r00tz WORKSHOP DEF CON

Version 0.9
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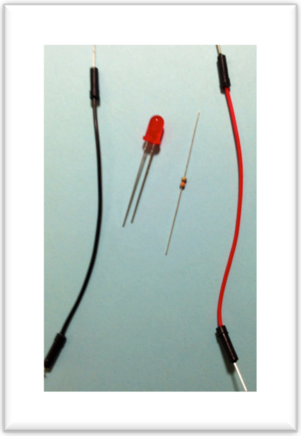
Welcome!

These Labs use a Raspberry Pi single board computer and a breadboard. There are many kits available, many for under $100. For a listing of resources, code and this document, visit the web site at http://aarphacker.com . I hope you enjoy these Labs and please send comments to vesonder@mac.com.

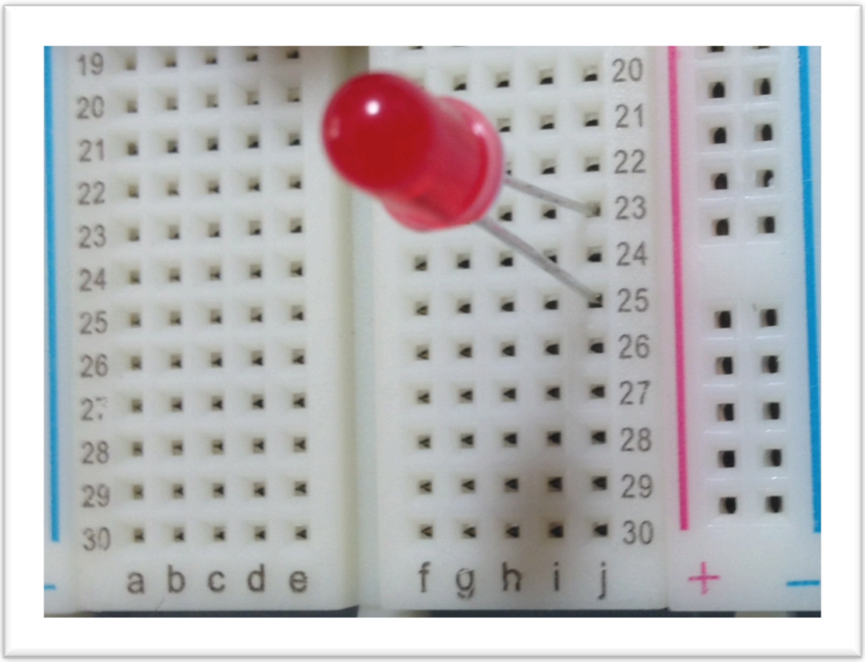
Lab 1: Light!

One of the popular examples to do on a Raspberry Pi or raspi is to make a LED (Light Emitting Diode) blink. This requires wiring a breadboard connected to the raspi with a LED and accompanying resistor, writing the code and running it. However first we are just going to light up a LED to understand the circuit



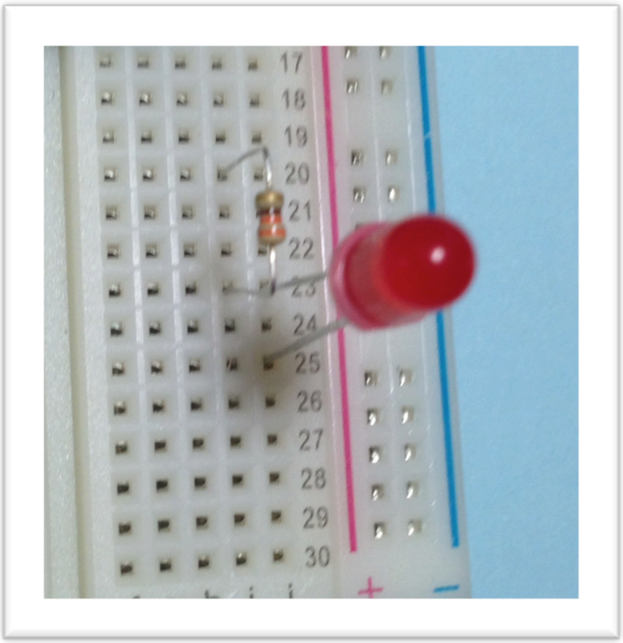
1) Parts list:
   - LED
   - Resistor under 1000 ohms
   - 2 jumper wires, 1 black and 1 red

2) Make sure the raspi is disconnected from the power.
3) In the parts list picture you will notice that the LED has two leads and that one is longer than the other. That is the positive lead and, by elimination, the shorter is the negative lead! If some prankster, snipped both leads to the same size you could look at the bulb and see that one of the leads expands to a squarish area, which is attached to the negative lead. Another sign is that usually the lower ring on the LED bulb is flat on the negative side.
4) Take the led, and on the fghij rows, place the positive element in row 23, column j and the negative element in (25, j) – note from now on I will use this (row, column) notation. It should look like this:



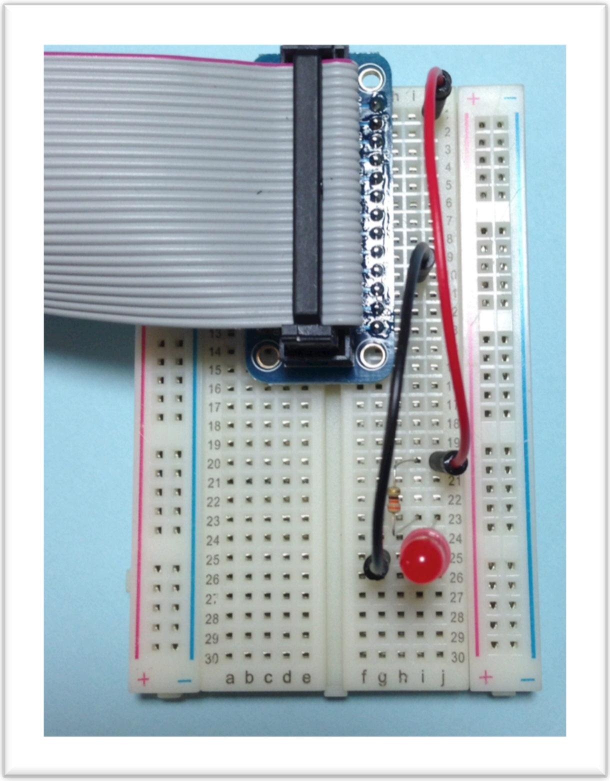
5) Now it is time to add the resistor. In the picture above note that each row has five slots. Each of these slots is electrically connected to each other. So if I want to attach something to the positive lead I can use the slots in row 23 f-i to connect them. That is what makes breadboards special allowing experimenters like us to make quick connections. I am taking advantage of this to connect the resistor. First I bent the leads of the resistor to make it easier to insert into the board (yours are already bent). Place one of the leads, either will work, in (23,i). Place the other end of the resistor lead in

