Worksheets to turn in start here.

1) Which mode of the probe (10x or 1x) is affected by the adjustment screw? _____

2) What is graphed on the vertical axis? Voltage or time? _____

3) What is graphed on the horizontal axis? Voltage or time? _____

4) What happens when you turn the dial labeled Horizontal Position (the little Horizontal dial)? Does the scale of the graph change or is the graph translated?

_____

5) What happens when you turn the dial labeled Vertical Position (the little Ch 1 dial)? Does the scale of the graph change or is the graph translated?

_____

6) What happens when you turn the Horizontal sec/div dial? Scale change or translation?

_____

7) What happens when you turn the Ch 1 V/div dial? Scale change or translation?

_____

8) Effectively the _____dial can be used to zoom in or out on the voltage axis

of the graph while the _____ dial can be used to zoom in or out on the time

axis. Meanwhile the _____ dial is used to align the voltage axis with a

convenient point on the screen while the _____ dial is used to align the time

axis with a convenient point on the screen.

- Connect the 1x probe to the PROBE COMP (small brass loops near bottom right of screen) on the scope.
- Hit AUTORANGE and wait for the scope to react.
- Now adjust the V/div and sec/div until you get the largest possible graph on the screen that clearly shows at least two full wave forms. If the edges of the waveform are right at the edge of the screen, decrease wither the V/div or sec/div one increment even if the graph becomes a little smaller (this clearly shows the periodicity of the wave).
- Now use the Horizontal Position dial to line up the graph with the axes on the screen.
- Verify 0 Volts aligns with the horizontal axis at the middle of the screen. You might need to hit Ch1 Menu and fiddle with the "coupling". If not aligned, use the Vertical Position dial to make the adjustment.

9) Make a sketch of the screen below.
   On the t-axis, include both numbers and units (get this from the sec/div on screen).
   On the V-axis, include both numbers and units (get this from the sec/div on screen).
   On the sketch, clearly indicate the period by drawing a horizontal line (with arrowheads) the length of the period.
   Label this line with $T = \#$ with units (use the number *obtained from your sketch*…not the measure button).
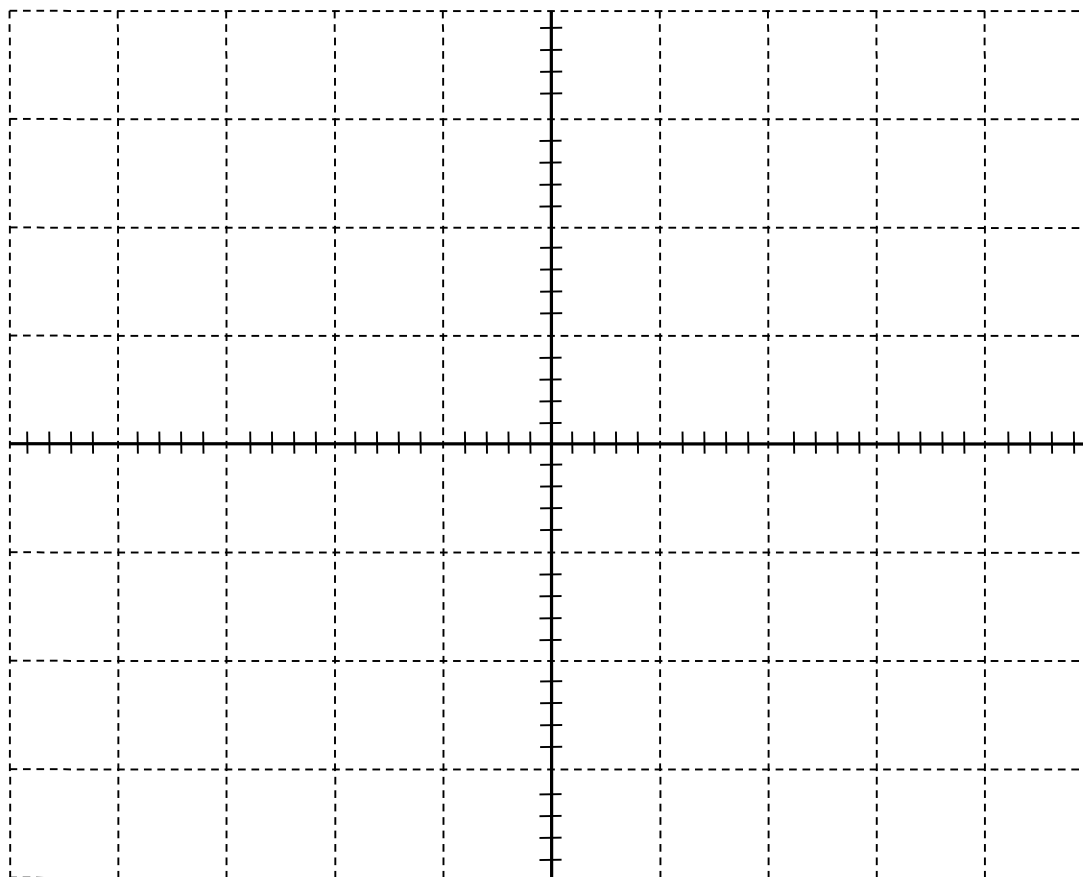   Clearly indicate the peak-to peak voltage by drawing a vertical line (with arrowheads).
   Label this line with $V_{pp} = \#$ with units (use the number *obtained from your sketch*…not the measure button).
   Compute $f = \frac{1}{Period}$ and $A = amplitude = \frac{1}{2}\left(\Delta V_{peak\ to\ peak}\right)$.
   Think about how many sig figs are reasonable from reading the plot. Don't forget units!!!

