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 attempt to draw across the resistor?
    i. **Due to ohm's law the I = V/R. We can calculate the current drawn. 5/1 which is = 5 A.**
    b. The Rpi adaptor provides 5V and up to 2 Amps, is this current sufficient?
        i. **Yes there is not enough current from the Rpi.**
    c. What do you think might happen? Please don't actually do this.
        i. **You would just get 2 A. We would short the pie and get an error because it won't go through. It would burn.**
7. Connect a resistor of more than at least 100Ω (Why might this be enough resistance?)
    i. **With 100Ω the current would be 5/100 = 0.05 A. which is enough current that the Rpi can handle.**
    b. If you have a multi-meter able to measure current evaluate the current across the resistor, is it what you expected?
        i. 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
        ii. **We tested it with a resistance of 220 Ω. We got a current of 0.001 A but sometimes nothing. The current expected is: 0.0227 A. There is some uncertainty in these measurements due to the fact that these machines are not as accurate to such small measurements.**

LED in a circuit:

1. Add an LED to your circuit
    a. Put it in series with the resistor and move the +/- connectors to the RPi 5V supply as needed
        i. 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?
        ii. **The diode, the long pin, faces the plus. The other way won't work and might burn up.**
    b. What is the voltage drop across the resistor? Was this what you expected?
        i. **The voltage drop = 1.68 V**
    c. What is the voltage drop across the LED?
        i. **The voltage drop = 3.84 V**
2. Try removing the resistor from the circuit, keeping the circuit closed - the LED is just in series with the 5V supply.
    a. What do you think will happen to the LED brightness?
        i. **The LED should get brighter and might burn out or get too hot (if there is too much current). Make sense because there is less current with the same resistance, thus, lower voltage drop.**
3. Try including resistors of different values - how does LED brightness change vs resistor strength?
    a. Do the voltage drops across the resistors and LED change?
        i. **Putting a resistor with lower resistance will cause a brighter LED due to more current flowing through the LED. More resistance = higher voltage drop.**
        ii. **Lower resistance = change in voltage = 1.6 V**
        iii. **Higher resistance = change in voltage = 1.8 V**
4. Using the configuration with the highest LED brightness now move the 5V connection on the RPi to one of the 3.3V pins.
    a. What do you expect to happen to the LED brightness?
        i. **The 3.3 V pins do not light up the LED. The LED on its own needs at least 3.84 V, thus 3.3 V is too little for the current provided and the resistance in the LED.**
5. Add a step-up circuit components to increase your RPi voltage from 5V to 10V but do not close your circuit yet
    a. Using the dimmest configuration for the LED explored previously (meaning select the appropriate resistor from those you tried previously) now
        i. **We got 11.02 V with the voltage step up circuit.**
    b. How will the LED brightness change?
        i. **We killed the LED because we attached the LED without a resistor so it was too much current for it. However, when we attached the LED with the resistor the LED was very bright (brighter than before).**
6. How would you quantify the LED brightness changes?

    i. **The LED has electrons which are exciting into different orbits. When an electron excites and goes back to its previous state it will release energy which is in the form of visible light. When provided different electricity then the electrons will excite differently and thus release a different color or "strength" of visible light.**
    ii. **We can use a photoresistor measuring the brightness in a dark box to quantify the change in the amounts of light being emitted by the LED.**
7. 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.
    i. **All of the LEDs react the same to increases / decreases in voltages and resistance. More volts makes the LEDs brighter, higher resistance dims them. The blue LEDs are the brightest of them all.**

Photo-diode:

1. Replace the LED with a photo-diode (remove the step-up component as well if you had one included previously)
    a. 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?
        i. **The voltage difference is 5.3 V**
3. 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?
        i. **As we cover the photo-diode the resistance decreases. We can tell this by adding a LED and watching the brightness change as we move the photo-diode towards the light.**
        ii. **We added a resistance without covering the photo-diode. The Voltage drop is 0.028 V. as We cover it the voltage is 0.**
        iii. **As we change the 3.3 V pin to the Rpi we see the resistance being even less, it still is functioning which is different from not having a photo-diode in the circuit at all.**
    b. What is the dark current for this photo-diode? (Use the voltage across the resistor to determine diode current)
        i.
    c. Is 5V enough supply voltage to see a signal from this diode? Is 3.3V?
        i. **Yes but the 3.3 V causes a very low reading of the resistance, therefore, hard to read on the Voltmeter that was provided.**
    d. What happens if you attach the step-up circuit component to increase the supply up to 10V?
        i. **Adding more voltage to the**
4. What are the dark current and saturation current for the photo-diode?
        i. **The saturated current is: The voltage drop with the resistor is 0.004 V (not covered). We find the current which is V/R = 0.004/220 = 0.000018 A. In series the current is the same as the resistance. So the current of the photo-diode is 0.000018 A.**
        ii. **Dark current: The voltage drop with the resistor is 0.001 V (not covered). We find the current which is V/R = 0.001/220 = 0.0000045 A. In series the current is the same as the resistance. So the current of the photo-diode is 0.0000045 A.**
        iii. **dark current < saturated current (not covered, towards the light).**