(20, i). Your board should resemble this:



6) On resistors. The resistor we are using is 330 ohms. The bands on the resistor represent the value of the resistor. This resistor has bands in order: orange, orange, brown and gold. Orange stands for 3 and brown, when in the 3rd position, stands for x10. So the value is 33 x 10 or 330 ohms. (the bands are aligned so that the gold or the silver band is at the far end). Why did we use 330 ohms. Because that is a safe value for this LED. The resistor lowers the current flow so we do not burn up the LED. It depends on a few factors beyond the scope of this class but worth exploring on the web.
7) Attach the jumper wires. By convention the black wire always links ground to the negative lead. Place one end of the jumper wire into a slot on row 25, connected to the negative lead of the led. In the picture it is attached to (25,g). Insert the other end into a ground slot of the interface board, row 10. The interface board "extends " the interface pins of the raspi to the breadboard. I selected the ground slot, labeled GND on the right hand side of the board, represented by slot (10,i). If you look carefully you will see GND labeled at that slot on the board. Next attach the red wire to power, in this

case 5 volts. Insert the red jumper in row 1, in the picture it is (1,j).



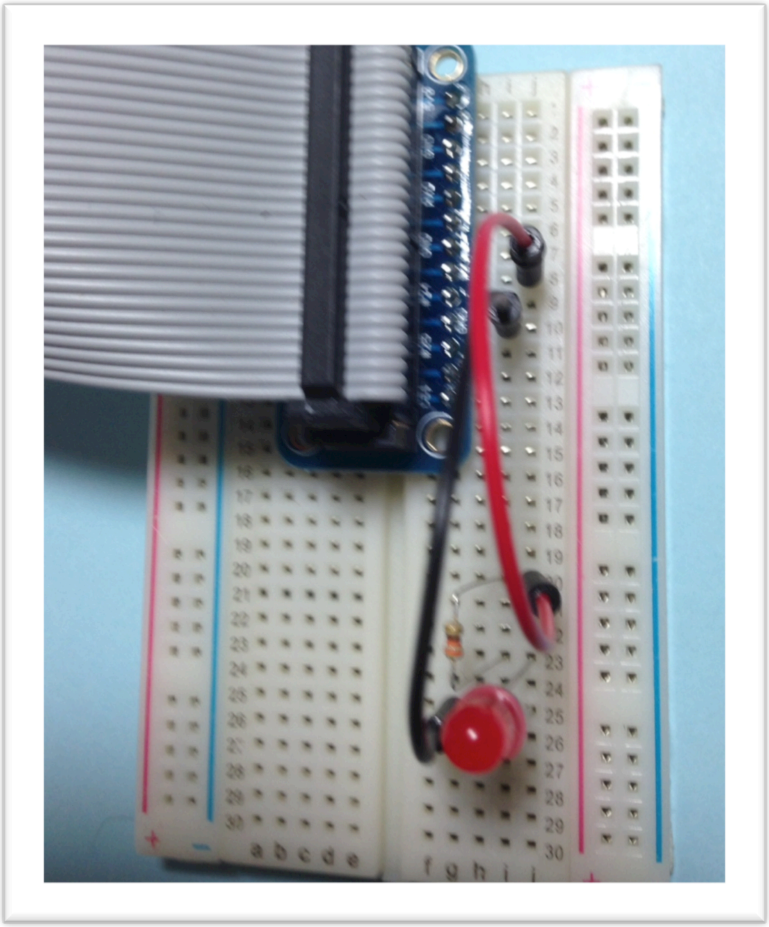
8) Time to test it! First, **please have your instructor check your wiring.** After the instructor checks your wiring power up the raspi by inserting the micro usb connector into the raspi. The LED lights! Congratulations you have wired your first electronic circuit! Unplug the raspi and onto your next adventure.

Lab 2: You Blinked!

In Lab 1 the raspi was used merely as a power source. We used none of its ability to actually control circuits. In this Lab you will program the LED to blink. There is a lot going on in this Lab, it provides the foundation for the rest of the Labs. First let's build the circuit we will use.

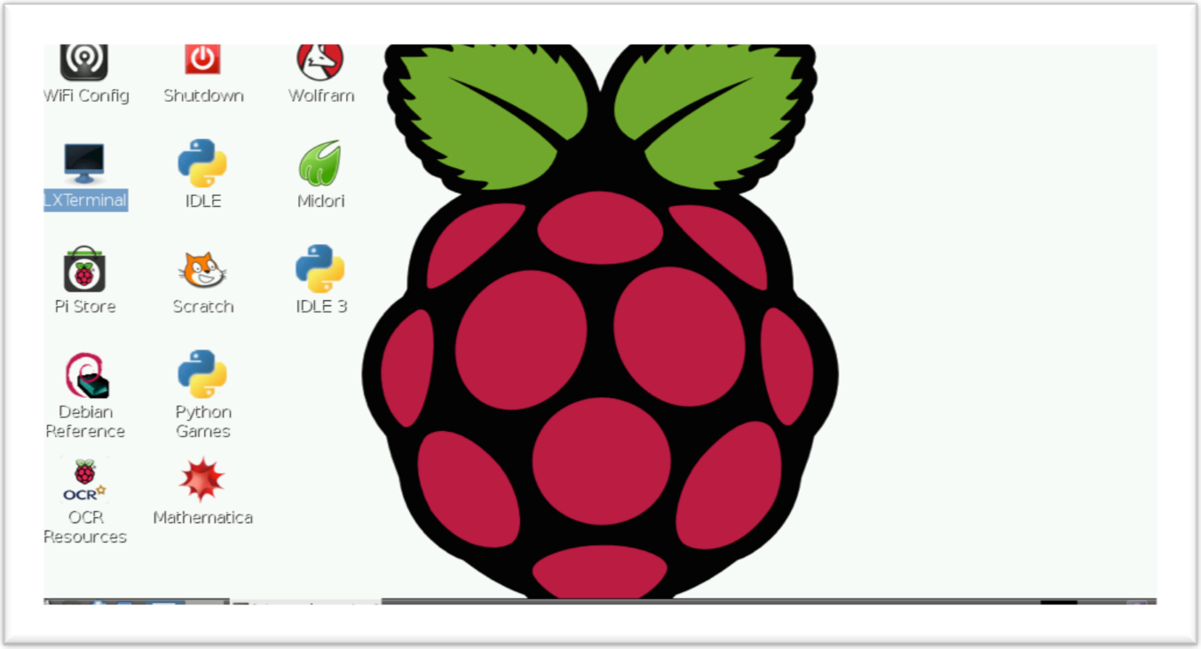
1) The parts are the same as the first Lab: a 330Ω resistor, an LED and a red and a black jumper wire. Ω is the symbol for ohms, the resistance value of a resistor that we discussed in Lab 1.
2) Wire the circuit exactly as you wired it in Lab 1 with one exception, instead of placing the red jumper leading from the resistor to (1,j) place the end to (8,j); this connects the power to a pin that can be controlled through the raspi by a

program. Your board should look like this:



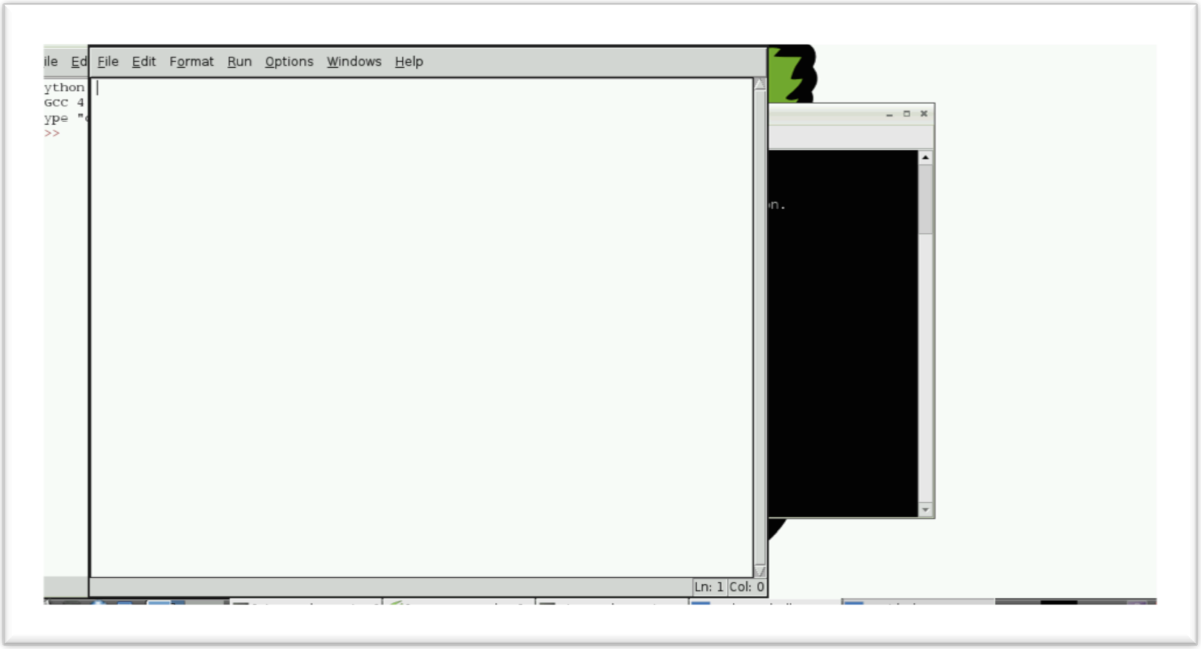
3) Have your instructor check your board. After the instructor checks it, plug in the power supply and wait for the computer to start. It will take a minute or so.
4) If everything goes fine you will get a login prompt. Type `pi` – note that whenever there is an entry on the screen I will use `this font`. You will now be prompted for a password. Ask your instructor for it if the instructor has not done so. If successful you should get the prompt: `pi@raspberrypi ~$.` At the prompt type `startx`. This command will take you from the command line interface of linux to the window interface of linux. Your

screen should look like this:

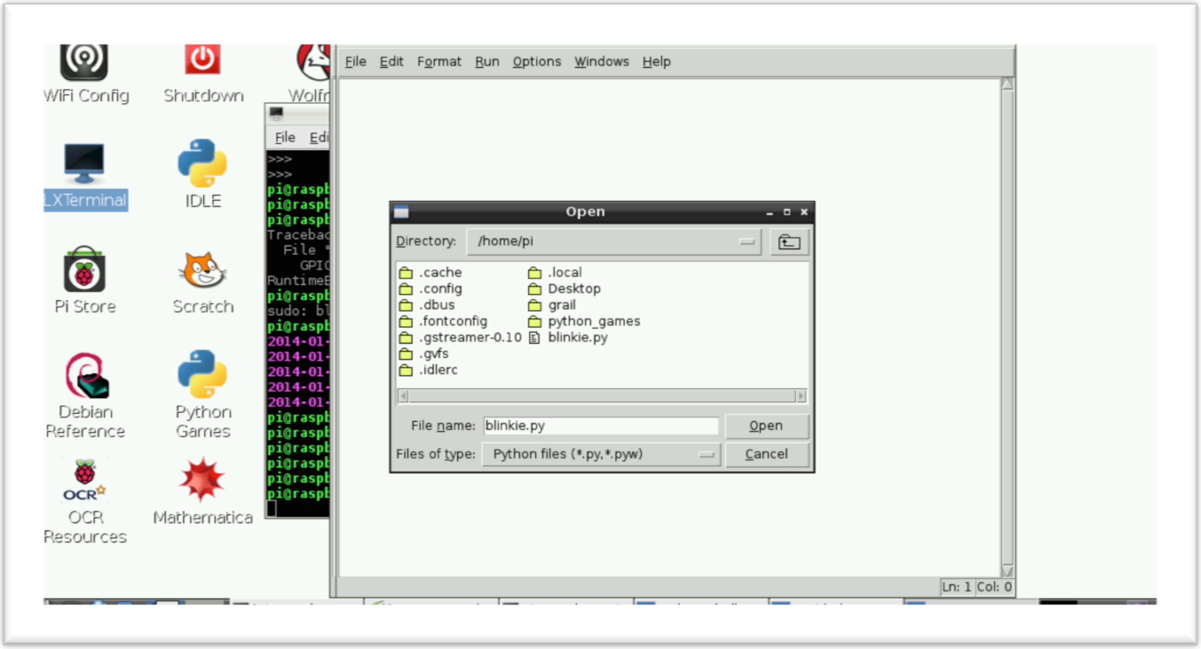


5) Time to start the programming environment. For all of our Labs we will be using the Python language and the IDLE programming environment. The Python language is a popular language that is used by students, educators and professional developers. Python was not named after a snake but after a British comedy group, Monty Python. One of their movies, *Monty Python and the Holy Grail* is on my top ten list. Back to programming. Point the mouse to LXTerminal, and double click quickly on it. This takes you into a command line window. Type `sudo idle` at the prompt and this will launch the Python programming environment. Point the mouse at the file menu item at the top of the window, click and then select "New Window." This will open an editor in the IDLE programming environment. If everything goes right

your screen should now look like this:



6) In order to save time, a partial version of the program blinkie.py has been prepared for you. Load it now by moving the mouse to the file menu and selecting "Open". Choose blinkie.py, and your screen should look like this:



```
Directory: /home/pi

.cache          .local
.config         Desktop
.dbus           grail
.fontconfig     python_games
.gstreamer-0.10 blinkie.py
.gvfs
.idlerc

File name:     blinkie.py
Files of type: Python files (*.py,*.pyw)
```

Select open and the program will display in a simple editor. Your task is to code two lines at the end of this program in the `for` loop. In the first line you must replace the question marks with instructions. You must write the complete second line, replacing the question marks on that line. Please note that Python is white space sensitive. The indentation of lines following the `for` command indicates that those lines belong within the `for` loop. When you think you have completed the program, ask your instructor to check it and then "Save" the file using the file menu and after the save completes, select the Run menu and choose "Run module". Watch the blinking light. Congratulations, with this new found skill you are ready to control the world through the raspi!

