Preliminary (Take Note)

*** During Movement Control Order (MCO), students are not allowed to attend Face-to-face practical class.**

If students are allowed to return to laboratory for self learning, or MCO lifted by fulfilling the Standard Operation Procedure, the following guidelines are strictly applied:

1) Practical classes will be conducted based on Two (2) students per group.

2) Each group will obtain a blue tool box with a specified box number, please remember the number and it will be used until the end of the course.
   * Strictly ***NOT ALLOW*** to exchange the box number and items inside without the permission of the practical instructor / lecturer / lab assistant.

3) Register the box number (per group) via Lab Assistant / provided Google Form (if required)

4) Examine the box items with the provided list of items, every time before the practical class.
   - Raspberry Pi (Board and Casing)
   - Grove Pi Board
   - Power Adapter
   - Connector cables (Male-Female & Male-Male)
   - Grove Pi Starter Kit box (green box)
   - Micro HDMI to VGA converter
   - Breadboard
   - Proskit MT-1210 Multimeter
   - Components Pack
     - Push button switch, Buzzer, Relay 5V, LEDs,
     - Resistor 1KΩ, 10kΩ, 560Ω
     - Transistor 2N3904

- For campuses that are **only** having **ONE practical group**, students may borrow (follow **SOP** to return to the lab for collection) the box items and conduct practical class at home via Google Meet, based on the scheduled timetable.
- For campuses that are **more than ONE practical group**, students may conduct virtual practical class without the physical box items. Practical instructors will perform practical works via Google Meet and students have to attend all the practical classes for learning and understanding the details of practical content.

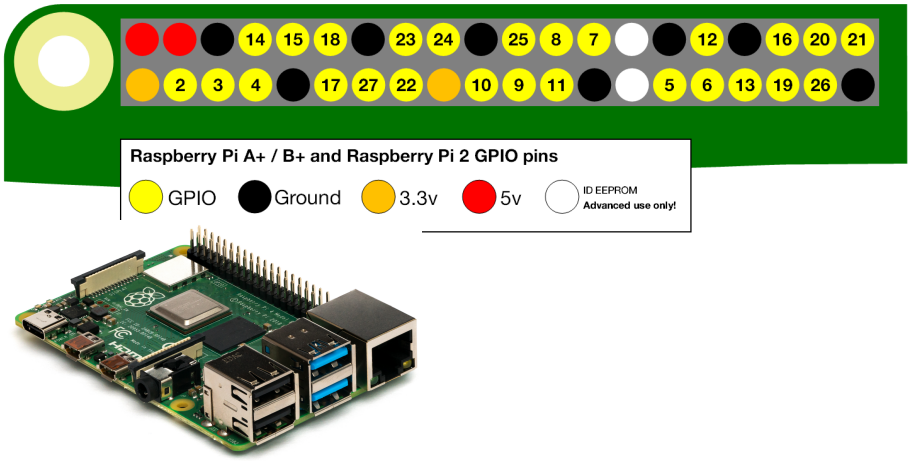
All students are required to answer all the Practical Questions correctly, by referring to the Coursework Assessment > Practical Assessment, provided in the Google Classroom to obtain 20% practical assessment marks.

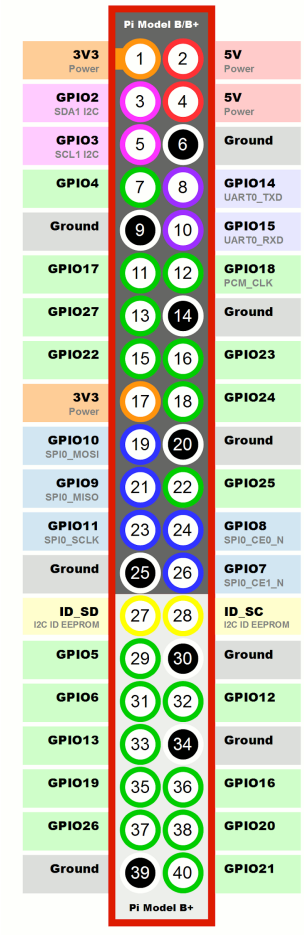
Understanding the Tools

1) Either one type of Multimeter will be provided

Digital Multimeter with manual ranging selections

2) Understand the Raspberry Pi 40 GPIO pins.





