

**University of Jordan
School of Engineering
Electrical Engineering Department**

**EE 204
Electrical Engineering Lab**

**EXPERIMENT 1
MEASUREMENT DEVICES**

Prepared by: Prof. Mohammed Hawa

EXPERIMENT 1

MEASUREMENT DEVICES

OBJECTIVE

When you have completed this exercise, you will be familiar with the main devices and equipment you will use in this Lab, including: multimeters, oscilloscopes, power supplies, function generators and breadboards. You will also have connected a simple circuit, and made basic measurements.

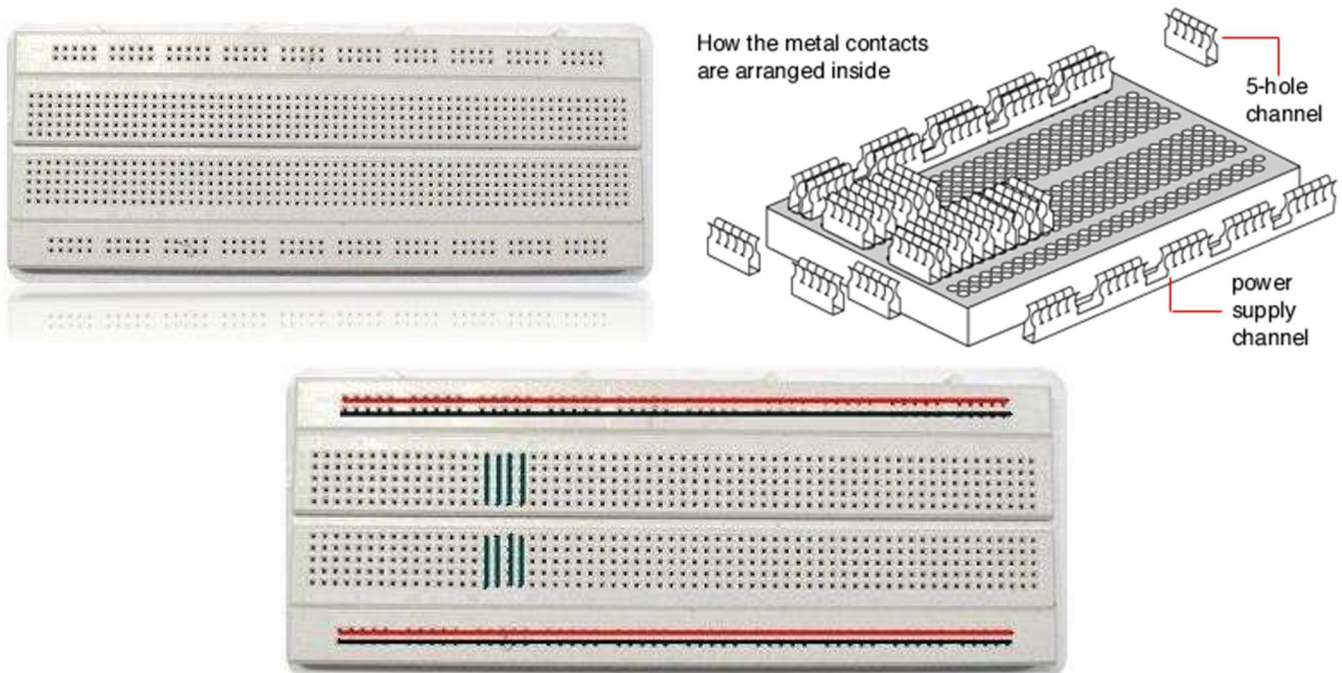
DISCUSSION

Breadboard

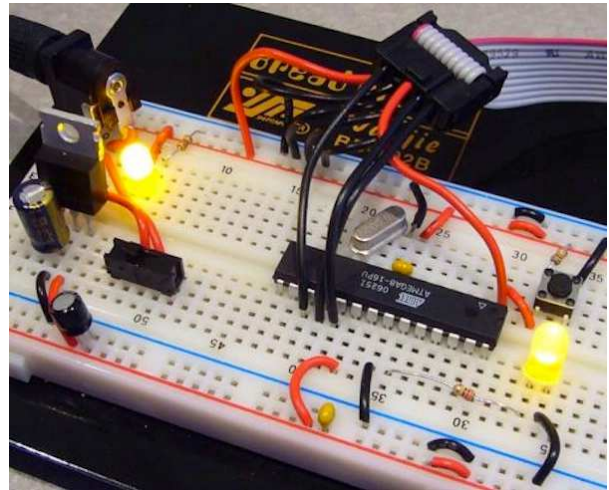
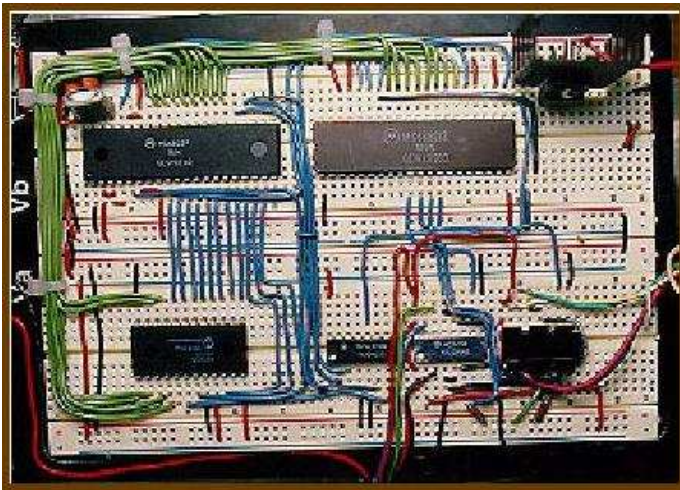
A breadboard (shown below) is usually used to build a prototype of an electrical circuit, without the need for soldering, usually for quick temporary testing.

