Building circuits

Record all measurements made as part of the lab under the relevant section. Graphs of current or resistance versus voltage when relevant are encouraged.

## Basic circuit:

1. Turn on the Raspberry pi (Rpi)
2. Connect one of the 5V pins on the Rpi to the + column on the breadboard
3. Connect one of the ground pins on the Rpi to the - column on the breadboard
4. Run a connector from the + column to one row on the main part of the breadboard
5. Run a connector from the - column to a different (but close) row on the main part of the breadboard
6. If we connected a 1Ω resistor between these two rows - so that it is in a closed loop with the 5V supply from the Rpi, how much current would this circuit attemwoupt to draw across the resistor?

The current would be 5 Amps, using the V equals to current over resistance.

* 1. The Rpi adaptor provides 5V and up to 2 Amps, is this current sufficient?

The current is not sufficient as it would attempt to flow at 2 Amps with 5 V.

* 1. What do you think might happen? Please don’t actually do this.

We would try to draw 2 Amps because we have 5 Volts, which would try to 5 Volts when there are only two amps.

1. Connect a resistor of more than at least 100Ω (Why might this be enough resistance?)
   1. If you have a multi-meter able to measure current evaluate the current across the resistor, is it what you expected?
      1. NOTE: to measure current, you have to put the meter in series with the rest of the circuit – it cannot measure current like it would voltage (connecting leads to +/- side of a component) – the current has to run through the meter

Note: we initially short-circuited because we attached the rows next to each other, and the resistor was in parallel, only one path had resistance, so the volts were concentrated in just one path.

The current was as expected when set-up properly. We connected a dupont connector on the first row aligned with one point of the 100 Ohms resistor, and with the negative side. We connected another dupont connector on the 7th row aligned with the other point of the 100 Ohms resistor. The positive side is all connected while the rows from the negative side to the middle of the breadboard are all connected. On the multi-meter, we switched to measuring with a max of 10 amps. With this change, we got 0.04 amps, as expected with the additional internal resistance of the power supply.

## LED in a circuit:

1. Add an LED to your circuit
   1. Put it in series with the resistor and move the +/- connectors to the RPi 5V supply as needed
      1. How does the diode need to be oriented? Which wire on the LED goes to the +5V side and which goes to the GND connector?

Anode (longer lead) is the positive lead, and the cathode (shorter lead) is the negative lead. We connected the LED in series (of the same row) to the resistor.

* 1. What is the voltage drop across the resistor? Was this what you expected?

We switched the multi-meter to measure voltage and connected the dupont wires for positive and negative again. We measured the voltage drop to be 2.17 volts across the resistor.

* 1. What is the voltage drop across the LED?

We measured the voltage drop across the LED as 2.83 volts.

1. Try removing the resistor from the circuit, keeping the circuit closed - the LED is just in series with the 5V supply.
   1. What do you think will happen to the LED brightness?

The LED brightness increased without the resistor using the V = IR equation, current decreases as resistance decreases and vice versa.

1. Try including resistors of different values - how does LED brightness change vs resistor strength?

Using a 100 Ohms resistor, the LED seems medium bright. The voltage drop is 1.82 volts. Using a 220 Ohms resistor, the LED seems less bright compared to the previous one. The voltage drop is 3.00 volts.

* 1. Do the voltage drops across the resistors and LED change?

The voltage drops became bigger for the LED and smaller for the resistors, and vice versa.

1. Using the configuration with the highest LED brightness now move the 5V connection on the RPi to one of the 3.3V pins.
   1. What do you expect to happen to the LED brightness?

We moved the 5V connection to the 3.3V pins. We expect the LED brightness to lessen as there is less voltage to draw current from.

1. Add a step-up circuit components to increase your RPi voltage from 5V to 10V but do not close your circuit yet
   1. Using the dimmest configuration for the LED explored previously (meaning select the appropriate resistor from those you tried previously) now

Putting the 220 Ohm resistor and by connecting the boost converter to the raspberry pi.

* 1. How will the LED brightness change?

The LED became brighter from the initial connection to the 5V to the connection to the 10V.

1. How would you quantify the LED brightness changes?

Using the equation of power, which is the current times the voltage, and the equation of voltage, which is the current times the resistance, and if the resistance is the same for both, then a doubling of the voltage (from 5V to 10V) would be a doubling of the power output, which would be the equivalent of twice the voltage and twice the current.

1. Do any of these results change with different color LEDs? Specifically do any voltage drop values change, is the relative brightness similar for different color LEDs, etc.

With 5V and 220 Ohms:

Blue = 3.11 V

Green = 2.84 V

Red = 2.08 V

Yellow = 2.06V

White = 2.76V

With 3.3V and 220 Ohms:

Blue = 2.78V

Green = 2.55V

Red = 1.97V

Yellow = 1.98V

White = 2.65V

There is clear variation, with red and yellow emitting closely related values of light, with blue emitting the most light from both voltages.

The shorter the wavelength (green, blue), the greater the voltage change between the supplies.

## Photo-diode:

1. Replace the LED with a photo-diode (remove the step-up component as well if you had one included previously)
   1. NOTE: photo-diodes operate in reverse bias mode so you will need to orient the diode accordingly
2. What is the voltage across the resistor when you simply connect the 5V supply to close this circuit?

The voltage across the resistor is 54.6 mVolts.

1. What happens if you cover the photo-diode? What happens if you change the +connector to go to the 3.3V pin on the Rpi?

At 5V with the photo-diode covered, it measures 3.5 mVolts. At 3.3V, the resistor measures 68.7 mvolts. With the photo-diode is covered, it measures 4.1 mVolts.

* 1. What is the dark current for this photo-diode? (Use the voltage across the resistor to determine diode current)

It is 3.5mVolts as aforementioned.

* 1. Is 5V enough supply voltage to see a signal from this diode? Is 3.3V?

5V and 3.3V are enough to see a signal from this diode, especially with the 1000 Ohms resistor.

* 1. What happens if you attach the step-up circuit component to increase the supply up to 10V?

It is 46 mVolts.

1. What are the dark current and saturation current for the photo-diode?

The dark current is 4.0mV. Changed resistor to 220 Ohms to better measure saturation current, which is unlikely to be measured. Using the phone light, in slowly increasing it, we got to a max. of 4.12microV.