Practical 1: Construct a circuit to control the low current (< 10mA) output devices

Objective

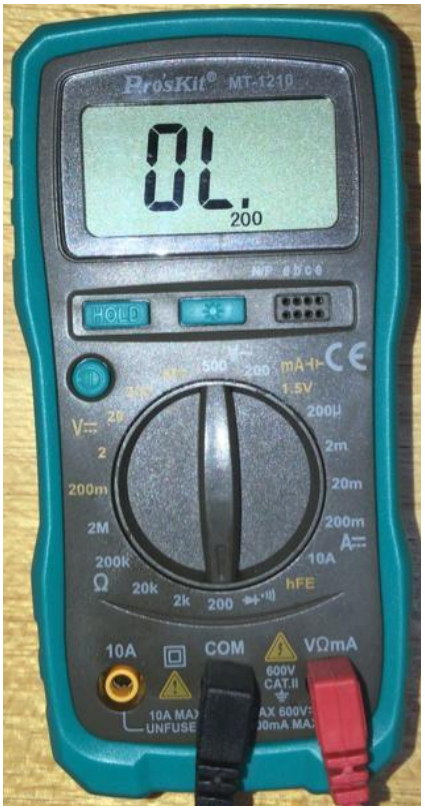
Understand how to use a resistor to limit the flow of current into a low current device such as Light Emitting Diode (LED)

Procedure

Step 1: Learn to test open and short circuit using a multimeter

- **OPEN CIRCUIT = DISCONNECTED**
- **SHORT CIRCUIT / CLOSED CIRCUIT = CONNECTED**

(i) Rotate the selector to Ω (Ohm) group, select 200 Ω range. Plug the electrodes into the input jacks of multimeter, red electrode (+) to red jack with label of "VΩmA", black electrode (-) to black jack with label of "COM".



(ii)

Short the red electrode to the black electrode, the multimeter reading is close to zero, 000, beeping

Open both electrodes, the multimeter reading is infinity, 0L, silent

Question: What does the multimeter reading mean when both electrodes are *short* and *open*?

Short circuit (000 or close to zero) means they are connected, no resistance (zero Ohms).
Open circuit (0L) means they are disconnected, infinite resistance.

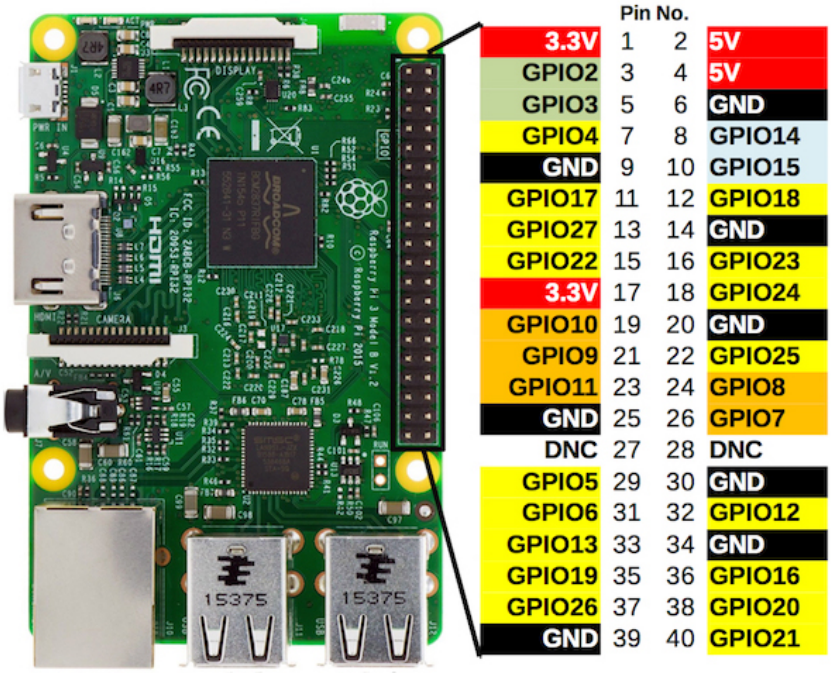
* Try the Diode / Beep sounds symbol and repeat the step to short / open both electrodes.