A breadboard consists of a perforated block of plastic with numerous metal spring clips under the perforations. Such metal clips are laid out in groups of fives as shown below. Discrete electrical components (such as capacitors, resistors, inductors, etc) can be inserted into the free holes to complete the circuit topology. The holes are made so that they will hold the component in place. A typical breadboard will also have metallic strips, known as bus strips, down both sides to carry the power rails.

However, due to large stray capacitance between contact points, breadboards are usually limited to relatively low frequencies, usually less than 10 MHz, depending on the nature of the circuit.



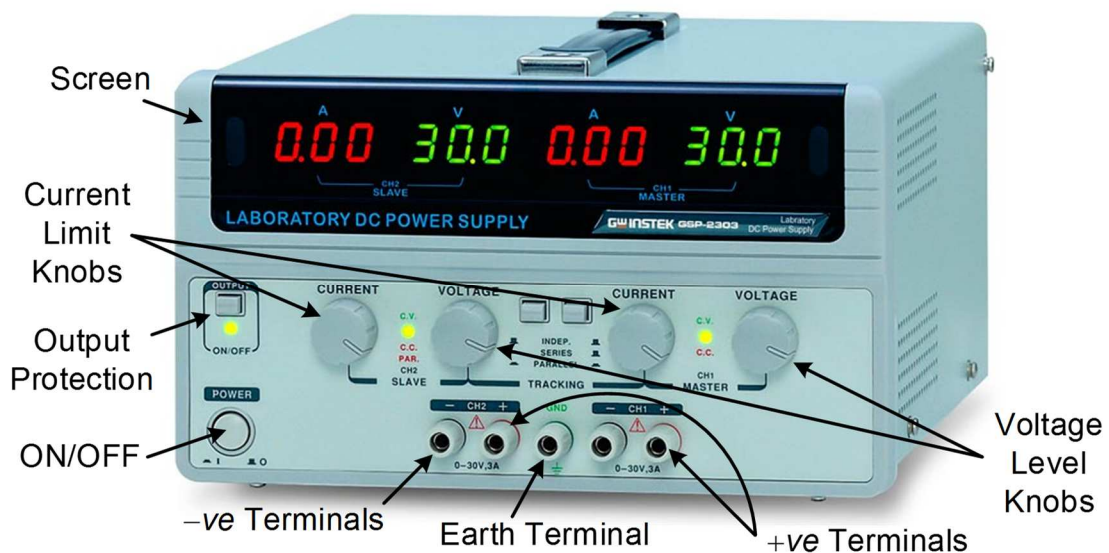
Some examples of circuits built by placing components and connecting them on breadboards are shown below.