A bit on the program

The first part of any code is a description of what the code does. In Python # indicates that what follows on that line is text and is not to be interpreted as code. After describing the program, additional modules necessary for the operation of the program are loaded through the `import` command. The module can be renamed with the `as` command. The module `RPi.GPIO` renamed as `GPIO`, provides the program access to the pins on the computer that were wired on the breadboard. The module time provides the sleep command that permits the code to do nothing for a specified time, so that the LED will stay on or off for that interval.

The next section of the program sets up the environment for the blinking led. First set a variable, `repeat`, that indicates how many times the LED should blink. The next two lines talk about the code's interface to the breadboard. `GPIO.BOARD`, indicates that we are identifying the pins by the physical location of the pin on the interface board, not the name that the raspi board uses, which would be #23 and is labeled as such on the interface board. Given that the next line indicates the pin, 16. It is 16 because, facing the board the numbering starts at the upper left corner of the interface board as 1, the upper right corner as 2 and continues to alternate. Therefore all odd pin numbers are on the left hand side and even pins on the right hand side. The jumper wire was inserted in (8,j) which counting is 16. An easy way is just to double the row number to get the addressable pin number. Since the pin will be used to light theLEDit is an `OUT` port. If the port was used to collect a button press that the software would read it would be an `IN` port, since it would input data to the program.

This brings us to the `for` loop. The `for` loop is a way to repeat a set of commands for a specified number of times. As you learn Python, you will discover that there are many wondrous ways to specify this, but the current code uses a basic count variable which we set as `repeat`. Loops and other Python mechanisms end their description with a `:`. Usually that `:` will be followed by indented lines. The indentation indicates that those lines are part of the body of the `for` loop.
The first line in the body of the `for` loop turns on the LED by setting the pin to `HIGH`. `time.sleep` then sleeps, i.e., does nothing for the interval specified within the parentheses which indicates the number of seconds to sleep. The next two lines you contribute. What do you want to do next? Turn off the LED and wait. So if the LED is turned on by setting it to `HIGH` then turn off the LED by setting it to ???. It should then stay off for a time before it begins the next loop. The last command ensures that the program ends with all pins in a default state. Phew! Here's the code:

```
#
# blinkie.py, a program to blink an led
# based on a program by Rahul Kar
# http://www.rpiblog.com
#
# add some essential modules
#

import RPi.GPIO as GPIO
import time

#
# GPIO provides access to the board pins
# from the program.
# time provides us with a sleep capability
# so that we can add a delay
#

repeat = 60

#
#indicates how many times to blink
#

#
#setup board access
#

GPIO.setmode(GPIO.BOARD)
GPIO.setup(16, GPIO.OUT)

for i in range(0,repeat):
    GPIO.output(16, GPIO.HIGH)
    time.sleep(1)
    GPIO.output(16, GPIO.LOW)
    time.sleep(1)

#
#cleanup
#
GPIO.cleanup()
```

Lab 3: Help!

In this Lab we will use all we have learned to this point to send a distress message to the world. An international indicator of distress is SOS, the acronym has been described as an abbreviation for "Save Our Souls", "Save Our Ship" or even "Send Out Succour"! More on the history of SOS can be found in wikipedia. Our task is to use the LED to send out a constant SOS to the world. The way we will do this is to vary the duration of the blinks and that can be used to send Morse Code.

Morse Code transmits information as a series of on-off lights, tones, clicks of a certain duration. It has been around since the mid 1800s and is still in use today. Again Wikipedia has an excellent article on its history.

Letters in Morse Code are sent as a series of dots (sometimes called dits) and dashes. A dash is 3 times longer than a dot. Letters are a collection of dots and dashes. The morse code for a S is 3 dots, and for an O is 3 dashes. A dash is 3 times longer than a dot. There are also specific pauses between dots and dashes, letters and words to indicate the various separators. This table summarizes the relationship:

Element	**Units of duration**
dot	1
dash	3
Pause between dot or dash	1
Pause between letters	3
Pause between words	7

So our goal in this program is to have the board, through the led, send out a continuous SOS signal.

1) First check the board. If you have not done so wire the board as in Lab 2.
2) Now start a new IDLE session by typing `sudo idle` at the command line. When the IDLE screen appears, select "File" with your mouse and then select "New Window". When the Window appears, select File and then Open with your mouse and load the sos.py file.
3) In this programming task you must code the S, O and SOS Python functions. Ask your instructor if you are having difficulty.
4) When you think you have completed the program, ask your instructor to check it and then "Save" the file using the file menu and after the save completes, select the Run menu and choose "Run module". Now just wait until help comes to Save Our Ship!

A bit on the code

This code builds on the code of blinkie.py. The new thing introduced is functions. A function provides a way to capture code that is used frequently. A function should represent one task. In this case our tasks were building dits, dashes, pauses, letters and a word, SOS. Functions can be built from other functions and this becomes a very powerful tool. In Python we define a function by starting with the special word `def`, then name the function (the name should be a clear indication of what it does) and then provide a list of zero or more arguments, items that you want the function to use. In this case we always passed `unit`, which was the duration of one sleep unit, later set to 0.1 or a tenth of a second. The identifying line of the function ends with a `:` signifying that the indented lines that follow belong with the function. `return` indicates the end of each of these functions. In Python you do not have to use `return` to end a function but I think it is useful, especially in Python, since otherwise the end is indicated by lack of indentation. `return` can also return values to a calling module but that is beyond this Lab!