Step 2: Learn to measure voltage using a multimeter

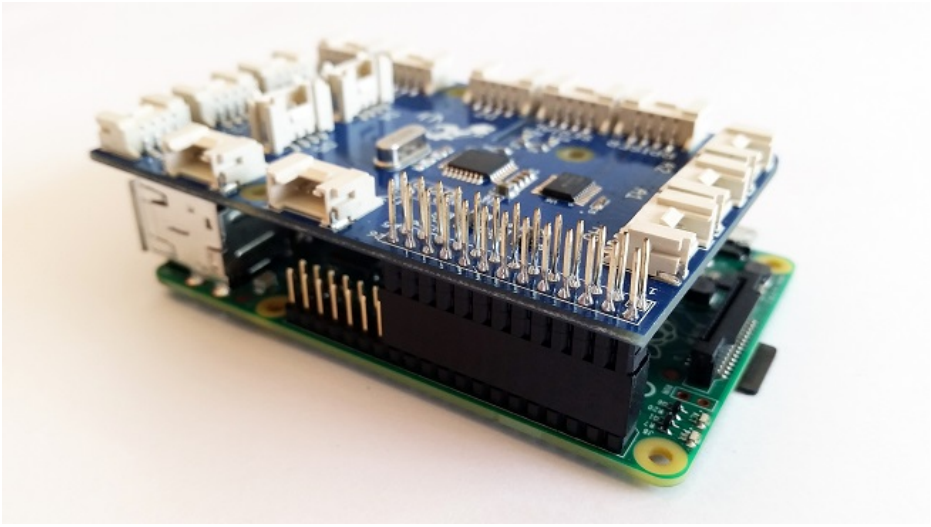
(i) Press copper wire into the breadboard as shown below. Then turn on the Raspberry board.

(1) PIN4 (pin number 2 at right row) - 5 V (RED)
(2) PIN1 (pin number 1 at left row) - 3.3 V (RED)
(3) PIN9 (pin number 5 at left row) - GND (BLACK)

Notes:
GPIO = General Purpose Input/Output
GND = Ground - 0 volts, used to complete a circuit, lighting (the current of lighthing will eventually go down the ground), safety purpose (won't get electric shock)



Practical 1 and 2 ***DO NOT*** require a GrovePi board. Starting from Practical 3, students are required to install the GrovePi Board on the Raspberry Pi board.



*** ONLY INSTALL GROVEPI STARTING FROM PRACTICAL 3.**

(ii) Rotate the multimeter selector to voltage (V) range and select **20 V**. Plug the electrodes into the input jacks of multimeter, red electrode (+) to red jack with label of "VΩmA", black electrode (-) to black jack with label of "COM". (Note: multimeter Ω (Ohm) group CANNOT used to measure voltage)

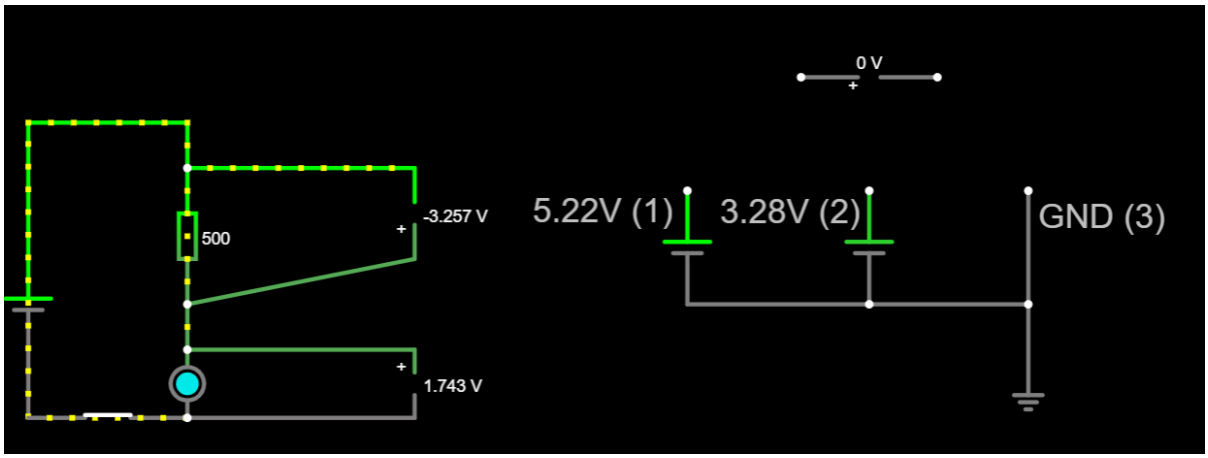
(iii) Touch the multimeter electrodes to wires and fill up the table below. (Note: multimeter Ω (Ohm) group CANNOT used to measure voltage)