DC Power Supply

A DC power supply is used to generate a constant DC voltage (just like a battery). Recall that DC is short for *direct current*. In the Lab, the voltage produced by the DC power supply is controlled by the knobs labeled "Voltage" as shown below. The current can be limited by adjusting the knobs labeled "Current" to prevent the power supply from generating more current than it is safe to avoid damaging the electrical components in your circuit. As long as the circuit does not attempt to draw more current than the value set by the "Current" knobs, the voltage will remain constant.

Both "voltage level" and "current limit" settings can be adjusted by two adjacent knobs. Sometimes there is a "Coarse" knob used for quick changes in values (i.e., high number of steps), and a "Fine" knob that is used for more accurate values with smaller steps.



When connecting the DC power supply to the breadboard use suitable wires to connect both the "+ terminal" (high voltage terminal) and the "- terminal" (low voltage terminal) to your circuit. "Real GND" is for earth grounding and it is connected to the device chassis. In this Lab we will not use the earth grounding terminal.

Multimeter

A multimeter is a measuring device that can perform multiple functions. For example, it can act as a Voltmeter, Ammeter, Ohmmeter, etc. The following is a description of some of these functions:

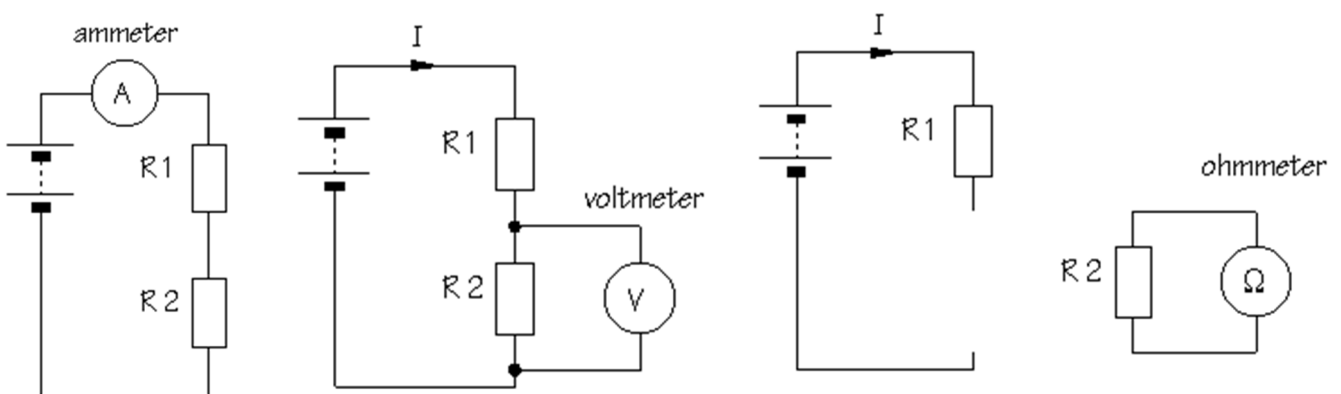
Ammeter: Measures DC or AC current (in units of μA , mA and A). You must connect the Ammeter in series with the element in the circuit through which you want to measure the current. The ammeter has a very small internal resistance so it does not disturb the current it is trying to measure. Due to this fact, however, if it is connected by accident in parallel with the circuit element, a large amount of current will flow through it, thus damaging it. That is why ammeters are usually protected by a current limiting fuse.

Voltmeter: Measures DC or AC voltage (in units of mV and V). You must connect the Voltmeter in parallel with the element in the circuit across which you want to measure the voltage. To avoid drawing extra current, thus disturbing the voltage it is trying to measure, the internal impedance of the voltmeter is very large.

