CamJam EduKit Worksheet Two

Project Controlling LEDs with Python

Description In this project, you will learn how to connect and control LEDs (Light Emitting Diode) with the Raspberry Pi.

NOTE: This worksheet can use a Raspberry Pi Model A, B or B+. The first 26 pins on the B+ (when looking at the Pi with the pins in the top left) are exactly the same as the Model A and Model B.

Equipment Required

□ Raspberry Pi & SD card	□ Power supply	□ 1 x Red LED	□ 3 x 330Ω Resistors
□ Keyboard & Mouse	□ 400 Point Breadboard	□ 1 x Yellow LED	
□ Monitor & HDMI Cable	□ 4 x M/F jumper wires	□ 1 x Green LED	

The Parts

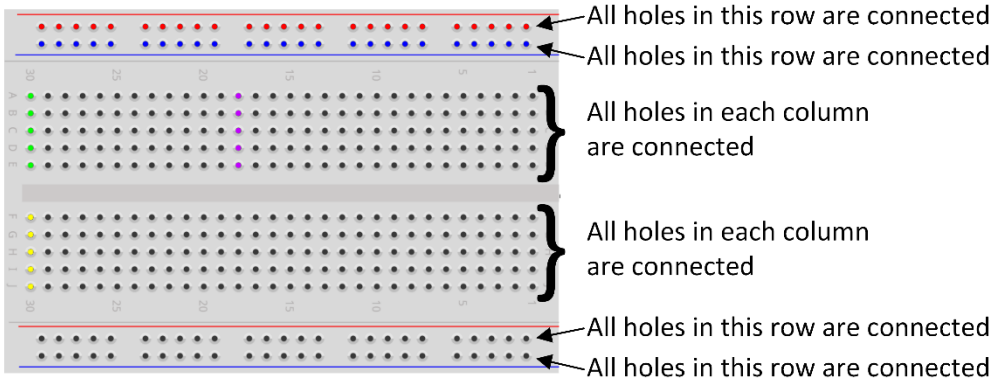
In this first circuit, you will be connecting three LEDs to the GPIO header of your Raspberry Pi and using Python to turn the LEDs on and off.

It is important that you read this section as you need to understand how the holes in the breadboard are connected together, and which leg of the LED is which.

Before you build the circuit, let us look at the parts you are going to use.

The Breadboard

The breadboard is a way of connecting electronic components to each other without having to solder them together. They are often used to test a circuit design before creating a Printed Circuit Board (PCB).



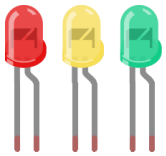
The holes on the breadboard are connected in a pattern.

The Parts

With the breadboard in the CamJam EduKit, the top row of holes are all connected together – marked with red dots. And so are the second row of holes – marked with blue dots. The same goes for the two rows of holes at the bottom of the breadboard.

In the middle, the columns of wires are connected together with a break in the middle. So, for example, all the green holes marked are connected together, but they are not connected to the yellow holes, nor the purple ones. Therefore, any wire you poke into the green holes will be connected to other wires poked into the other green holes.

The LEDs



Three LEDs are supplied in the EduKit – one red, one yellow, and one green. LED stands for Light Emitting Diode, and glows when electricity is passed through it.

When you pick up the LED, you will notice that one leg is longer than the other is. The longer leg (known as the 'anode'), is always connected to the positive supply of the circuit. The shorter leg (known as the 'cathode') is connected to the negative side of the power supply, known as 'ground'.

LEDs will only work if power is supplied the correct way round (i.e. if the 'polarity' is correct). You will not break the LEDs if you connect them the wrong way round – they will just not light. If you find that they do not light in your circuit, it may be because they have been connected the wrong way round.

Resistors

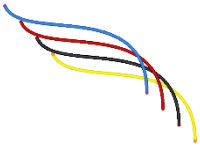
Resistors are a way of limiting the amount of electricity going through a circuit; specifically, they limit the amount of 'current' that is allowed to flow. The measure of resistance is called the Ohm (Ω), and the larger the resistance, the more it limits the current. The value of a resistor is marked with coloured bands along the length of the resistor body.

The EduKit is supplied with two sets of resistors. There are three 330Ω resistors and one 4.7kΩ (or 4700Ω) resistor. In the LED circuit, you will be using the three 330Ω resistors. You can identify the 330Ω resistors by the colour bands along the body. The band colour will be Orange, Orange, Brown, and then Gold.

You have to use resistors to connect LEDs up to the GPIO pins of the Raspberry Pi. The Raspberry Pi can only supply a small current (about 60mA). The LEDs will want to draw more, and if allowed to they will burn out the Raspberry Pi. Therefore putting the resistors in the circuit will ensure that only this small current will flow and the Pi will not be damaged.

It does not matter which way round you connect the resistors. Current flows in both ways through them.