(positive) (negative)

Red Electrode	Black Electrode	Voltage (V) Reading
1	3	5.22(Close to +/- 5.0 V)
3	1	-5.22(Close to +/- 5.0 V)
2	3	3.28(Close to +/- 3.3 V)
3	2	-3.28(Close to +/- 3.3 V)

Question: Explain the result in table when red and black electrodes are reversed

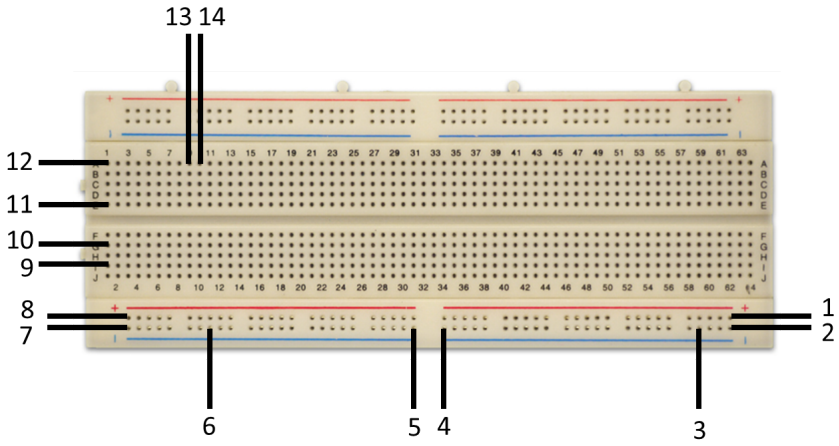
The magnitude remains unchanged but a negative sign will appear as the current now is flow in the reverse order (can refer to the table above)



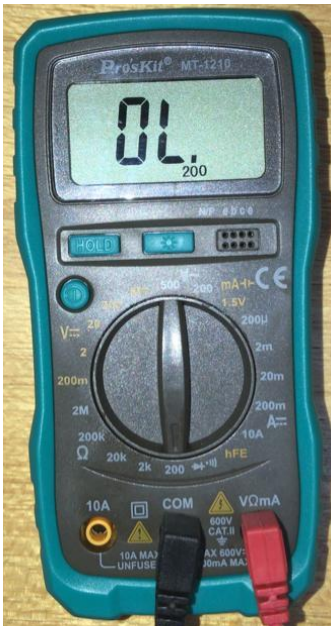
Falstah simulation for this voltage measurement

Step 3: Understand the breadboard connection layout

(i) Plug copper wire numbers from 1 to 14 into the holes of the breadboard.



(ii) Rotate the selector to 200 Ω range. Plug the electrodes into the input jacks of multimeter, red electrode (+) to red jack with label of "VΩmA", black electrode (-) to black jack with label of "COM".



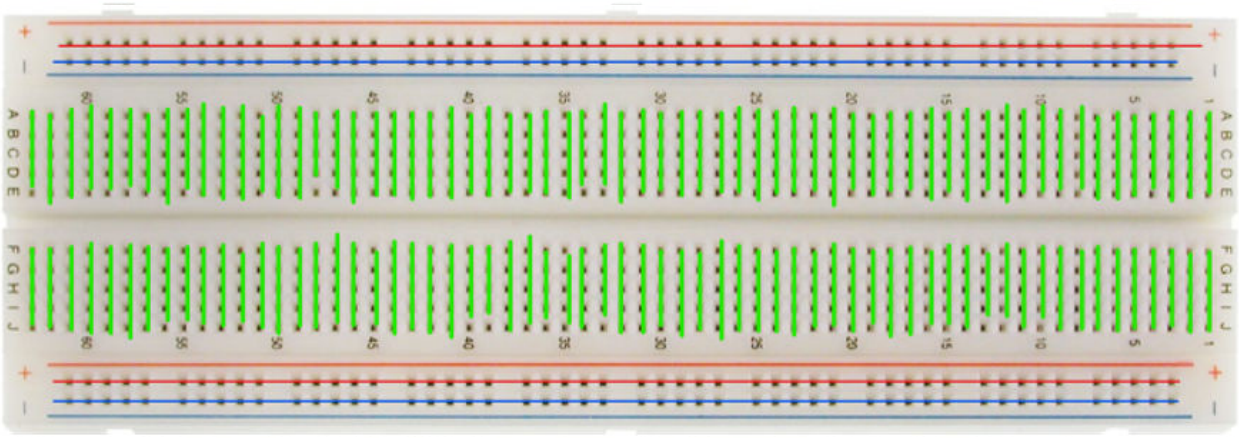
(iii) Using the multimeter to test the wires are open or short according to the table given.