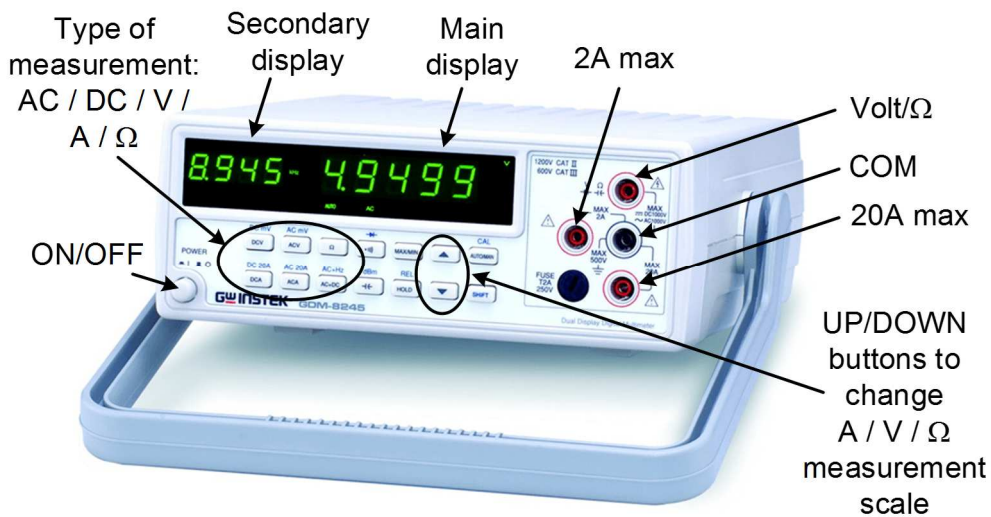
Ohmmeter: Measures resistance (in units of Ω and $\text{K}\Omega$). You must connect the Ohmmeter in parallel with the element in the circuit for which you want to measure the resistance. An Ohmmeter usually employs an internal battery (voltage source) across the resistance you are trying to measure. The battery drives a current into the resistor, which is measured by a current sensor. The value of the resistance is calculated from Ohm's law by dividing the battery voltage by the current. Hence, be careful *not* to connect any external power supply to the resistor you are trying to measure because an extra current can damage the ohmmeter and can also affect the overall Thevenin resistance the ohmmeter measures.

Continuity test: You can test the existence of a short circuit between two nodes in your circuit using the continuity test function in the multimeter. This is helpful in discovering faulty cables.

Diode and transistor test: Using this function you can discover faulty diodes and transistors.

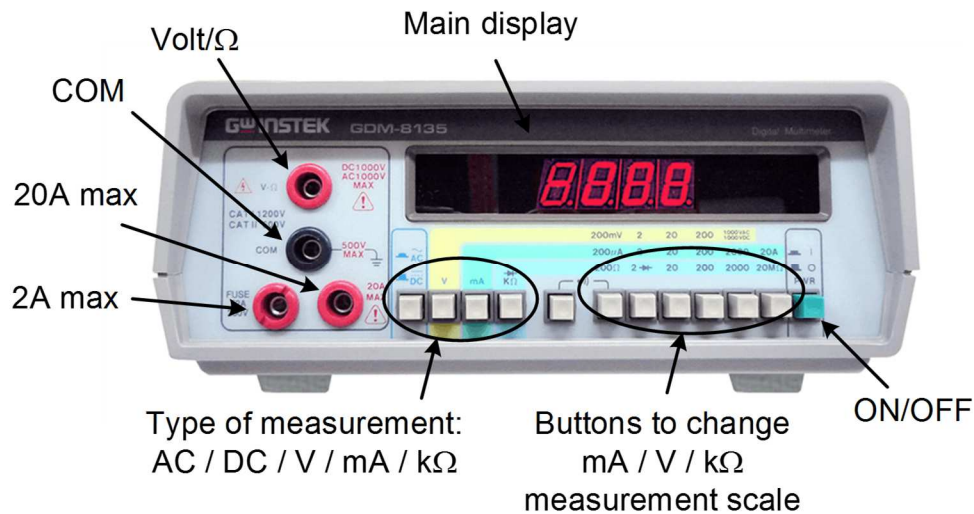


The Figure below shows two types of digital multimeters (DMM) available the Lab: a *portable* multimeter and a *bench-type* multimeter. A brief description of the main buttons is also provided.



- **DCV:** Set to Voltmeter for DC (*average*) value measurements.
- **ACV:** Set to Voltmeter for AC (*rms*) value measurements.
- **DCA:** Set to Ammeter for DC (*average*) value measurements.
- **ACA:** Set to Ammeter for AC (*rms*) value measurements.
- **Ω :** Set to Ohmmeter.
- **V/ Ω :** Positive terminal for voltage or resistance measurements.
- **2A max:** Positive terminal for low current measurements with maximum value of 2A.
- **20A max:** Positive terminal for high current measurements with maximum value of 20A.
- **COM:** Negative terminal that is common for all types of measurements.
- **Scale:** Up/Down buttons to switch the measurement range. For example, if **50V** range was selected, the voltmeter reading will be as accurate as possible if the measured value is between 5V and 50V. If the value is less than 5V a less accurate reading will appear on the multimeter screen, and if the value is higher than 50V an overload reading will appear on the screen.