One final aspect to this program is the `while True:` statement. This provides a way for us to loop until the program is interrupted. Stop the program by selecting "Exit" in the file menu. In effect the loop can go on forever since a while body loops if the condition is `True`. Since the condition in this case is `True`, it always loops. Using `while True` is a convenient way for waiting an indeterminate amount of time for input. In this case our rescue ship home! Here's the code for the Lab:

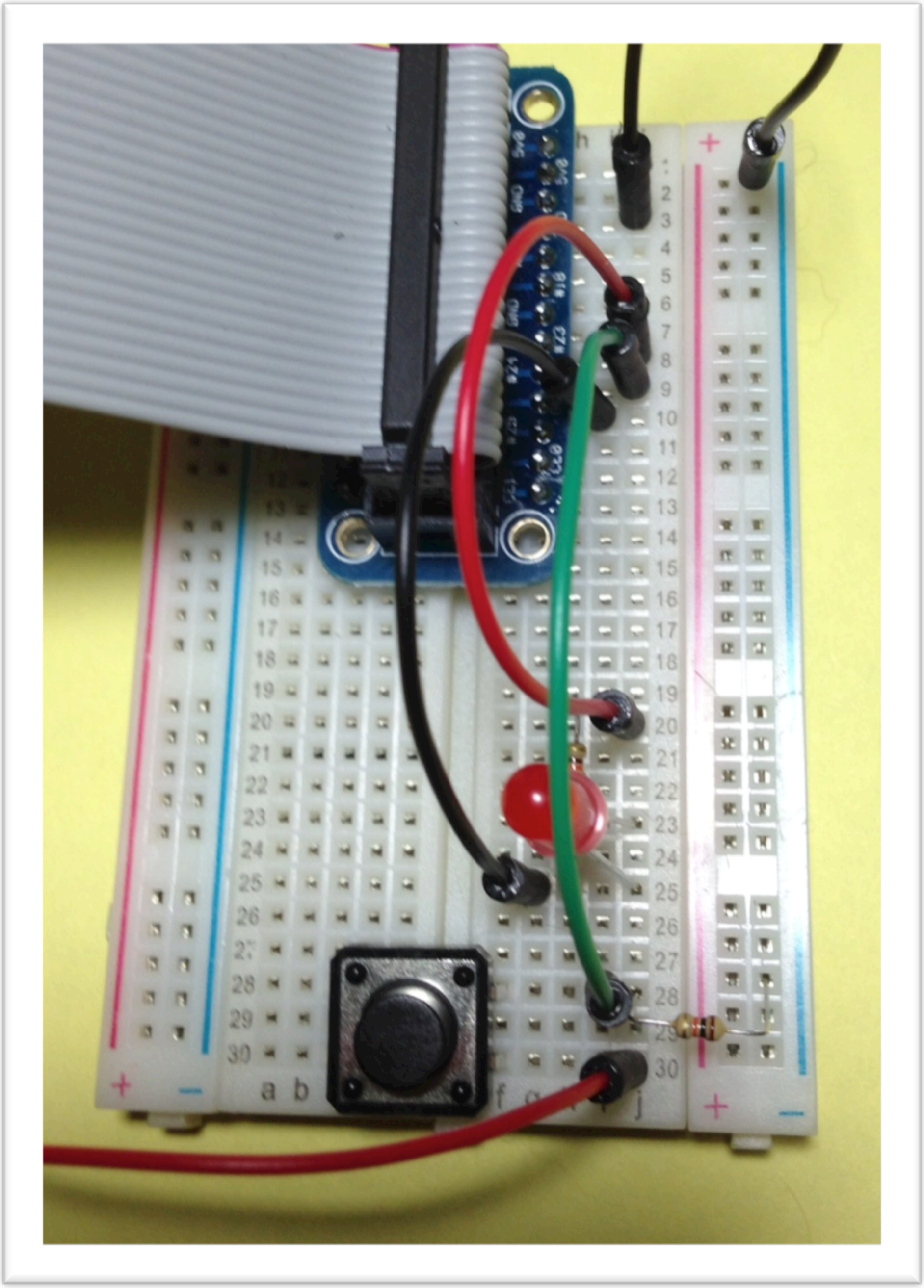
```
#
# sos.py
# program to do morse code
#
# import necessary libraries.
# GPIo accesses the ports of Raspi
# time provides us with sleep
#

import RPi.GPIO as GPIO
import time

#
# morse code info
# sos in morse code is:
# ... --- ...
# dashes are 3 times longer than
# dit. 1 unit space within a letter
# 3 unit space between letters,
# 7 unit space between words
#

repeat = 50
pin = 16
GPIO.setmode(GPIO.BOARD)
GPIO.setup(pin,GPIO.OUT)

#
# define dit (dot)
#

def dit(unit):
    GPIO.output(pin, GPIO.HIGH)
    time.sleep(unit)
    GPIO.output(pin, GPIO.LOW)
    time.sleep(unit)
    #pause between elements of a letter
    return

def dash(unit):
    GPIO.output(pin, GPIO.HIGH)
    time.sleep(unit * 3)
    #dash is 3 times dit
    GPIO.output(pin, GPIO.LOW)
    time.sleep(unit)
    #pause between elements of a letter
    return

def letter_pause(unit):
    time.sleep(unit * 2)
    # why 2? each unit has a pause
    # at end, just add 2 more
    # to make it 3.
    return

def word_pause(unit):
    time.sleep(unit * 6)
    # again accommodating
    # unit pause
    return

def s_letter(unit):
    #code S
    return

def o_letter(unit):
    #code O
    return

def sos(unit):
    #code SOS
    return
#
# for ever
#

while True:
    sos(0.1)

#
#time to cleanup
#


GPIO.cleanup()
```

Lab 4: Make it So(s)

The last lab demonstrated that software can affect physical devices and use them to send information. But how can humans send information to the raspi? In the first labs we demonstrated output to the physical world but what about input from the physical world. This lab demonstrates simple input to the raspi. In this lab we will wire a button to the raspi and when the button is pushed the raspi will begin sending SOS. Now we can control when the SOS message is sent. So our goal is to wire and add software so that an SOS is sent only when we want it to be, when Captain Picard wants us to "make it so(s)."

1. Start with the circuit from Lab 3 (actually Lab 2).
2. In this lab we will add more to the breadboard. Our parts list is:
   - 1 button
   - 3 jumpers, 1 long red, 1 green and 1 black
   - 1 10,000 Ω resistor (bands are brown, black, orange)
3. The button fits in the circuit board in only 2 possible ways, either would be correct. Have the button straddle the channel in the middle of the board. The pins should be plugged into (30,f), (28,f), (30,c) and (28,c). It is important to place it there to ensure that when you press the button you do not disturb the other wiring.
4. Next take the long red jumper, insert it first in (30,j) and insert the other end in slot (1,a); you may have to lift the ribbon cable. Slot (1,a) is connected to one of the 3.3v pins on the breakout board. This connects one side of the button to the 3.3v.
5. Take a green jumper and insert it first in slot (28, i) and then in slot (9,j). This connects the button to pin 18 on theboard.
6. Take the 10,000 Ω resistor and insert one leg in (28,j) and the other leg to the right, same row ,in the blue minus column (28,-) if you will.
7. Take the black jumper insert one end in (3,j) and the other in (1,-). This provides ground from the raspi to the ground row, making it a true ground row.
8. All of this was to wire the button. We first attached one leg of the button to power (step 3) and the other leg of the button to both ground and pin 18 on the breadboard (steps 4-6). When the button is pressed a circuit is established and current flows to pin 18 pulling it high, indicating a button press. The resistor was part of the circuit to protect pin 18. Your finished

board should look like this:



Coding Task

Have your instructor check your circuit before you plug in the raspi! Your coding task is to first complete the `GPIO.setup` for the button and then construct the loop that tests for the button push and if pushed signals SOS. As always, do not read "A bit on the code" until you have completed your Lab.