* Alternatively, you can search and use the ***sound icon*** on your multimeter.

Wire number	Wire number	Short (Just tick "✓")	Open (Just tick "✓")
1	2		y
2	3	y	
3	4	y	
4	5	y	
5	6	y	
6	7	y	
7	8		y
1	8	y	
2	7	y	
8	9		y
9	10	y	
10	11		y
11	12	y	
12	13		y
13	14		y

Notes: For some of the breadboard, the left and right section are not connected, however, the demonstration done by tutor (Dr Poh), both section are connected.

Question: What is the connectivity arrangement of the holes on the breadboard? (Draw a line for connected holes)

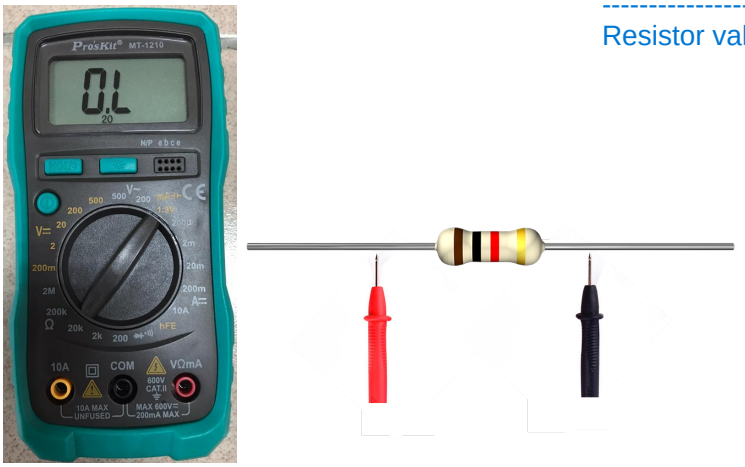


Step 4: Learn how to measure the resistance of resistor

(i) Pick one resistor with the color bands of brown-black-red. Rotate the multimeter selector to 2 kΩ (2000 Ω). Then touch multimeter electrodes to the leads of the resistor., the multimeter reading is 0.9k Ohms / 981 Ohms

brown-black-orange

Resistor value:10k Ohms 5%



(ii) Repeat the same process to the resistor with color bands of green-blue-brown, the multimeter reading is 560 Ohms .

Question: What is the unit of resistance for both resistors?