   $f=$_____ $A=$_____

- On the function generator, make sure the -20db button is depressed.
- On the function generator, set the FINE dial to the 12 o'clock position.
- Now press the 5 kHz button on the function generator (allowing frequencies **UP TO** 5 kHz).
- Near the far right of the function generator are three buttons for sine, square, and triangle wave. Ensure the sine wave button is depressed.
- Set the function generator to *roughly* 1 kHz frequency using the COARSE dial. Make it exactly 1 kHz using the FINE dial.
- Turn up the OUTPUT dial all the way (approximately the 5 o'clock position).
- Connect the BNC-to-alligator clip cable to the output BNC connector on the front panel of the function generator. Notice there is a red and a black output on this cable. Black is tied to ground.
- First connect the tip of the scope probe to the Red output of the function generator. Hit the AUTORANGE button and wait for the scope to respond. You should see a graph appear even though the ground connector of the scope is not connected to the Black ground of the function generator. This is because the connection is essentially already made.

10) In the last step, it appears that a complete circuit is not made but the two devices are actually connected in two places. One is where the positive or red leads touch. How are the scope and the function generator grounds connected? Hint: consider the power cables plugged into the wall for each piece of equipment.

_____

_____

Now incorrectly connect the Black cable from the function generator output to the tip of the probe. Try connecting the ground of the probe (little black alligator clip) to the Red output from the function generator. No graph will appear on the screen because the potential difference across the probe is zero (both tip and ground are connected to ground). That means the voltage produced by the function generator is going somewhere else. In general this is not a good idea as you could fry out some electronics this way. In this special case no damage is done.

- Leaving the cables incorrectly attached (Black to tip and Red to ground), turn off the power to the function generator.
- Unplug the power cable. Then connect the grey, 2-to-3 prong converter on the end of the function generator power cable and plug it back in. Be sure the metal ground connector (small metal loop on the adapter plug) does not touch any metal on the outlet.
- Turn the function generator back on and, if necessary, hit AUTORANGE on the scope. You should now see the graph on the scope even though the grounds appear to be incorrectly connected. Since the function generator is not connected to any ground at the electric socket, it is said to be floating.

In general, never float the ground of anything unless you are a competent electrician or have further training. If you have ground issues, ask your instructor for help rather than risk electric shock. The 2-to-3 prong converter is designed to be safely used only when the grounding loop is securely fastened to the screw at the center of the outlet. Failure to do this can be lethal.

Finally, reconnect the probe in the proper fashion and remove the 2-to-3 prong converter. One student in a lab called these "death plugs". Try a web search for "cheater plugs" if you want to learn more.

Adjust the wave until the output is 2 Volts peak-to-peak (which is 1V amplitude). **These questions assume you are adjusting the triggering just after hitting the Autorange button.** Now go the section of controls on the scope labeled TRIGGERING. Try adjusting the triggering level and note what happens to the waveform. Look at the very edge of the screen (right or left) and you might see the little arrow indicating the triggering *level*. Look at the top or bottom edge of the screen to see the triggering *position* (where the waveform starts). Try pressing the slope button. In the sentences below, circle the best answers to fill in the blanks.

11) The trigger _(level or slope)_ is the Voltage of the waveform at the _(left side, right side, or the origin)__.

12) The trigger _(level or slope)_ determines the *slope* of the waveform at the _(left end, right end, or origin)_.

Adjust the triggering level until the arrow is above the top of the waveform. Notice the graph gets blurred out. If the waveform never reaches the triggering level, the scope does not have a clear starting point for making the graph.