- **Main display:** Shows the current measurement value (units are also shown on the screen).
- **Secondary display:** Shows the frequency of the signal in AC measurements if the user presses SHIFT button followed by the (AC+Hz) button.

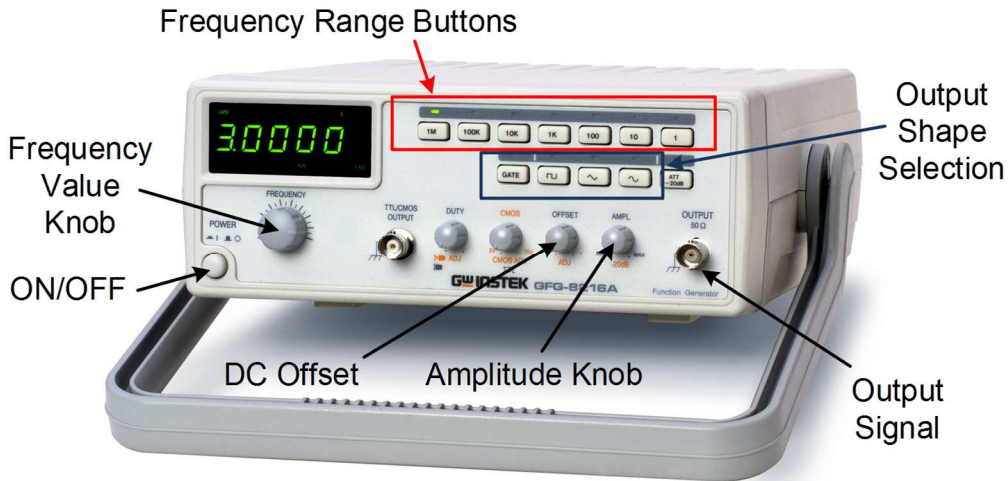


- **DC:** Choose to perform DC (*average*) value measurements.
- **AC:** Choose to perform AC (*rms*) value measurements.
- **V:** Set to Voltmeter (in **Volts** if the range button did not indicate another unit).
- **mA:** Set to Ammeter (in **milli Amperes** if range button did not indicate another unit).
- **kΩ:** Set to Ohmmeter (in **kilo Ohms** if the range button did not indicate another unit).
- **V/Ω:** Positive terminal for voltage or resistance measurements.
- **2A max:** Positive terminal for low current measurements with maximum value of 2A.
- **20A max:** Positive terminal for high current measurements with maximum value of 20A.
- **COM:** Negative terminal that is common for all types of measurements.
- **Scale:** Several range buttons available. For example, if **20V** range was selected, the voltmeter reading will be as accurate as possible if the measured value is between 2V and 20V. If the value is less than 2V a less accurate reading will appear on the multimeter screen, and if the value is higher than 20V an overload reading will appear on the screen.

Function Generator

A function generator is a device that can produce various patterns of voltage at a variety of frequencies and amplitudes, such as sinusoidal signals, square waves, etc. It is connected to the circuit similar to how you connect any voltage source. The function generator in the Lab has four major control blocks:

- *Amplitude knob:* controls the voltage difference between the high and low voltage of the output signal.
- *DC offset knob:* varies the average voltage of a signal relative to the ground.
- *Frequency knob and frequency ranges:* control the frequency at which output signal oscillates.
- *Output shape:* controls the shape of the output from a number of options, such as: square wave, sine wave, triangular wave, etc.