Jumper Wires



Jumper wires are used on breadboards to 'jump' from one connection to another. The ones you will be using in this circuit have different connectors on each end. Then end with the 'pin' will go into the Breadboard. The end with the piece of plastic with a hole in it will go onto the Raspberry Pi's GPIO pins.

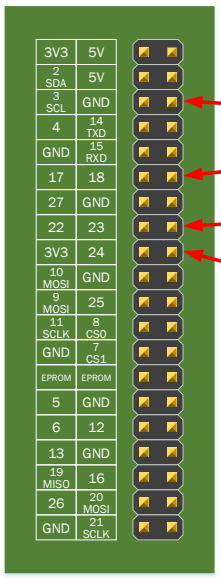
The Parts

The colour jumper wires supplied in the EduKit will vary, and are unlikely to match the colours used in the diagrams.

Building the Circuit

Models A & B

Model B+



While you can build the circuit with the Pi turned on, it's probably best to turn it off at this stage.

First, lets look at the Raspberry Pi's '**GPIO**' pins. GPIO stands for **General Purpose Input Output**. It is a way the Raspberry Pi can control and monitor the outside world by being connected to electronic circuits. The Pi is able to control LEDs, turning them on or off, or motors, or many other things. It is also able to detect whether a switch has been pressed, or temperature, or light. In the CamJam EduKit you will learn to control LEDs and a buzzer, and detect when a button has been pressed.

The diagram on the left shows the pin layout for a Raspberry Pi Models A and B (Rev 2 - the original Rev 1 Pi is slightly different), looking at the Pi with the pins in the top right corner. The new Raspberry Pi B+ shares exactly the same layout of pins for the top 13 rows of GPIO pins. The pin layout for the B+ is on the left.

You will be using one of the 'ground' (GND) pins to act like the 'negative' or 0 volt ends of a battery.

Building the Circuit

The 'positive' ends of the battery will be provided by three of the other GPIO pins, one for each of the three LEDs. You will be using the pins marked 18, 23 and 24 for the Red, Yellow and Green LEDs respectively.

When they are 'taken high', which means they output 3.3 volts, the LEDs will light.

Now take a look at the circuit diagram below.

The power for each LED will be provided by the Pi, from GPIO pins 18, 23 and 24. You can control them from Python, meaning you can make the GPIO pins supply either 0 volts (off) or 3.3 volts (on).

There are in fact three separate circuits in the diagram below. Each one consists of the power supply (the Pi), an LED that lights when the power is applied, and a resistor to limit the current that can flow through the circuit.

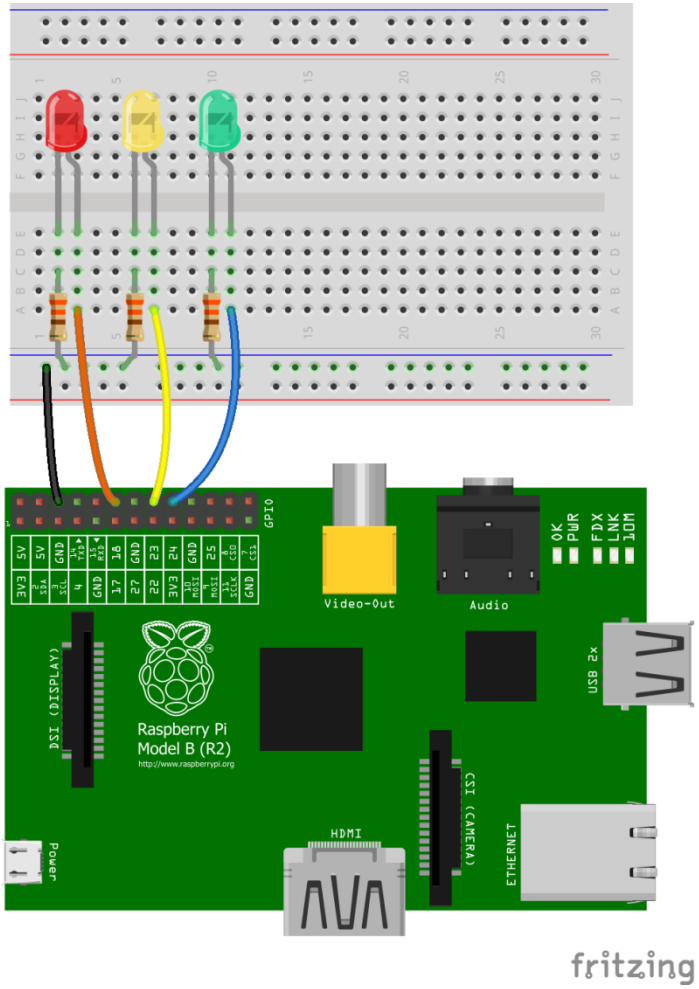
Each circuit is going to share a 'common ground rail'. In other words, you will be connecting all of the circuits to the same 'ground' (0 volts) pin of the Raspberry Pi. You're going to use the second row up from the bottom of the breadboard. Remember that the holes on the two top and two bottom rows are all connected together? So, connect one of the Jumper wires from the third pin from the left on the top row of the Pi to the second row up of the breadboard, as shown in the diagram (the black wire).