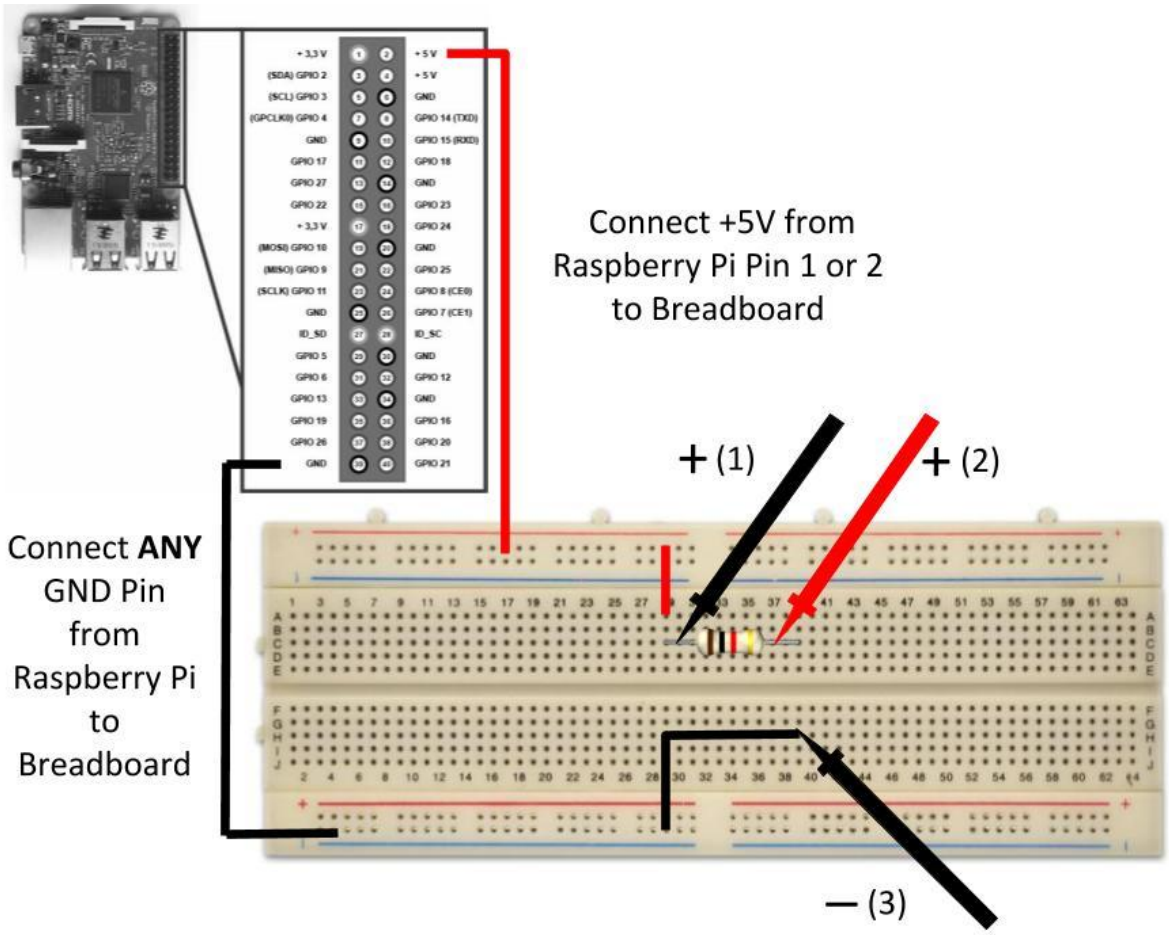
Ohms

Reference link : https://www.calculator.net/resistor-calculator.html

Step 5: Construct a resistor circuit without Light Emitting Diode (LED)

*** Please go through the Additional Note for extra precaution on circuit design.**

(i) Make sure the Raspberry board is **turned off**. Press 1 kΩ resistor into the breadboard on lines 29 and 39. Pulling copper wires and pressing into the breadboard as shown below. Then **turn on** the Raspberry board. **Pin2 / Pin4 = 5V, Pin9 / Pin6 / Pin14... = GND*



**Notes: 981 Ohms for resistor

(ii) Rotate the multimeter selector to voltage (V) range and select **20 V**. ***Turn on the Raspberry board***. Touch the multimeter electrodes to wires 1 and 2, the multimeter reading is 5 V. (Note: multimeter Ω (Ohm) CANNOT used to measure voltage)

(iii) Multimeter selector remains at the same selected **20 V,** touches the multimeter electrodes to wires 2 and 3, the multimeter reading is 5 V. (Note: multimeter Ω (Ohm) CANNOT used to measure voltage)

(iv) Using Ohm's Law (voltage = current x resistance) using the result in (iii), the calculated current is 5.097 mA. V = IR
I = V/R = 5/981 = 5.097mA

Question: Explain the measured voltage (using multimeter), calculated current (using Ohm's Law) with different resistances without LED.