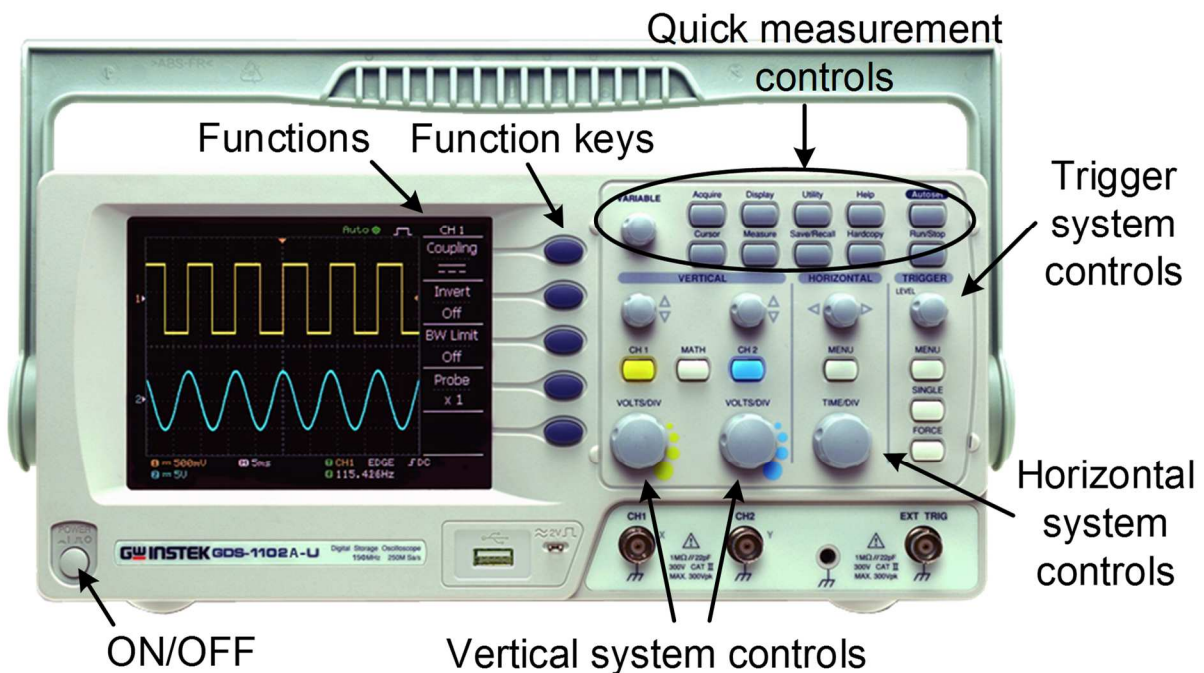


Oscilloscope

An oscilloscope is a measurement device designed to measure and display voltages. Unlike a voltmeter, however, an oscilloscope does not display a single number. Instead, it displays signals (waveforms) that are functions of time. Such a signal shape allows you to measure certain signal parameters, such as its frequency, period, peak-to-peak voltage, DC offset value, phase shift, pulse width, rise time, delay time, etc. Notice that the oscilloscope is suitable for displaying signals that are periodic (i.e., repeat themselves in time), such as sinusoidal, triangular and square wave signals, but unfortunately it cannot display *aperiodic* signals.

The oscilloscope has extremely high input impedance (1 M Ω parallel with 25 pF), which means it will not significantly affect the input signal when connected in parallel with the circuit. The oscilloscope screen almost always has 8 squares (divisions) on the vertical axis (which indicates voltage), and 10 squares (divisions) on the horizontal axis (which indicates time).

The oscilloscope consists of **five** subsystems (see below): Horizontal controls, Vertical controls, Trigger controls, Quick measurement controls and Function keys.



The main **Horizontal** controls are:

- **Scale (Time-Per-Division):** Determines the amount of time displayed.
- **Position:** Moves the waveform left and right (horizontally) on the display.

The main **Vertical** controls are:

- **Scale (Volts-Per-Division):** Varies the size of the waveform on the screen.
- **Position:** Moves the waveform up and down (vertically) on the display.
- **Input coupling:** Determines which part of the signal is displayed as follows:
 - *DC Coupling:* Shows all of the input signal.
 - *AC Coupling:* Blocks the DC component of the signal, centering the waveform at 0 volts.
 - *Ground Coupling:* Disconnects the input signal to show where 0 volts is on the screen.

The main **Trigger** controls are:

- **Source:** Determines which signal is used for triggering the sweep.
- **Level:** Determines where on the edge of the source signal the trigger point occurs.
- **Slope:** Determines whether the trigger point is on the rising edge (positive slope) or the falling edge (negative slope) of the source signal.