Next push three LEDs legs into the breadboard, with the long leg on the right as shown in the circuit diagram.

Then connect the three 330Ω resistors between the 'common ground rail' and the left leg of the LEDs. You will need to bend the legs of each of the resistors to fit, but please make sure that the wires of each leg do not cross each other.

Lastly, using three Jumper wires, complete the circuit by connecting pins 18, 23 and 24 to the right hand leg of each LED. These are shown here with the orange, yellow, and blue wires.

You are now ready to write some code to switch the LEDs on.



Code

Follow the instructions in Worksheet One to turn on your Pi and open the terminal window. In the terminal window:

1. Change directory to the directory you created in Worksheet One using:
```
cd ~/EduKit/
```
2. Create a new text file "2-on.py" by typing the following:
```
nano 2-on.py
```
3. Type in the following code:
```
import RPi.GPIO as GPIO
GPIO.setmode(GPIO.BCM)
GPIO.setwarnings(False)
GPIO.setup(18,GPIO.OUT)
GPIO.setup(23,GPIO.OUT)
GPIO.setup(24,GPIO.OUT)
print "Lights on"
GPIO.output(18,GPIO.HIGH)
GPIO.output(23,GPIO.HIGH)
GPIO.output(24,GPIO.HIGH)
```
4. Once you have typed all the code and checked it, save and exit the text editor with "Ctrl + x" then "y" then "enter".

You now need to repeat most of the above to create the second file which will be used to turn the LEDs off:

1. Create a new text file "2-off.py" by typing the following:
```
nano 2-off.py
```
2. Type in the following code:
```
import RPi.GPIO as GPIO
GPIO.setmode(GPIO.BCM)
GPIO.setwarnings(False)
GPIO.setup(18,GPIO.OUT)
GPIO.setup(23,GPIO.OUT)
GPIO.setup(24,GPIO.OUT)
print "Lights off"
GPIO.output(18,GPIO.LOW)
GPIO.output(23,GPIO.LOW)
GPIO.output(24,GPIO.LOW)
GPIO.cleanup()
```
3. Once you have typed all the code and checked it, save and exit the text editor with "Ctrl + x" then "y" then "enter".

So, what is happening in the code? Let's go through it a section at a time, taking "2-on.py" as an example:

```
import RPi.GPIO as GPIO
```

The first line tells the Python interpreter (the thing that runs the Python code) that it will be using a 'library' that will tell it how to work with the Raspberry Pi's GPIO pins. A 'library' gives a programming language extra commands that can be

Code

	used to do something different that it previously did not know how to do. This is like adding a new channel to your TV so you can watch something different.
`GPIO.setmode(GPIO.BCM)`	Each pin on the Pi has several different names, so you need to tell the program which naming convention is to be used.
`GPIO.setwarnings(False)`	This tells Python not to print GPIO warning messages to the screen.

`GPIO.setup(18,GPIO.OUT)`
`GPIO.setup(23,GPIO.OUT)`
`GPIO.setup(24,GPIO.OUT)`
	These three lines are telling the Python interpreter that pins 18, 23 and 24 are going to be used for outputting information, which means you are going to be able to turn the pins 'on' and 'off'.

`print "Lights on"`	This line prints some information to the terminal.

`GPIO.output(18,GPIO.HIGH)`
`GPIO.output(23,GPIO.HIGH)`
`GPIO.output(24,GPIO.HIGH)`
	These three lines turn the GPIO pins 'on'. What this actually means is that these three pins are made to provide power of 3.3volts. This is enough to turn the LEDs in our circuit on.
	To turn the LEDs off, you need to replace the GPIO.HIGH with GPIO.LOW. This will turn the pins off so that they no longer supply any voltage.

`GPIO.cleanup()`	Then there's the extra line in 2-off.py. The GPIO.cleanup() command at the end is necessary to reset the status of any GPIO pins when you exit the program. If you don't use this, then the GPIO pins will remain at whatever state they were last set to.

Running the Code

You are now ready to run the code.

To turn the LEDs on, type the following into the terminal window:

```
sudo python 2-on.py
```

To turn the LEDs off, type the following into the terminal window:

```
sudo python 2-off.py
```

If you find that the code does not run correctly there may be an error in the code you have typed. You can re-edit the code by using the nano editor, typing `nano 2-on.py` or `nano 2-off.py`.

What you are doing here is telling the Python interpreter to run the commands in file "2-on.py" or "2-off.py". You have to tell Python to run as a special user, called the 'Super User', by adding the command '`sudo`' (meaning 'Super User do'). This user has special permissions to allow it to do things on the Pi that a normal user is not allowed to do, like use the GPIO pins.

Note

Do not disassemble this circuit, as it will be used in the following worksheets.