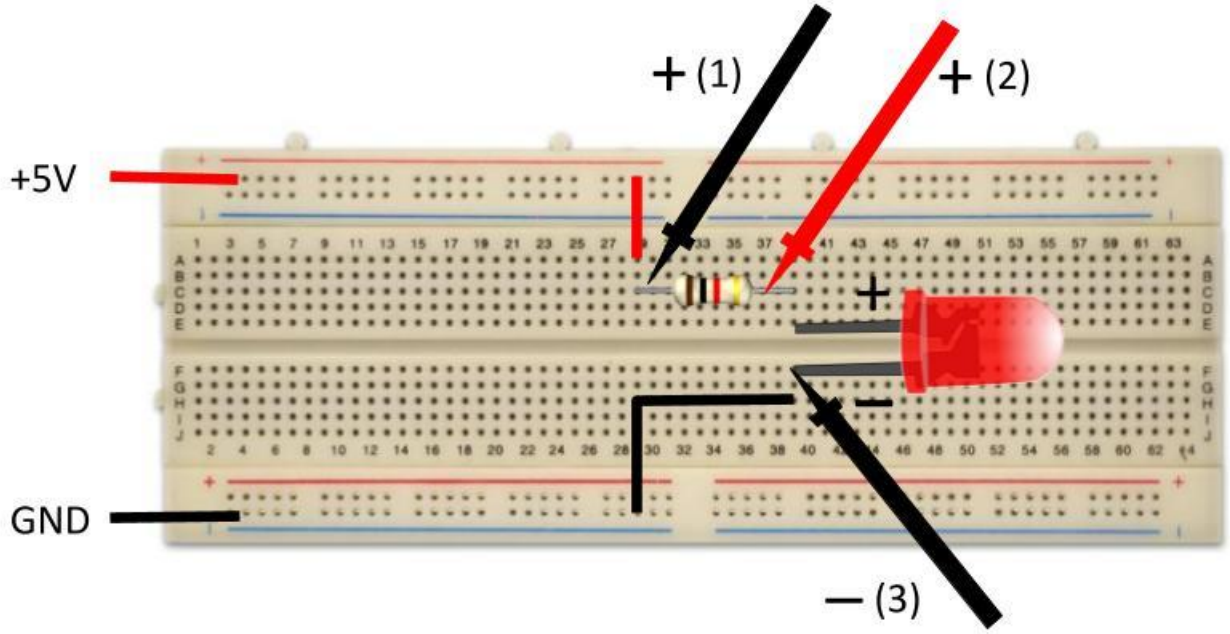
Resistance=981 Ohms,
I = V/R = 5/981 = 5.097mA

Resistance=3.9k Ohms,
I = V/R = 5/3900 = 1.276mA

- Lower resistance allows more current to flow
- Higher resistance restricts more current

Step 6: Construct a resistor circuit with Light Emitting Diode (LED)

(i) Make sure the Raspberry board is turned off. Pick one Light Emitting Diode (LED), press it into the breadboard from Step 4 as shown below. If the LED is not turned on, pull the LED out, reverse the LED and press it into the breadboard again. Then turn on the Raspberry board.



(ii) Rotate the multimeter selector to voltage (V) range and select **20 V.** ***Turned on the Raspberry board***. Touch the multimeter electrodes to wires 1 and 2, the multimeter reading is 3.32 V. (Note: multimeter Ω (Ohm) group CANNOT used to measure voltage)

(iii) Multimeter selector remains at the same selected **20 V**, touches the multimeter electrodes to wires 2 and 3, the multimeter reading is 1.68 V. (Note: multimeter Ω (Ohm) group CANNOT used to measure voltage)

(iv) Using Ohm's Law (voltage = current x resistance) using the result in (iii), the calculated current is 1.71 mA.

V = IR
I = V/R = 1.68/981 = 1.71mA

Notes : Smaller voltage should be black electrode while larger voltage should be placed at red electrode to give positive multimeter reading

(v) Pull out the resistor and replace it with a 10k Ω resistor. Make sure the leads of the resistor are on lines 29 and 39 of the breadboard.

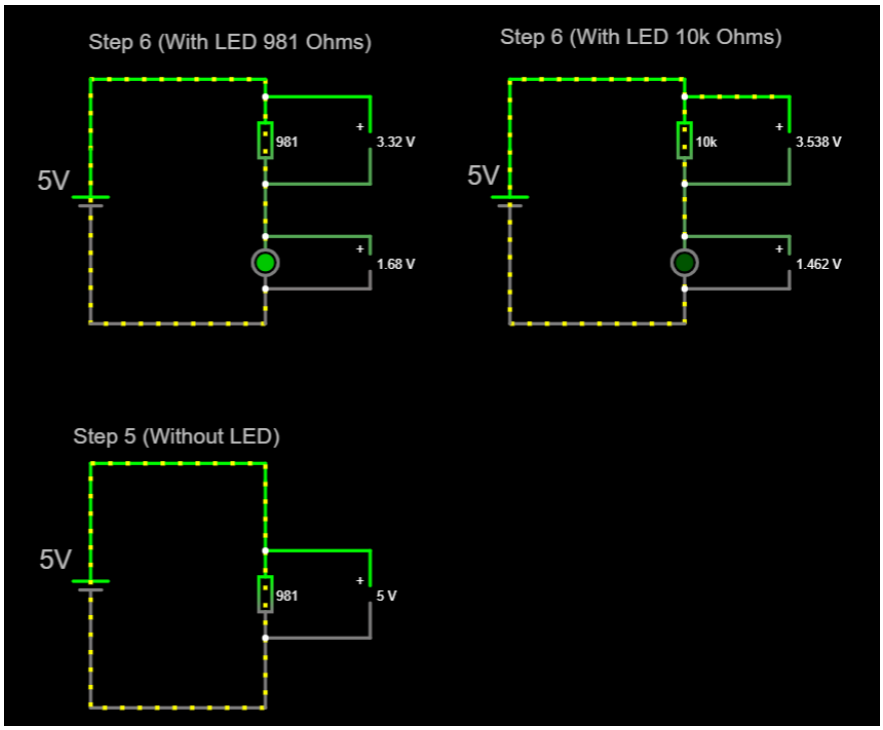
(vi) Rotate the multimeter selector to voltage (V) range and select **20 V**, touch the multimeter electrodes to wires 1 and 2, the multimeter reading is 3.54 V. (Note: multimeter Ω (Ohm) group CANNOT used to measure voltage)

