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. **The current will be greater than 1Ampere, which would make the raspberry pi really hot and potentially burn.**
    ii. **I = V/R = 5V/1Ω = 5A**
    b. The Rpi adaptor provides 5V and up to 2 Amps, is this current sufficient?
        i. **No, it's still really big. We want a current < 1Amp**
    c. What do you think might happen? Please don't actually do this.
        i. **Voltage regulator may shut down or overheat, and the board itself could be damaged**
7. Connect a resistor of more than at least 100Ω (Why might this be enough resistance?)
    i. **Because it will keep the current at a low value, which will not make the Raspberry Pi hot and potentially burn the circuits.**
    b. If you have a multi-meter able to measure current and evaluate the current across the resistor, is it what you expected?
        i. **Yes, we got 5.08V which is the voltage we expected (full voltage).**
        ii. 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

LED in a circuit:

1. Add an LED to your circuit
    i. **Yellow LED - 2.0V-2.2V // Blue LED - 3.0V-3.2V**
    ii. **Longer wire is anode**
    b. 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?
            1. **The longer lead (anode) goes to the +5V side (+ve side), and the shorter lead (cathode) goes to the GND side (-ve side).**
    c. What is the voltage drop across the resistor? Was this what you expected? What is the voltage drop across the LED?
            1. **3.10V Measured across the resistor, expected. 1.97V across the LED, lower than expected.**
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 would likely burn out if left for too long, because the current would be high, since the LED is providing light thus using some of the energy from the current.**
        ii. **Brightness goes up, because there is no resistance, so more current flows through the LED.**
3. Try including resistors of different values - how does LED brightness change vs resistor strength?
        i. **We chose the Blue LED light**
        ii. **With No resistor - Very bright**
        iii. **120 Ohm - Medium brightness**
        iv. **280 Ohm - Low brightness**
    b. Do the voltage drops across the resistors and LED change?
        i. **280 Ohm - 2.27V / LED - 2.80V**
        ii. **120 Ohm - 1.80V / LED - 3.22V**
        iii. **No resistor - LED - 4.79V**
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. **Less bright, because there is less voltage and thus less current flowing through 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
    b. How will the LED brightness change?
        i. **Brightness got up because we increased the Voltage**

6. How would you quantify the LED brightness changes?
    i. **V is proportional to Luminosity**
    ii. **Luminosity is inversely proportional to resistance**
    iii. $L \propto \frac{V}{R}$
    iv. **If we want to know the exact value, we can use the light sensor to measure the luminosity, or measure the current through the circuit.**
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. **Now we're trying the green LED**
    ii. **280Ohm - Resistor: 7.14V // LED:2.80 V (*for 10V Step-up)***
    iii. **280Ohm - Resistor: 2.42V// LED: 2.52V *(for 5V from Raspberry Pi)***
    iv. **No Resistor - LED: 4.53V *(for 5V from Raspberry Pi)***
    v. **Now we're trying the Red LED**
    vi. **280Ohm - Resistor: 7.91V // LED:2.02 V (*for 10V Step-up)***
    vii. **280Ohm - Resistor: 3.10V// LED: 1.92V *(for 5V from Raspberry Pi)***
    viii. **No Resistor - LED: LED Burned *(for 5V from Raspberry Pi)***

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. **9.5mV**
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. **The voltage across the resistor decreases**
        ii. **Dark current for 5V: 0.5 mV, saturation current for 5V: 9.5 mV**
    b. What is the dark current for this photo-diode? (Use the voltage across the resistor to determine diode current)
        i. **0.5 mV**
        ii. **Calculate through V=IR**
    c. Is 5V enough supply voltage to see a signal from this diode? Is 3.3V?
        i. **The current is already low with 5V. Switching to 3.3V decreases the overall voltage, might affect the current flow.**
    d. What happens if you attach the step-up circuit component to increase the supply up to 10V?
        i. **The overall voltage increases**

4. What are the dark current and saturation current for the photo-diode?
        i. **Dark current is the small leakage current when no light is present, and saturation current is the maximum current the diode can conduct under strong illumination.**
        ii. **Dark current for 10V: 0.9 mV, saturation current for 10V: 11 mV**
        iii. **Resistance: 280 ohms**
        iv. **Use I = V/R to estimate the current**
        v. **Dark current - we cover the diode so it doesn't get light.**