- Set up a random waveform (**each student must use a unique, randomized waveform**).
- Try using the 500 Hz, 5 kHz, or 50 kHz range on the function generator.
- Then use the course adjust dial of the function generator to select some oddball frequency.
- Lastly, adjust the output level dial of the function generator so the amplitude is randomized as well.
- Use the V/div & sec/div dials to make the graph as large as possible while still having at least one full waveform appear on the screen.
- Use the horizontal and vertical position dials to line up the waveform in some convenient location. You may also want to check the ground level by hitting Ch1 Menu and looking at the "Coupling" mode.

13) Sketch the graph below including numbers and units on both the *V*-axis and *t*-axis. **Tip:** you could snap a photo of your waveform so you can sketch it while the other students set-up their waveforms…
Sketch the period and peak-to-peak voltages on the graph as done in the previous sketch.
Obtain estimates for the frequency and amplitude of the waveform (think about sig figs & units).

f_{screen}=_____ A_{screen}=_____
Verify these values using the MEASURE button from the scope (include units).

$f_{measurebutton}$=_____ $A_{fromVppmeasurebutton}$=_____
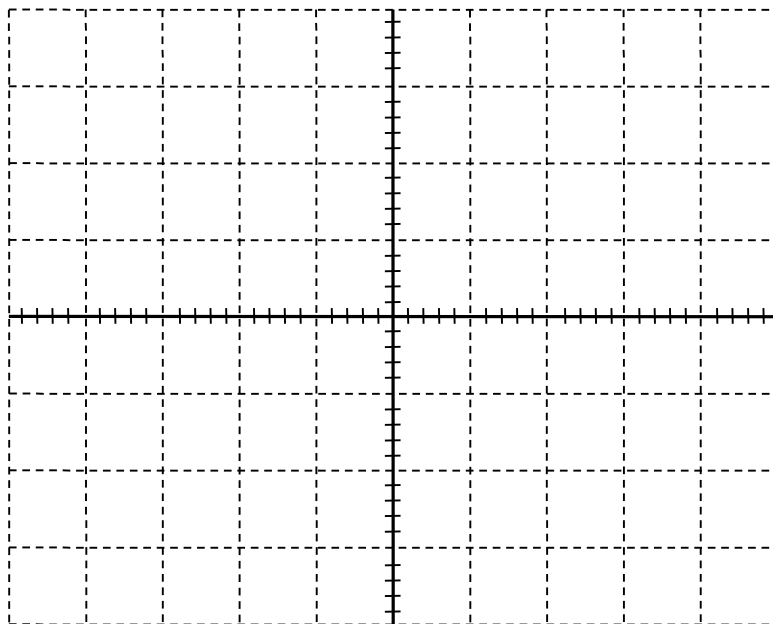
Now use the function generator to set up a 0.5V amplitude sine wave at a frequency of 10 kHz. Remember: you'll need to ensure that the -20dB button is depressed. Hit AUTORANGE on the scope. Then hit the Channel 1 Menu button. Find a button just to the right of the screen associated with coupling. Press the button a few times to see the various options of coupling. Notice that Ground shows you where 0V is located. The most commonly used modes are "DC Coupling" and "AC Coupling".

Turn on the DC offset button of your function generator by pressing it; it should remain depressed after pressing. Adjust the dial for the DC offset on the function generator.
Try the same thing while in AC coupling on the scope.

14) While the scope is in <u>DC coupling mode</u>, how does rotating the DC offset dial (of the function generator) <u>clockwise</u> affect the graph on the screen?

_____

15) While the scope is in <u>AC coupling mode</u>, how does rotating the DC offset dial (of the function generator) <u>clockwise</u> affect the graph on the screen?

_____

The DC offset on the function generator adds or subtracts a constant voltage to the waveform. **Note that this differs from simply turning the vertical position dial on the scope.** If you add too much DC offset to a waveform it will eventually distort because of the limitations of the function generator.

For example, by adding a 2V DC offset to a 2V amplitude wave implies the wave will oscillate between 0V and 4V (not -2V and +2V). This property could potentially be useful (or harmful) to your electronics.

On the contrary, suppose you had the same 2V amplitude wave without any DC offset. You can use the position dials to cause the waveform on the screen to *appear* as an oscillation between 0V and 4V. However, the actual output of the function generator is still oscillating between -2V and 2V. If, for example, your electronics cannot handle a reverse bias (negative voltage) you would be in trouble.

