz is 25,000 samples per second

Multiplexer (MUX) shares the sample rate among all the channels of acquisition
- Less expensive
- Good for low freq events

Simultaneous Sample/Hold reserves a separate acquisition sample for each individual channel
- More expensive
- Needed for higher freq.
Sampling rate of the ADC is specified as a maximum that is possible. Basically, the digitizer is taking a series of “snapshots” at a very fast rate as time progresses.
Each sample is spaced delta t seconds apart. Sufficient sampling is needed in order to assure that the entire event is captured. The maximum observable frequency is inversely proportional to the delta time step used.

\[
\text{Rayleigh Criteria} \quad f_{\text{max}} = \frac{1}{2 \Delta t}
\]
The user (software) can sample at a lower rate but the user must be aware that the sampling must occur to prevent aliasing!

Aliasing results when the sampling does not occur fast enough.

Sampling must occur faster than twice the highest frequency to be measured in the data - sampling of 10 to 20 times the signal is sufficient for most time representations of varying signals.

Anti-aliasing filters are used to prevent aliasing.

These are typically Low Pass Analog Filters.
Anti-aliasing filters are typically specified with a cut-off frequency. The roll-off of the filter will determine how quickly the signal will be attenuated and is specified in dB/octave.

\[ G_{dB} = 20 \log_{10} G = 20 \log_{10} \frac{V_{out}}{V_{in}} \]

The cut-off frequency is usually specified at the 3 dB down point (which is where the filter attenuates 3 dB of signal).

Butterworth, Chebyshev, elliptic, Bessel are common filters.
Filtering is performed for a variety of reasons too numerous to identify here. Some common filters are:

- **Low Pass Filter**
- **Band Stop Filter**
- **Band Pass Filter**
- **High Pass Filter**
Sampling refers to the rate at which the signal is collected. Quantization refers to the amplitude description of the signal.

A 4 bit ADC has $2^4$ or 16 possible values
A 6 bit ADC has $2^6$ or 64 possible values
A 12 bit ADC has $2^{12}$ or 4096 possible values
A UNIPOLE converter can only handle “same” sign signals
(0 to 5 V signal or -10 to -2 V signal)

A BIPOLE converter can handle both “+” and “-” signals

Depending on the type of converter used, there may be a difference of plus or minus one bit.

A UNIPOLE uses a simple binary output to represent the signal.

A BIPOLE may represent the signal using either an offset binary representation or 2’s complement approach.
An offset BIPOLE uses the output code of zero for the lowest possible minus signal to be measured.

A 2’s complement BIPOLE uses the output code of zero as the zero value - plus and minus are identified by the MSB where 1 is used for the minus values and 0 is used for the plus values.
Quantization errors refer to the accuracy of the amplitude measured. The 6 bit ADC represents the signal shown much better than a 4 bit ADC.
Underloading of the ADC causes amplitude errors in the signal.

All of the available dynamic range of the analog to digital converter is not used effectively.

0.5 volt signal

This causes amplitude and phase distortion of the measured signal.
A large DC bias can cause amplitude errors in the alternating part of the signal. AC coupling uses a high pass filter to remove the DC component from the signal.

All of the available dynamic range of the analog to digital converter is dominated by the DC signal.

The alternating part of the signal suffers from quantization error.

This causes amplitude and phase distortion of the measured signal.

10 volt range on ADC.
Overloading of the ADC causes severe errors also.

The ADC range is set too low for the signal to be measured and causes clipping of the signal.

This causes amplitude and phase distortion of the measured signal.
Digital Data Acquisition Lab
Both hardware and software are used for the laboratory. Some equipment and software considerations are discussed next.
A separate write up discusses the digital data acquisition software. The main items are to start the software, setup the instrumentation and acquire data with different sampling parameters.
**Function generator** - used to create a signal

- **Range Settings**
- **Variable Control**
- **Signal Type**
- **Output**
**Multimeter** - used to measure voltage

Settings
**Oscilloscope** - used to observe signals

- **Screen**
- **Intensity**
- **Focus**
- **Power**
- **Horizontal Control** (Time)
- **Vertical Control** (Amplitude)
- **AC/DC Coupling**
- **Triggering**