ECE 376 - Test #1: Name ______________________

September 21, 2017

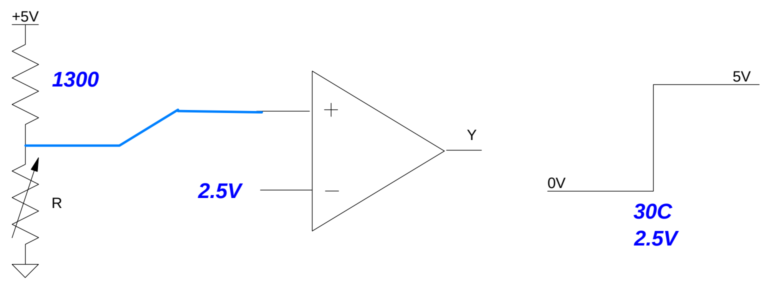
1**) Hardware: Digital Inputs.** A temperature sensor has the following resistance where T is degrees C

$$R = 1000 \cdot (1 + 0.01T)\Omega$$

1a) Design a circuit which outputs 5V when the temperature is more than 30C

At 30C, R = 1300 Ohms. Let the resistor in the voltage divider be 1300 Ohms so you switch at 2.5V.

$$V_{30C} = \left(\frac{1300}{1300+1300}\right)5V = 2.5V$$



As temperature goes up, R goes up and V goes up. Connect to the + terminal so that when really hot, Vo = 5V.

1b) Design a circuit whose output

- Becomes +5V for T > 30C
- Becomes 0V for T < 20C

At 20C

- R = 1200
- Va = 2.4V

When it's really hot

- R is large
- Vin is large
- Vout is large

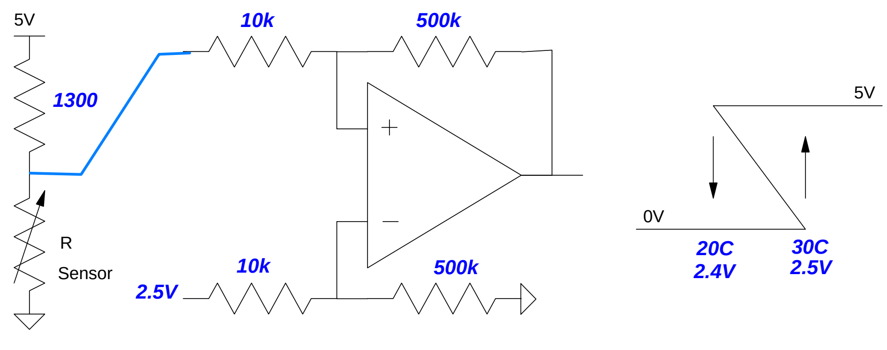
Connect to the + input.

The gain you need is

$$gain = \left(\frac{5V-0V}{2.5V-2.4V}\right) = 50$$

Pick the resistors in a 50:1 ratio

When the output is 0V, you switch at 2.5V (30C). The offset is 2.5V



2) Hardware: Digital Outputs. Assume

- The PIC can output 0V or +5V, capable of sourcing or sinking up to 25mA.
- A transistor is available with a gain of 200 (if needed)
- 3W white LED with Vf = 3.0V @ 100mA @ 30 Lumen

2a) Design a circuit so that a PIC can turn on and off the LED at 10mA

The PIC can drive the LED dirctly since it needs less than 5V and less than 25mA.

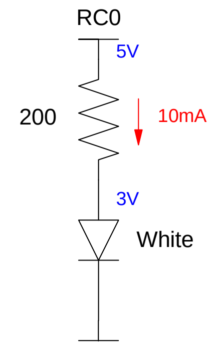
The PIC outputs +5V when logic 1.

The LED drops +3V when on.

The remaining 2V is across the resistor.

To get 20mA

$$R = \frac{2V}{10mA} = 200\Omega$$



2b) Design a circuit so that a PIC can turn on and off the LED at 100mA

The current is more than a PIC can output: you need to use a transistor.

Vcc: Pick anything more than 3.2V. +5V is usual since you have a +5V supply on your PIC board.

Rc: To set the current to 100mA, note that the resistor has a 1.8V drop across it:

$$R_c = \frac{1.8V}{100mA} = 18\Omega$$

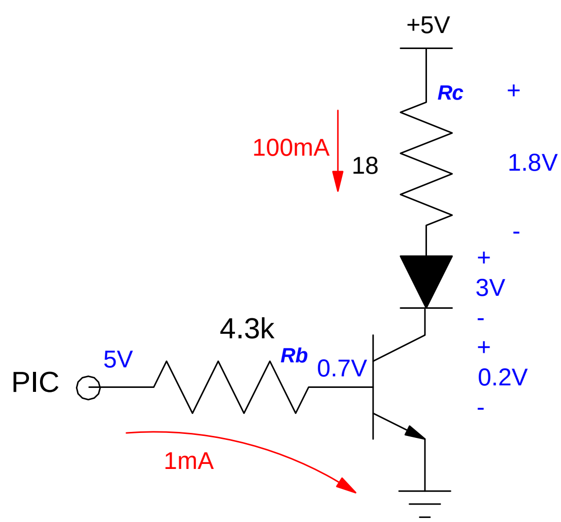
Rb: To saturate the transistor

$$\beta I_b > I_c$$

$$I_b > \frac{100mA}{200} = 0.5mA$$

(but less than 25mA since that's all the PIC can output). Let Ib = 1mA

$$R_b = \left(\frac{5V - 0.7V}{1mA}\right) = 4.3k\Omega$$



3a) Assembler: Determine the number of clocks the following assembler subroutine takes to execute

```
Wait:
     nop                                   4 instructions with a goto (return)
     movlw     40 (188)                    = 5 clocks
     movwf     CNT2
W2:
        nop                                6 instructions in green with a goto
        nop                                = 7 clocks
        movlw  60                          executed 40 times
        movwf  CNT1                        7 * 40 = 280 clocks
W1:
               nop                         7 instructions in blue with a goto
               nop                         = 8 clocks
               nop                         executed 60 * 40 times
               movlw   80                  8 * 60 * 40 = 19,200 clocks
               movwf   CNT0
W0:                                        10 instructions and a goto
                   nop                     = 11 clocks
                   nop                     executed 80 * 60 * 40 times
                   nop                     11 * 80 * 60 * 40 = 2,112,000 clocks
                   nop
                   nop
                   nop
                   nop
                   nop                     Total Clocks = 2,131,485
                   decfsz  CNT0,F
                   goto W0

               decfsz   CNT1,F
               goto     W1

        decfsz CNT2,F
        goto   W2

     return
```

3b) Modify this routine so that it takes 10,000,000 clocks to execute (1 second)

To make it 10,000,000 clocks, make the routine take

$$\left(\frac{10{,}000{,}000}{2131485}\right)40 = 187.66$$

Change the first number to 188.

This results in the number of clocks being 10,017,961 clocks

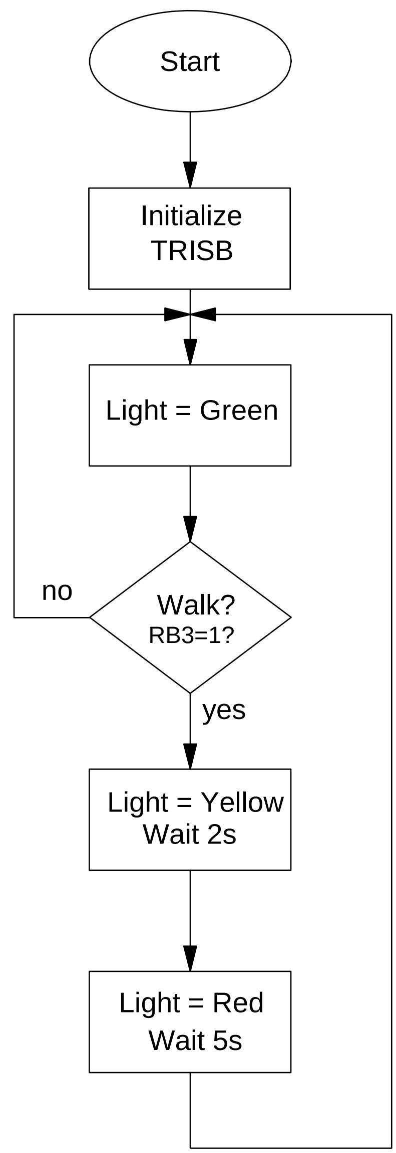
4) Assembler: The following code runs a traffic light at a crosswalk. Normally, the light is green. When you press the Walk button (RB0 =1), the light turns yellow then red then goes back to green

Write the assembler code for the stoplight. For a 1 second wait routine, use the Wait subroutine from problem #3

Assume that PORTB is connected to the lights and the Walk Button as follows:

7	6	5	4	RB3	RB2	RB1	RB0
-	-	-	-	Walk Button	Red	Yellow	Green

```
#include <p18f4620.inc>
; Start of code:
     org 0x800
     movlw 0x0F
     movwf ADCON1



     movlw     8
     movwf     TRISB


Loop:

; green light
     movlw     1
     movwf     PORTB

; Walk?
     btfss     PORTB,3
     goto      Loop

; yellow light
     movlw     2
     movwf     PORTB
     call      Wait
     call      Wait

; red light
     movlw     4
     movwf     PORTB
     call      Wait
     call      Wait
     call      Wait
     call      Wait
     call      Wait

; repeat
     goto      Loop
```



Bernie Sanders Trivia!!! Bernie Sanders proposed making college free - but that was deemed too expensive. Yesterday, the Senate approved a budget which increased defense spending by $80 billion. How many college students can $80 billion cover assuming the cost of tuition and is $9268/year (the in-state cost of NDSU)?

$$N = \left(\frac{\$80\text{ billion}}{\$9268}\right) = 8,631,852$$

Instead of allocating an additional $80 billion to the Department of Defense each year, you could pay the tuition and fees for 8.6 million college students

To put this in perspective

- There are 300 million people in the U.S.
- Assume a uniform distribution from the ages of 0 to 70, that means there are 17.1 million people between the age of 18 and 22
- Assuming that half of all Americans go to college, there should be 8.57 million students in college at any given time.

$80 billion dollars is more than enough to make college free at all public universities and colleges.