Measuring in a real circuit:

For the last portion of the assignment you will connect a circuit like the one shown. First we will derive some theoretical results about this circuit. Then you will make measurements with the scope (just like a DMM) and compare the experimental values to the theoretical values with a percent difference.
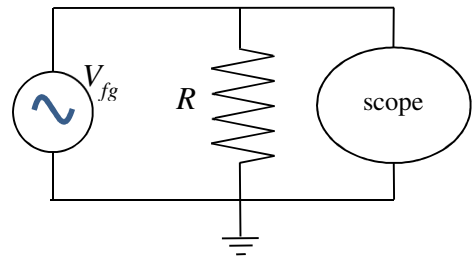
The symbol at the very bottom of the figure with three horizontal lines in a triangular shape indicates the ground of the circuit. R is your load resistor (the resistor you are measuring). The scope is in parallel with the load resistor and is measuring voltage (just like you did with a DMM). The function generator has its internal resistance explicitly shown in figure as R_{fg}. Note: for our function generators $R_{fg}=50\ \Omega$. R_{fg} is in series with the load resistor R. Since the scope has a very large resistance (10 MΩ or more) in parallel with the load resistor R, it has negligible effect on the circuit.

16) Verify scope resistance is negligible by finding the equivalent resistance of the 10 MΩ scope in parallel with the 10 kΩ resistor. Determine the percent change from 10 kΩ when the scope is placed in parallel with it. Show work and put your answers in the boxes.
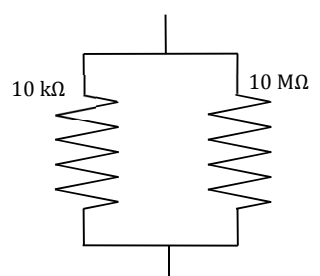
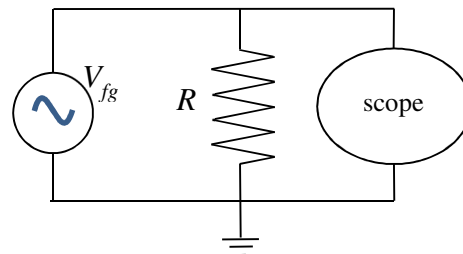|	
R (in kΩ) when 10 MΩ in parallel with 10 kΩ	
percent change from 10 kΩ	

17) We can model function generator as an ideal source with potential differnce V_{fg} in series with a small internal resistance of R_{fg}. Determine the theoretical current I_{th} in this circuit in terms of V_{fg}, R, and R_{fg}. Show all work for credit. Determine the theoretical voltage $\Delta V_{R\ th}$ across the resistor R in terms of V_{fg}, R, and R_{fg}.
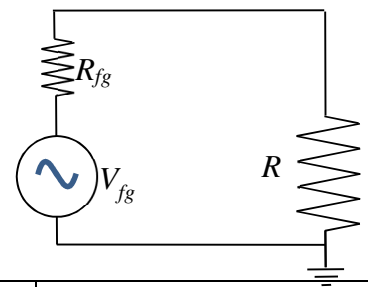
I_{th}	
$\Delta V_{R\ th}$	

- Now actually set up the circuit as shown.
- Use the controls on the function generator to create a <u>square wave</u> that oscillates between 0.0 V and 1.0 V operating at 1.0 kHz. If you adjust the dials while the scope is connected (and use the MEASURE button) you should be able to set this up fairly quickly. You'll need 1.0 V peak to peak plus 0.5 V DC offset. **Check it with the scope before connecting it to any resistor.**
    - o If you are having trouble, you might hit the Ch1 Menu button and verify the Probe Voltage on the scope screen is set to the same setting (1x vs 10x) as the switch on the probe itself.
    - o You may also need to change the coupling mode (also on screen after hitting Ch1 Menu). To use the DC offset you probably want to have the scope set in DC coupling.
- Once this is done, disconnect the scope probe from the function generator leads.
- Obtain three resistors with resistances of about 0.1 kΩ, 1 kΩ, and 10 kΩ.
- Measure the values of these resistors with the DMM and record the measured values (not the approximate values) in the table below.
- Predict the theoretical voltage across the load resistor using your previous results. Now select one of the resistors and connect it to the function generator leads.
- Now connect the probe leads from the scope so as not to cause a short circuit ground error. Remember the alligator clip is ground on the scope so it must go to ground of the function generator.
- Measure the voltage across the resistor. By this I mean look at the scope and read off the max voltage (or use the MEASURE button). It will not be exactly 1.0 V but should be somewhat close to it. Fill in this value in the $\Delta V_{R\,exp}$ column of the table below.
- Determine a %difference between the theoretical and experimental values.
- Repeat this process for the other two resistors.

	R_{DMM} (kΩ)	$\Delta V_{R\,th}$ (V)	$\Delta V_{R\,exp}$ (V)	%diff
18				
19				
20				

21) Suppose you have a function generator operating with a 1.00V amplitude with no load. The internal resistance of this function generator is 50.0 Ω. What load resistor R should be used if we want 99% of the function generator's 1.00 V amplitude across the load? Again, assume the internal resistance of the function generator is in series with the load resistor. Include units and use three sig figs.

21)	