ECE 476/676 - Homework #3

Binary Outputs, Binary Inputs - Due Monday, September 15th

Transistor Switch

1) Write a Python program which turns on

- GP16 (LED), and
- GP18 (not used at present)

when button GP15 is pressed, and turns these pins off when GP15 is released.

Collect data to verify your Python program is working correctly.

```
from machine import Pin
from time import sleep_ms

B15 = Pin(15, Pin.IN, Pin.PULL_UP)
B14 = Pin(14, Pin.IN, Pin.PULL_UP)

D16 = Pin(16, Pin.OUT)
D18 = Pin(18, Pin.OUT)

while(1):
    if(B15.value() == 0):
        D16.value(1)
        D18.value(1)
    else:
        D16.value(0)
        D18.value(0)
    sleep_ms(1)
```

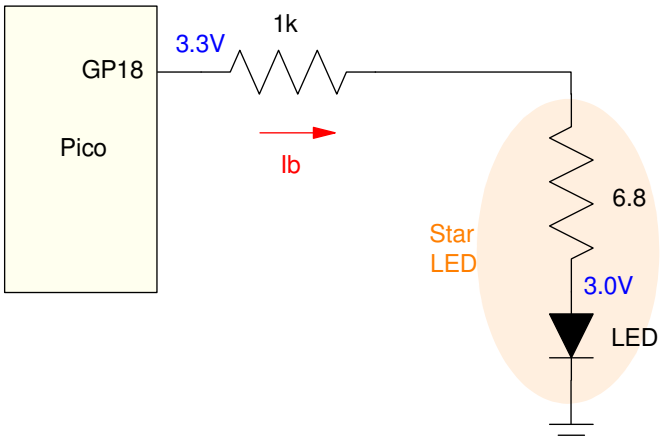
Validation:

- Press GP15
  - LED 16 turns on
- Release GP15
  - LED 16 turns off

2) The Star LED in your lab kit is a 1W LED with a built-in 6.8 Ohm resistor

- Rd = 6.8 Ohms (hard-wired in series with the LED)
- Vd = 3.0V @ 330mA
- 200 Lumens @ 330mA

Design a circuit which turns on and off the 1W white LED in your lab kit at 10mA when GP18 goes high and low.



To limit the current to 10mA

$$(R + 6.8) = \left(\frac{3.3V - 3.0V}{10mA}\right)$$

$$R = 23.2\Omega$$

I don't have a 23.2 Ohm resisor, so let's use a 1k resistor instead

$$I_b = \left(\frac{3.3V - 3.0V}{1k\Omega + 6.8\Omega}\right) = 298\mu A$$

The Pico is capable of 12mA, so this should work

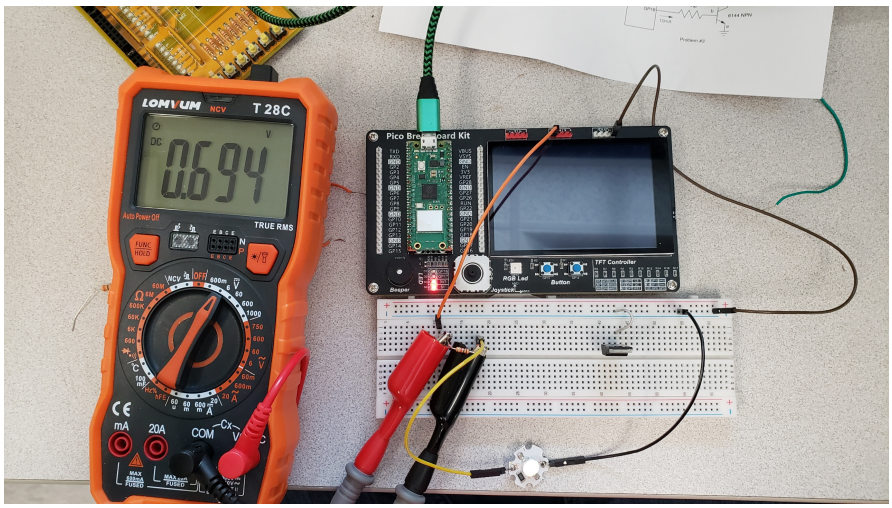
Verify that the LED is turning on and off with GP18:

- LED turns on (faint, but on)

Measure the current when the LED is on:

	Calculated	Measured
Vd (LED voltage)	3.0V @ 330mA	2.566V
Id (LED current)	298uA	694uA

note: The voltage drop across the LED is a little less. It's not an ideal diode.



3) Design a circuit which turns on and off the 1W white LED at 5V when GP18 goes high and low.

- Circuit to the right
- Pick Rb so that the transistor saturates

Start with Ic:

$$I_c = \left(\frac{5V - 3.0V - 0.2V}{6.8\Omega}\right) = 264.7mA$$

To saturate

$$\beta I_b > I_c$$

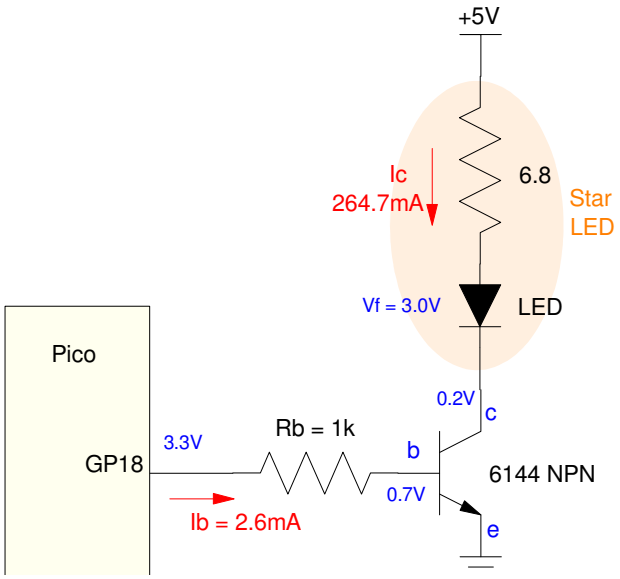
$$I_b > \frac{264.7mA}{200} = 1.32mA$$

A 1k resistor for Rb results in 2.6mA (more than enough to saturate the transistor)

$$R_b = 1k\Omega$$

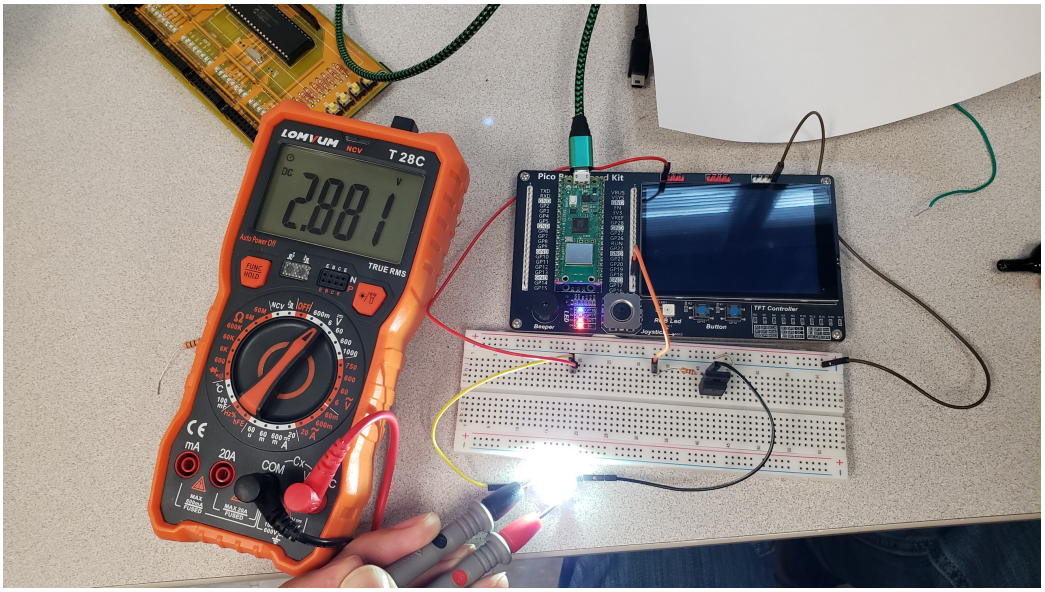
$$I_b = \left(\frac{3.3V - 0.7V}{1k}\right) = 2.6mA$$