A bit on the code

This project is interesting for several reasons. First, let's discuss the hardware setup (yes I know it is not code but it affects the code). This is the first Lab where the board is crowded due to the number of elements, mostly jumper wires. You should think carefully about placement of the elements on the board, both to make it easy on the user and ensure that the user cannot inadvertently damage the setup. One nod to this was placing the button at the bottom and trying to move jumpers away from the button. There is a way to implement a cleaner design involving the large, red jumper connecting 3.3 volts. Do you have any suggestions to improve it?

The current design sacrifices simplicity of the board setup for simplicity in the code. Note that the `GPIO.setup` line was fairly straightforward, as was the loop, requiring only one more line, an `if` statement. The `if` statement itself was fairly simple, the trick was using white space appropriately to signify the bodies of both the `if` and `while` statements. There was an alternate design that simplified the breadboard setup and used the built-in, software controlled resistors of the raspi. This alternate design had an obtuse declaration, `GPIO.setup(button_pin, GPIO.IN, pull_up_down = GPIO.PUD_UP)`, to setup the software controlled resistors in the raspi. Similarly the loop involved a body element that also is more complex: `GPIO.wait_for_edge(button_pin, GPIO.RISING)`. The explanation for this line of code is beyond the scope of this course , but it involves waiting for the initiation of a change in state of the signal from the button. Our experiments also indicated that using the hardware resistor resulted in a more accurate detection of the button press.

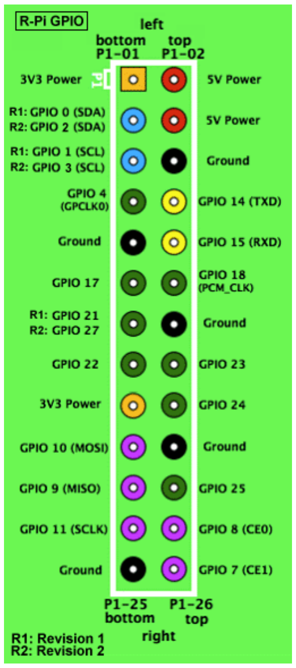
The new code construct introduced in this Lab was the `if` statement. The `if` statement involves testing the condition after the `if` to determine whether it is `True` (the logical elements `True` and `False` in Python begin with a capital T and F). If it is True, as in not zero, then the body of the if statement is executed, else the body is ignored and it proceeds to the next statement after the body. In our example, `if GPIO.input(button_pin):`, if `GPIO.input` returns a value greater than 0 indicating the switch is pressed, the body of the `if` is executed, `sos(0.1)`, if not the control passes to the `while` loop and the `if` is tested yet again. The next statement after the body of an `if` statement can be an `else` statement or an `elif` (else if) which can perform further tests on variables or values. For experienced language folks, `elif` can simulate switch or case statements in other languages. In this example an `if` was sufficient. Here's the code for the Lab:

```
#
#alarm.py
# program to activate
# sos on a button press
#
# import necessary libraries.
# GPIo accesses the ports of Raspi
# time provides us with sleep
#

import RPi.GPIO as GPIO
import time

#
# morse code info
# sos in morse code is:
# ... --- ...
# dashes are 3 times longer than
# dit. 1 unit space within a letter
# 3 unit space between letters,
# 7 unit space between words
#
# set up GPIO ports
# button_pin will control
# button using pin 18
#

led_pin = 16
button_pin = 18
GPIO.setmode(GPIO.BOARD)
GPIO.setup(button_pin, GPIO.IN)
GPIO.setup(led_pin,GPIO.OUT)

#
# define dit (dot)
#

def dit(unit):
    GPIO.output(led_pin, GPIO.HIGH)
    time.sleep(unit)
    GPIO.output(led_pin, GPIO.LOW)
    time.sleep(unit)
    # pause between elements of a letter
    return

def dash(unit):
    GPIO.output(led_pin, GPIO.HIGH)
    time.sleep(unit * 3)
    #dash is 3 times dit
    GPIO.output(led_pin, GPIO.LOW)
    time.sleep(unit)
    # pause between elements of a letter
    return

def letter_pause(unit):
    time.sleep(unit * 2)
    # why 2? each unit has a pause
    # at end, just add 2 more
    # to make it 3.
    return

def word_pause(unit):
    time.sleep(unit * 6)
    # again accommodating
    # unit pause
    return

def s_letter(unit):
    dit(unit)
    dit(unit)
    dit(unit)
    return

def o_letter(unit):
    dash(unit)
    dash(unit)
    dash(unit)
    return

def sos(unit):
    s_letter(unit)
    letter_pause(unit)
    o_letter(unit)
    letter_pause(unit)
    s_letter(unit)
    word_pause(unit)
    return
#
# for ever
#
while True:
    if GPIO.input(button_pin):
     while True:
                sos(0.1)
#
# time to cleanup
#


GPIO.cleanup()
```

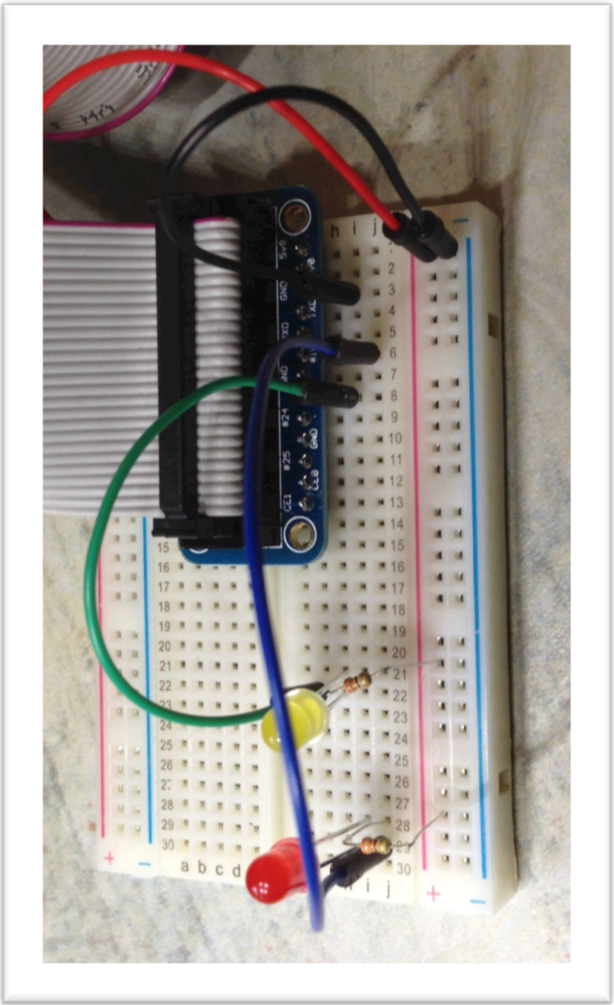
Lab 5: Was it a Dit or Dah?

