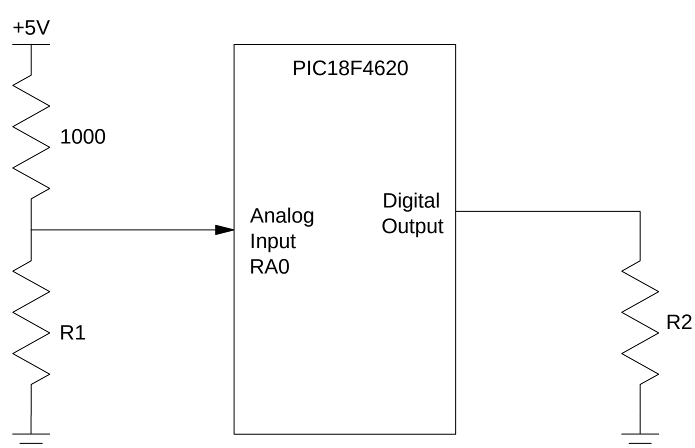
ECE 376 - Homework #1

PIC Background. Due Wednesday, September 4th, 2019

	Answer
1) A PIC processor can drive up to 25mA on its I/O pins. Assuming the output is 5V, what is the smallest R2 can be?	**200 Ohms**
2) The PIC processor we're using can measure time to 100ns. If you are running 10m/s (10 seconds for a 100m dash), how far do you travel in 100ns? (i.e. if a PIC was used at the Olympics, how close would the 2nd-place runner have to be for there to be a tie?)	**1 um**
3) Suppose you jump 30 inches. How many clocks elapse from the time you jump to the time you land?	**7,886,956 clocks**
4) The PIC processor we're using also has a 10-bit analog input with a range of 0V-5V, meaning that 0V reads 0 and 5V reads as 1023. The resolution on the A/D is 4.88mV (5V/1024). Suppose you use your PIC to measure resistance using a voltage divider shown below. If R1 is 500 Ohms, what is the resolution of the ohm-meter? (How much does R1 have to change so that the voltage at RA0 changes by 4.88mV?)	**2.20 Ohms**
5) If R1 is a temperature sensor (in your kit) with $R_1 \approx 1000 \cdot \exp\left(\frac{3903}{T} - \frac{3903}{298}\right)$ where T is the temperature in degrees Kelvin, what is the smallest change in temperature you can measure when R1 = 500 Ohms (as per problem #4)?	**0.11 C**



Problem 1) A PIC processor can drive up to 25mA on its I/O pins. Assuming the output is 5V, what is the smallest R2 can be?

$$R = \left(\frac{5V}{25mA}\right) = 200\Omega$$

You need at least 200 Ohms for any given load.

meaning

If you want to connect an 8 Ohm speaker to a PIC, add a 200 Ohm resistor in series to limit the current.

Problem 2) The PIC processor we're using can measure time to 100ns.

If you are running 10m/s (10 seconds for a 100m dash), how far do you travel in 100ns? (i.e. if a PIC was used at the Olympics, how close would the 2nd-place runner have to be for there to be a tie?)

$$t = (10\ \tfrac{\mathrm{m}}{s}) \cdot (100ns) = 1\mu m$$

If the 2nd-place person is 1um behind the winner, you can detect that difference.

To put this in context, a human hair is about 180 microns.

Problem 3) Suspose you jump 30 inches. How many clocks elapse from the time you jump to the time you land?

$$d = \tfrac{1}{2}at^2$$

$$0.762m = \tfrac{1}{2} \cdot 9.8\tfrac{m}{s^2} \cdot t^2$$

$$t = 0.3943s$$

This is for 1/2 of the jump. The total time is twice this

$$t = 0.7886s$$

At 100ns/clock, this is 7,886,956 clocks.

Problem 4) The PIC processor we're using also has a 10-bit analog input with a range of 0V-5V, meaning that 0V reads 0 and 5V reads as 1023. The resolution on the A/D is 4.88mV (5V/1024).

Suppose you use your PIC to measure resistance using a voltage divider shown below. If R1 is 500 Ohms, what is the resolution of the ohm-meter? (How much does R1 have to change so that the voltage at RA0 changes by 4.88mV?)

$$V = \left(\frac{500}{500+1000}\right)5V = 1.66667V$$

If you add 4.88mV, the resistance changes to

$$\left(\frac{R}{R+1000}\right)5V = 1.66667V + 4.88mV$$

$$R = 502.20\Omega$$

You can measure a change in resistance of 2.2 Ohms

Problem 5) If R1 is a temperature sensor (in your kit) with

$$R_1 \approx 1000 \cdot \exp\left(\frac{3903}{T} - \frac{3903}{298}\right)$$

where T is the temperature in degrees Kelvin, what is the smallest change in temperature you can measure when R1 = 500 Ohms (as per problem #4)?

500 Ohms corresponds to

T = 314.52K = 41.65C

502.20 Ohms corresponds to

T = 314.54K = 41.54C

The difference is 0.11C

The smallest change in temperature you can detect is 0.11C

6) Determine the result of the following operations

Operation	Result in binary 00000000 to 11111111	Result in hexadecimal 0x00 to 0xFF	Result in decimal 0 to 255

232 + 31	`1110 1000`
	`+ 0001 1111`
	`----------------`
	`= 0001` **`0000 0111`**
		`0xE8`
		`+ 0x1F`
		`-----------`
		`0x1`**`07`**
			7

232 - 31	`1110 1000`
	`- 0001 1111`
	`----------------`
	`=` **`1100 1001`**
		`0xE8`
		`- 0x1F`
		`-----------`
		`0xC9`
			201

232 * 31	`1110 1000`
	`* 0001 1111`
	`----------------`
	`0001 1100` **`0001 1000`**
		`0xE8`
		`* 0x1F`
		`-----------`
		`0x1C`**`18`**
			24
			7192 mod 256 = 24

232 / 31	`0000 0111`	`0x07`	**7** *7.4839 rounded down*

232 AND 31	`1110 1000`
	`& 0001 1111`
	`---------`
	`0000 1000`
		`0xE8`
		`& 0x1F`
		`------`
		`0x08`
			8

232 OR 31	`1110 1000`
	`| 0001 1111`
	`----------`
	`=` **`1111 1111`**
		`0xE8`
		`| 0x1F`
		`-------`
		`0xFF`
			255