The main **Quick measurement** controls are:

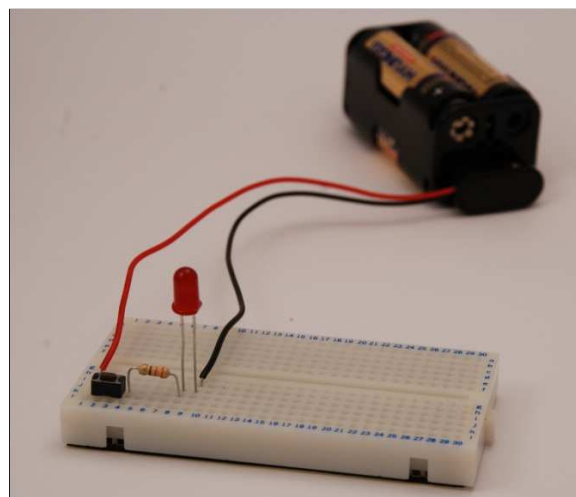
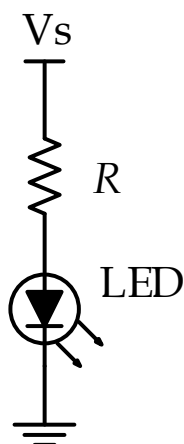
- **Autoset:** Adjusts horizontal, vertical and trigger settings automatically to display the input signals.
- **Cursor:** Places two horizontal or vertical lines (cursors) on top of the trace so the user can easily read values from the display.
- **Measure:** Automatically measures certain parameters from the screen (see Experiment 6).

PROCEDURE A - CONNECTING YOUR CIRCUIT

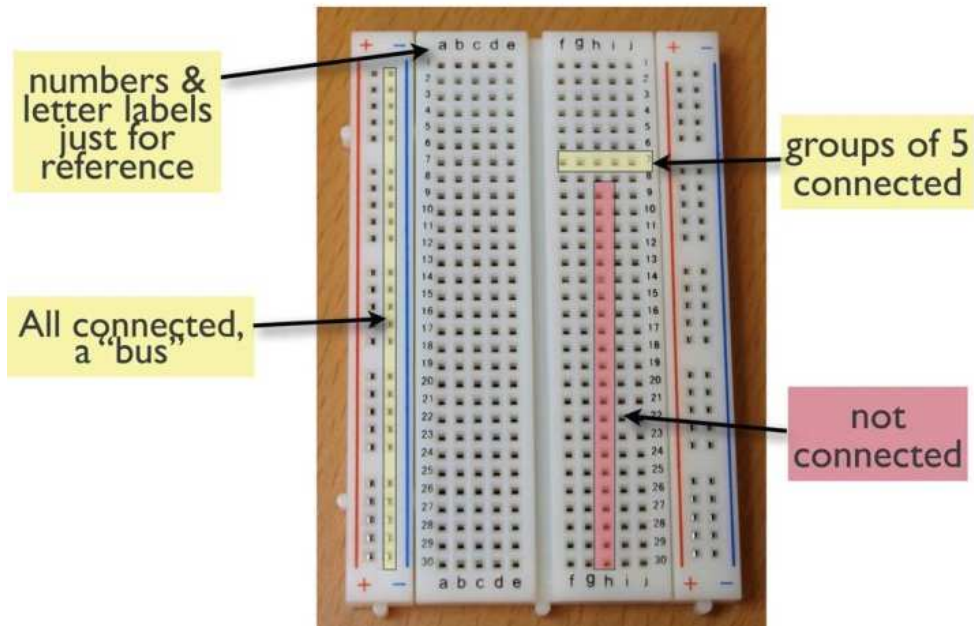
1. List the name of each device currently on your bench and count the number of such devices. For example, 1 oscilloscope, 4 multimeters, etc.