One challenge with using Morse Code to send messages is that it depends on your potential rescuers differentiating between a dot/dit and a dash/dah. This is further complicated by the fact that if your raspberry pi is doing a lot of other tasks, sleep becomes less accurate and dots may be elongated to look closer to dashes. One way to combat that is to use redundant cues providing multiple ways to determine a dot or a dash. This Lab will do just that.

The wiring for this Lab will be different from the previous labs. The wiring of the first four Labs was simplified to ease the patient reader into electronics. The key simplification was that we were relying on the raspi control pins to provide the power. Since in this Lab we will have more power needs, we are shifting to a more conventional wiring of our breadboard with a "separate" power source. We are using the power pins from the raspberry pi to provide us with power. The raspberry pi has two sources of power, 3.3 volts and 5 volts. This should be clear from this diagram from http://elinux.org/RPi_Low-level_peripherals:



These pins correspond to the pin placement on the breakout board on the breadboard. So, referring to the numbering scheme describe in Lab 1, 3.3 volts are available from pin 1 and pin 17 and 5 volts is available from pins 2 and 4. This Lab will use 3.3 volts. In order to easily access the 3.3 volts we will use the power and ground columns on the right hand side of the board. The entire circuit photo is provided for reference as the wiring proceeds.



1. Check that the the raspberry pi is not connected to power. Start with a bare breakout board, breadboard.
2. Unlike the 5 row columns on either side of the divide of the breadboard, the 2 separate columns on each end are linked electrically not by row, but by column. Therefore when power is provided to the "+", red row (1,+) in our notation, (2,+) to (30,+) can provide power. Similarly if (1,-) is grounded, (2,-) to (30,-) provides ground. Therefore we establish power and ground b, on the left hand side using breadboard pin 1, left hand side(1, a) and connecting it to right hand side (1,+). It is best to use a red or orange jumper to do this. Note the remainder of the connections will be on the right hand side. Ground will be established by connecting (3,i) to (1,-).
3. Place the yellow LED with the positive (longer) leg in (21,h) and the negative in (22,h). Place a 330Ω resistor leg in (21, j) and the other end of the leg in (21,+). Place one end of a green jumper in (22,g) and the other end of the jumper to (8,i), connecting the yellow LED to pin 12.
4. Place the red LED with the positive leg in (28,i) and the negative leg in (29,i). Place a 330Ω resistor leg in (28,j) and the other leg in (28,+). Place one end

of a blue jumper wire in (29,j) and the other end in (6,j) connecting the red LED to pin 16.

Coding Task

Have your instructor check the circuit. Power up the raspberry pi, startx and then launch a shell window and `sudo idle`. Your coding task is to add the code to operate the second LED and code the loop for it. Note the duration of sleep provided by the loop may need to be altered a bit.

A bit on the code

The code for this task adds no new coding constructs but it does add some logic twists in controlling items on the breadboard. Since two LEDs are now powered, the trickle of power the logic pins could provide was inadequate. We had to add power to the circuit and rely on the pin to complete the circuit when commanded by linking ground and closing the circuit. Therefore to close the circuit the pin needed to be pulled `LOW` and to open the circuit and turn off the light, it was pulled `HIGH`.

```
#
# sosry.py
# program to do morse code
# and provide redundant cues
# for dot and dash using yellow
# and red LEDs
#
# import necessary libraries.
# GPIo accesses the ports of Raspi
# time provides us with sleep
#

import RPi.GPIO as GPIO
import time

#
# morse code info
# sos in morse code is:
#  ... --- ...
# dashes are 3 times longer than
#  dit. 1 unit space within a letter
# 3 unit space between letters,
# 7 unit space between words
#
repeat = 50
pin = 12
#
# setup pin 2
#
# establish 2 pins
# to control LEDs
#
```

```
GPIO.setmode(GPIO.BOARD)
GPIO.setup(pin,GPIO.OUT)
GPIO.setup(pin2,GPIO.OUT)
#
# define dit (dot)
# note that LOW and HIGH
# have reversed, pulling
# pin LOW provides power
#
def dit(unit):
    GPIO.output(pin,GPIO.LOW)
    time.sleep(unit)
    GPIO.output(pin,GPIO.HIGH)
    time.sleep(unit)
    #pause between elements of a letter
    return

def dash(unit):

#
#define dash
#

def letter_pause(unit):
    time.sleep(unit * 2)
    # why 2? each unit has a pause
    # at end, just add 2 more
    # to make it 3.
    return

def word_pause(unit):
    time.sleep(unit * 6)
    # again accommodating
    # unit pause
    return

def s_letter(unit):
    dit(unit)
    dit(unit)
    dit(unit)
    #code S
    return

def o_letter(unit):
    dash(unit)
    dash(unit)
    dash(unit)
    #code O
    return
```

```
def sos(unit):
    s_letter(unit)
    letter_pause(unit)
    o_letter(unit)
    letter_pause(unit)
    s_letter(unit)
    word_pause(unit)
    #code SOS
    return
#
# for ever
#

#
# define loop
#

#
# time to cleanup
#


GPIO.cleanup()
```