$$I_b > 1.32mA \quad \text{(saturated)}$$



Verify that the LED turns on and off when GP18 goes high and low

	Calculated	Measured
Vbe	700mV	726mV
Vce	200mV	20mV
Vd (LED voltage)	3.0V @ 330mA	2.881V
Id (LED current)	264.7mA	195.4mA



Strobe Light (take 1)

4) Write a Python program which

- Prompts you for the period of a strobe light in ms, then
- Turns on the 1W white LED for 1ms
- Then off for N-1 ms where N is the period in ms.

```
from machine import Pin
from time import sleep_ms

B15 = Pin(15, Pin.IN, Pin.PULL_UP)
B14 = Pin(14, Pin.IN, Pin.PULL_UP)

D16 = Pin(16, Pin.OUT)
D18 = Pin(18, Pin.OUT)

while(1):
    Toff = int( input('Off Time (ms): ') )
    while(B14.value()):
        D16.value(1)
        D18.value(1)
        sleep_ms(1)
        D16.value(0)
        D18.value(0)
        sleep_ms(Toff)
```

5) Run your program on your Pico board and collect data to verify it works.

The shell window prompts you for the off time

When you press Button 14, it prompts you again

```
>> %Run -c $EDITOR_CONTENT

MPY: soft reboot
Off Time (ms): 999
Off Time (ms): 99
Off Time (ms): 9
Off Time (ms): 1999
```

At 999ms, the period is 1 second

At 1999ms, the period is 2 seconds

Strobe Light (take 2)

6) Write a Python program which
   - Turns on the 1W white LED for 1ms, and
   - Turns it off for N ms

Where N is adjustable using the buttons GP14 and GP15

- GP15 increases N
- GP14 decreases N

```
from machine import Pin
from time import sleep_ms

B15 = Pin(15, Pin.IN, Pin.PULL_UP)
B14 = Pin(14, Pin.IN, Pin.PULL_UP)

D16 = Pin(16, Pin.OUT)
D18 = Pin(18, Pin.OUT)

Ton = 1
Toff = 999

while(1):
    if(B14.value() == 0):
        Toff = int(Toff * 0.9)
    if(B15.value() == 0):
        Toff = int(Toff * 1.1)
    D16.value(1)
    D18.value(1)
    sleep_ms(Ton)
    D16.value(0)
    D18.value(0)
    sleep_ms(Toff)
```

7) Run your program on your Pico board and collect data to verify it works.
   - Add print statements to show the on/off times as you hold down buttons 14 and 15

```
Ton =  1     Toff =  999
Ton =  1     Toff =  999
Ton =  1     Toff =  999
Ton =  1     Toff =  999
Ton =  1     Toff =  999
Ton =  1     Toff =  1098
Ton =  1     Toff =  1207
Ton =  1     Toff =  1327
Ton =  1     Toff =  1327
Ton =  1     Toff =  1327
Ton =  1     Toff =  1194
Ton =  1     Toff =  1074
Ton =  1     Toff =  966
Ton =  1     Toff =  869
Ton =  1     Toff =  782
Ton =  1     Toff =  703
Ton =  1     Toff =  632
Ton =  1     Toff =  568
```

Demostration

8) Demonstrate either working program