(vii) Multimeter selector remains at the same selected **20 V**, touches the multimeter electrodes to wires 2 and 3, the multimeter reading is 1.46 V. (Note: multimeter Ω (Ohm) group CANNOT used to measure voltage)

(viii) Using Ohm's Law (voltage = current x resistance) using the result in (vii), the calculated current is 0.15 mA.

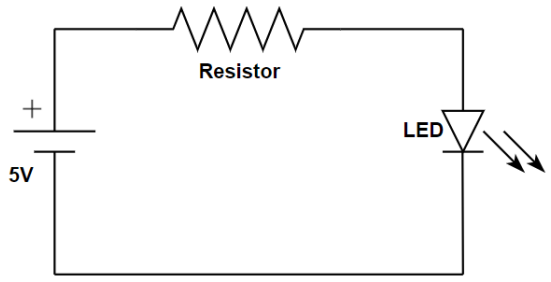
V = IR
I = V/R = 1.46/10000 = 0.15mA

(xi) Observe the LED brightness, higher LED brightness is using resistor with value of 981 Ohms, the lower LED brightness is using resistor with value of 10k Ohms.
~1k Ohms



Question: Draw the resistor with LED circuit using standard electronic symbols.

* You can use Windows “Paint” to draw a simple circuit, save as an image file and upload to google classroom.



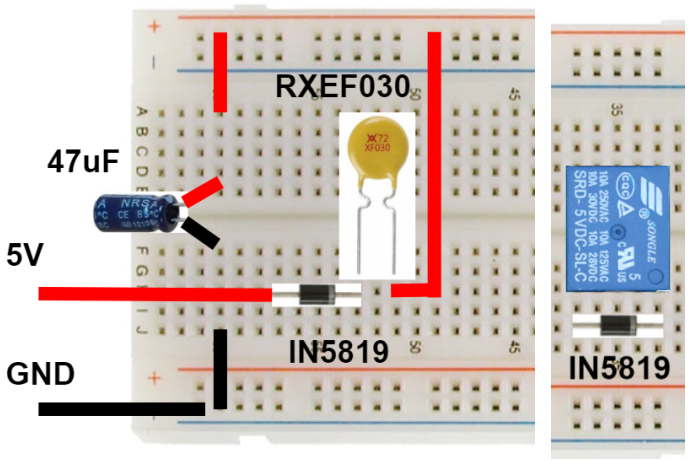
More exploration at here:

https://phet.colorado.edu/sims/html/circuit-construction-kit-dc-virtual-lab/latest/circuit-construction-kit-dc-virtual-lab_en.html

https://phet.colorado.edu/en/simulation/circuit-construction-kit-dc

Additional Note

We strongly suggest providing additional protection in our circuit design, by adding a 47uF capacitor, a 1N5819 diode and aRXEF030 resettable fuse, if it is available in the laboratory.



1. RXEF030 300mA resettable fuse is to mitigate damage to the +5V source due to short circuit while our hands muck around with the breadboard. Note that prolonged short circuit of 5V from Raspberry Pi can damage the PCB tracks and power regulator(s) on the board.

2. The 1N5819 Schottky diode after the +5V source is to prevent current from flowing back to the source (and damage it -- especially Raspberry Pi +5V). This might not be needed if there is no other external voltage source greater than 5V on the breadboard.

3. The 1N5819 (1A/40V) Schottky diode across pins 1 and 2 of the relay (see right) is to avoid voltage spike due to inductive kickback from the relay coil, when a NPN transistor abruptly switches off.