The most important tool for analyzing ac circuits is the cathode ray oscilloscope. A close relative of the TV, the oscilloscope allows one to view a graph representing the voltage verses time of an electronic signal.

We will do a few exercises and experiments with the oscilloscope to help you become familiar with its functions.

1. Locate a function generator. Set it for a sine wave output at 200 Hz. Display the output across a 5K resistor on the oscilloscope. Measure the amplitude of the sine-wave on the oscilloscope screen. Express your answer in $V_p$, $V_{p-p}$ and $V_{RMS}$. Do this for four amplitudes with only one below 0.1 volts and the rest over one volt. Compare your results with simultaneous measurements made with a DMM set for ac volts.

2. Use the same circuit as in step one. Pick a voltage above 1.0 $V_{pp}$. Measure the amplitude on the oscilloscope and the DMM for four frequencies near 10 Hz, 1000 Hz $10^4$ Hz and $10^6$ Hz. Compare these to the settings on your function generator.

3. Set up a series circuit with two different resistors, both in the KΩ range. Put 2 $V_{pp}$ across both resistors at a frequency of 1 KHz. Measure the voltage across each resistor with the oscilloscope (think carefully about how you can do this). Compare your measured results to calculated values. How does this compare to our dc measurements?
4. Replace one of the resistors in the above experiment with a 0.03 \( \mu F \) capacitor to form the circuit below. Talk to the lab instructor to find a good combination of R and C values.

   a. Measure the voltage across the capacitor. Drive the circuit with a square wave at 1000 Hz and 4.0 V_{pp}. Find the RC time constant by finding the time it takes for the capacitor voltage to drop to half its initial value and the equation \( t_{1/2} = 0.693RC \). Explain where this relation comes from. Measure the voltage as a function of time along one of the decay cycles. Match your data with calculated values.

   b. Switch the function generator to a sine wave output. Collect enough data to plot the ratio of the input voltage (from function generator) to the output voltage verses the frequency. Use a log-log plot and make sure you take data from 100 Hz to 1 MHz. Calculate a theoretical output curve for this circuit using the equation

   \[
   \frac{V_{out}}{V_{in}} = \frac{1}{1 + \frac{1}{RC}}
   \]

   and plot it on the same graph as the data.

5. Get two function generators. Use one of them to generate a 2 volt sine wave on the x axis and one of them to generate a 2 volt sine wave on the y axis. Adjust the amplitudes and positions on the scope so that you can see the whole pattern. Set the frequencies on the function generators to different ratios 1:1, 1:2, 2:1, 3:4, 1:3, etc. and tweak the frequencies to produce a stable pattern (called a lissajous figure) on the screen. Try to explain the pattern on the screen in light of the frequency ratios.

6. Get a speaker or microphone and connect it to the input of the oscilloscope. Sing, shout or otherwise make noise into the microphone. Describe what you see on the oscilloscope screen.