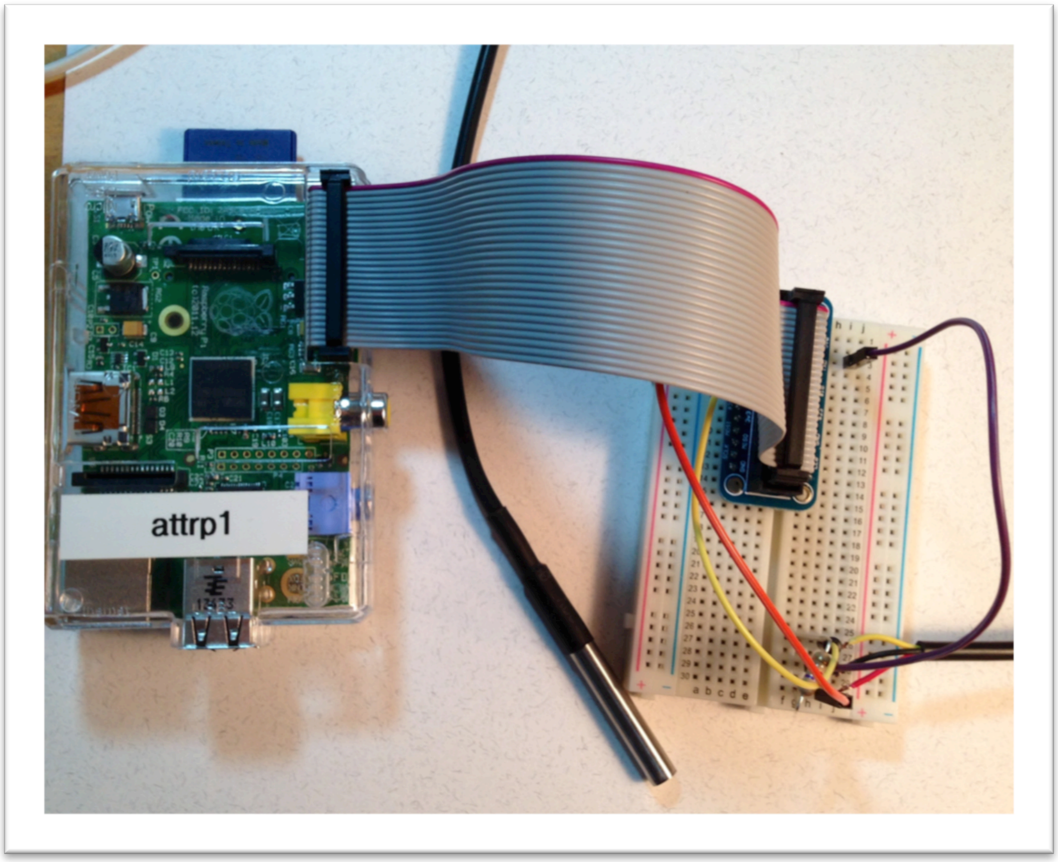
Lab 6: Sensored!

This lab explores reading sensors. It requires a bit more sophistication including comfort with command line computing, intricate, delicate wiring and some familiarity with python. The objective of this lab is to connect and read a digital temperature sensor.

Let's wire the breadboard first. The parts list:

- 3 jumper wires, red, yellow and black, if possible
- DS18b20 waterproof digital temperature sensor
- 4.7K Ω resistor (yellow, purple, red)

Follow these wiring directions carefully and make sure that your raspberry pi breadboard combination is disconnected from power.



1. Connect the digital temperature sensor to the breadboard. Do this carefuly since the wires are fragile and stranded. Place the red wire in (30,j), the black wire in (28,j) and the yellow wire in (26,j).
2. Place one end of the red jumper in (30,i) and the other end in (1,a). This connects the temperature sensor to 3.3 volts.
3. Place one end of the black jumper in (28,i) and the other end in (3,i). This connects the temperature sensor to ground.
4. Place one end of the yellow jumper in (26, i) and the other end in (4,a). This connects the temperature sensor to pin 4 on the GPIO bus. Note it is very important that it is attached to pin 4.
5. Finally place one end of the resistor in (26,g) and the other end of the resistor in (30,g).
6. Make sure that subsequent steps did not loosen any connections especially the connections of the temperature sensor to the breadboard.

Command Line Work

This lab requires some command line work. Connect the raspberry pi to power and once logged in, `startx` to the window interface and start an LXTerminal session. Follow these steps at the command line

1. Type `sudo modprobe w1-gpio` and `return`

2. Type `sudo modprobe w1-therm` and `return`
3. Type `cd /sys/bus/w1/devices` and `return`
4. Type `ls` and `return`
5. Note the numeric file name, this is the serial number of the sensor and we will use it to communicate with it.
6. Cd to the serial number file name, e.g., `cd 28-000006087458` and `return`
7. Type `cat w1_slave` and `return`
8. The last item on the second line returned t=28250 provides the temperature in centigrade, once you divide the number by 1000.

The previous steps were required to obtain the sensors serial number that you will use in the code. Attached is the code provided in temper.py in your home directory. This python code provides access to reading the probe. You must modify and add to this code. First replace the serial number with the correct serial number. Second place the temperature reading mechanism in a loop, so that it can constantly report the temperature at 10 sec intervals. Finally provide the code that converts the centigrade temperature to Fahrenheit. If you forget (I did) the formula is:

*Temp-centigrade *(9/5) +32*

The code provided is:

```
#
# temper.py - python temperature sensor
# program adopted from University of Cambridge
# Computer Laboratory.
#
import time
#
# enables sleep
#
tfile  = open ("/sys/bus/w1/devices/28-000006087458/w1_slave")
#
# read the file
# note that the number 28-...
# may be different and you acquire
# that from your command line
# investigations
#


#####
##### you will need a loop
#####

text = tfile.read()
tfile.close()
```

```
#
# discard the first line
#

secondline = text.split("\n")[1]

#
# dissect the second line
#

temperaturedata = secondline.split(" ")[9]

temperature = float(temperaturedata[2:])

####
#### prints out as centigrade/celsius, convert
#### to fahrenheit.  I know, but it is traditional!
####
print temperature/1000.0

time.sleep(10)
```

A bit on the code

This program illustrates file i/o and string manipulation. Python is particularly adept at string manipulation which makes it a wonderful choice for many applications, including social media analysis, big data, web apps and with the addition of other data structures (e.g., lists, tuples, sequences, …), artificial intelligence.

The command line manipulations were made possible by a hack to the linux kernel which bypassed some of the GPIO maneuvers we used in previous labs.

Lab 7: sudo? sure don't?

This lab is quite different from the others and it requires a fairly deep understanding of linux. There also is no structure for this lab, just a problem and some constraints for the solution. If you review any of the previous exercises you will note that we must use `sudo`, that is, become root, to access the raspberry pi's pins. This is not a best standard security practice. We should use root and `sudo` sparingly since it increases the hacking risk.

Your challenge is to find a way to access the raspberry pi's pins using python without being root. You can use root to set up the appropriate infrastructure. There are several solutions available at this time but they are far from ideal. Hint: most of the solutions require changes in permissions and some use chron. Success is measured as running the blinkie program (Lab 2) without using sudo. Good luck!

Summing Up

We hope you enjoyed these Labs and that it encourages you to explore Python, electronics and the raspi. There are many more single board computers and electronic components to explore. The website http://aarphacker.com will provide all the written materials and code for this course and also be a source for other resources to continue your exploration.

Thanks

I would like to thank all the experimenters on the web who provided insight into the marvels of python and the raspi. This includes:

- http://www.rpiblog.com
- https://www.cl.cam.ac.uk/projects/raspberrypi/tutorials/
- https://learn.adafruit.com/category/raspberry-pi
- https://projects.drogon.net/raspberry-pi/gpio-examples/tux-crossing/gpio-examples-1-a-single-led/

I would like to thank Kathy Vesonder for carefully reviewing this code for clarity, consistency, grammar and common sense.