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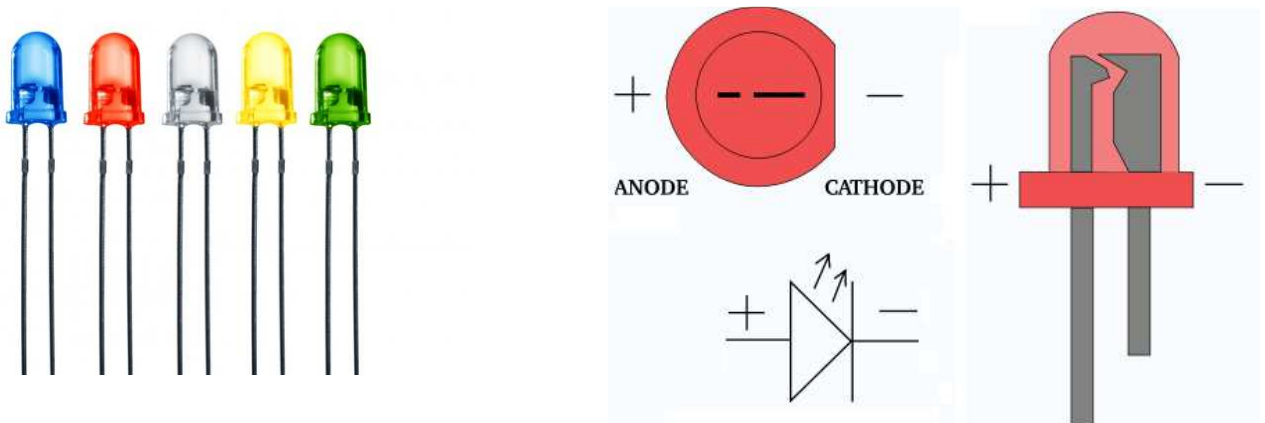
2. You will be provided with a resistor $R = 470 \Omega$ and an LED (light-emitting diode). Use the provided breadboard to connect these two elements in series, and then connect the DC power supply across them as in the schematic below. Set the power supply V_s to 8 V DC.



3. Remember that the breadboard pins are connected internally as shown below.



4. The LED is just like a small light bulb, but it has to be connected with the right polarity (anode to the positive side and cathode to the negative side) for it to light up.



5. Write one paragraph explaining the function of a breadboard.

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6. Write one paragraph explaining the function of a DC power supply.

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7. Use a Voltmeter to measure the **voltage** across R , and record it below. Remember to select the V button with a suitable range (depending on the screen reading), and to connect the voltmeter to the resistor using two suitable leads, the positive lead should be inserted in the V/ Ω terminal and the negative lead should be connected to the COM terminal. In DC measurements select the DC option, and **pay attention** to the polarity when connecting your voltmeter.

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8. Did you connect the Voltmeter in series or parallel with the resistor R ?

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9. Calculate the expected current in the resistor R and the LED using Ohm's law? Show your equation.

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10. Now use an Ammeter to measure the **current** in the LED, and record it below. Remember to select the DCA button with a suitable range (depending on the screen reading), and to connect the ammeter using two suitable leads, the positive lead should be inserted in the 2A or 20A terminal and the negative lead should be connected to the COM terminal. In DC measurements, select the DC option, and **pay attention** to the polarity when connecting your ammeter.

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11. Did you connect the Ammeter in series or parallel with the LED?

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12. Are the theoretical and measured values for the current in the LED close or far apart?

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13. Now use an Ohmmeter to measure the actual **resistance** value for R , and record it below. Remember to select the Ω button with a suitable range (depending on the screen reading), and to connect the ohmmeter to the resistor using two suitable leads, one lead should be inserted in the V/Ω terminal and the other lead should be connected to the COM terminal. Make sure you disconnect the resistor R from the circuit and move it somewhere else to measure its resistance.

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14. Explain why you should disconnect R from the circuit when measuring its resistance using an Ohmmeter.

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15. Is the actual resistance value for R exactly the same as its nominal value? Or slightly different?

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16. Now re-calculate using Ohm's law the expected current in the resistor R using its actual value (rather than its nominal value) and the value of the voltage across the resistor. Record this value below.

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17. Is the new current value close to the ammeter reading you had earlier in part 10?

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PROCEDURE B - ON/OFF AND REFRESH RATE

1. In the above circuit, replace the DC power supply V_s with a function generator that produces an 8 V_{pk-to-pk} and 100 Hz square wave signal. Which knobs did you fiddle with for the function generator?

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2. Connect the oscilloscope in parallel with the function generator and observe the signal on the oscilloscope. Explain how do you read the period, frequency, peak-to-peak voltage and peak voltage from the oscilloscope screen?

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3. Does the LED flicker at 100 Hz?

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4. Change the frequency of the function generator from 100 Hz slowly to 5 Hz? At which frequency did the LED start flickering?

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5. Search the Web for the refresh rate for a typical computer screen? Write it below. Why do you think they use this frequency?

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6. Reduce the peak-to-peak voltage from the function generator. How do you do that?

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7. What happens to the light from the LED as you decreased the voltage?

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8. Read the input impedance of your oscilloscope and record it below? Why is it high?

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**** End ****