Homework #1: Basic LED projects

Due Monday

1. Make an LED bar graph with 5 independently addressable red LEDs. Draw a circuit diagram.
2. Make a counter that counts up to 1000 at .01 sec per count and the number of lit LEDs increases with every count multiple of 200.
3. Repeat this but make it logarithmic: number of lit LEDs increases with every power of 4: 4^0 = 1 LED, $>4^1$ = 2 LEDs, $>4^2$ = 3 LEDs etc.
4. Make a random number. Depending on size of number the bar graph lights up different amounts. Repeat every 2 seconds. Use Random() and randomSeed().
5. Make your 5 LEDs count from 0 to 31 in binary. Code this in two different ways. How many more ways can you think of?

Connect two green LEDs each to a 1 kΩ resistor and two adjacent Digital Output pins.

6. Are they the same brightness?
7. Change the 1k resistor of one of them to 3 560 Ω resistors in parallel and compare the brightness of the two.
8. Write a program that rapidly turns on and off the bright LED so fast that you can't see the blinking. How fast is that?
9. Now experiment with having the blinking LED's off time different from its on time. Try to adjust the off time and on time of the bright LED so that the LED's brightness appears to be the same as the LED with the 1 kΩ resistor.

Make a short writeup describing your results for each of that and paste in your code.

Homework #2: Digital and Analog Input

Due Monday

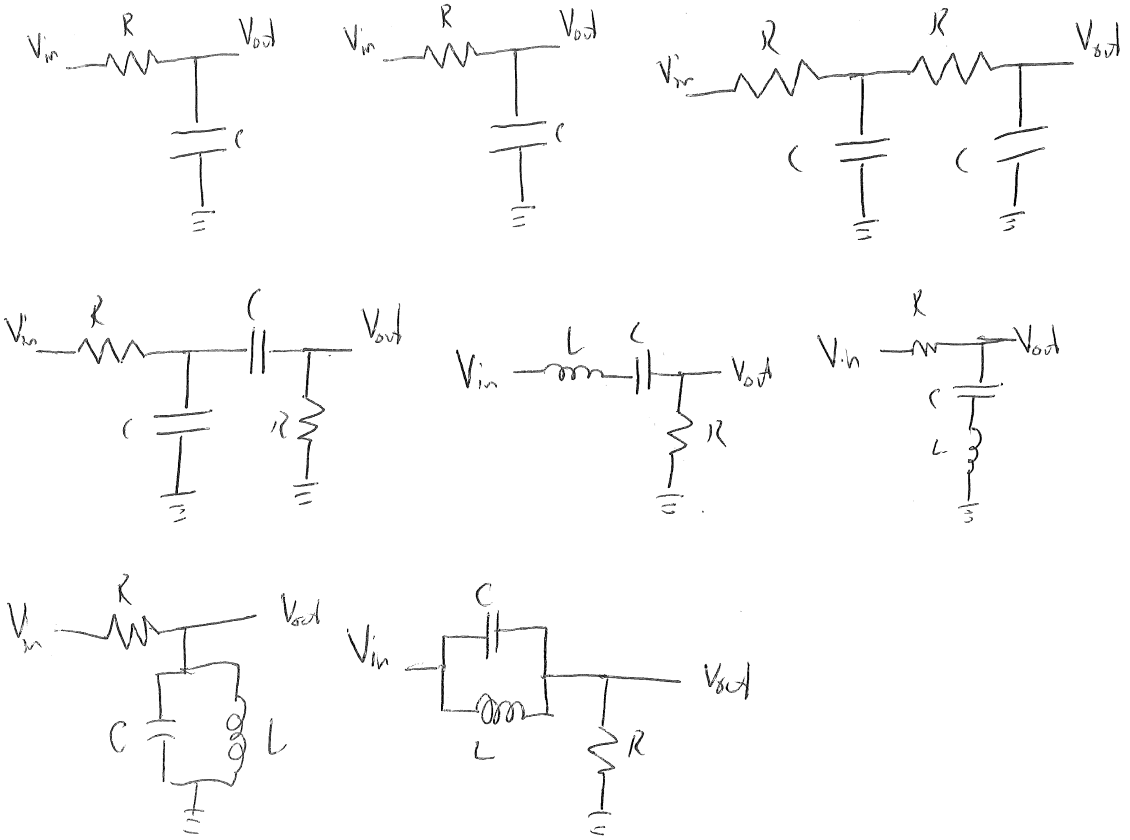
1. Connect your pushbutton switch to a digital input with a pullup resistor. Output to the serial monitor the count of the number of times the switch has been pressed.
2. Make a game with two digital input buttons that detects who presses their button first after an LED is lit, and prints to serial monitor their time in milliseconds. Use random and randomseed to vary the wait time until the LED is lit.
3. Make a row of 5 LEDs and try to make a perpendicular column of 5 LEDs. Each of the 10 LEDs is connected to a different Digital Output pin. Read the joystick; the value of the x position reading determines which of the row LEDs is illuminated (e.g. if the reading is in the "middle", near 2.5 V, then the center LED is lit. If the reading is near 0 V, then the left LED is let, if the reading is near 5V, then the right LED is lit.) Also do this for the Y joystick and the column LEDs.

   Make a short writeup describing your results for each and paste in your code.

Homework #4: Filtering

Due Wednesday

1. Find and sketch the Transfer function for each of these circuits:



Upload as “Problem #4.1”

2. Write a sketch making your Arduino AnalogWrite a steadily increasing voltage, then a steadily decreasing voltage, etc., repeating to essentially generate a triangle wave voltage at a frequency of ~10 Hz. (“Program #4.1”)
    a. Plot the raw PWM signal in serial plotter
    b. Construct a low pass filter with a 3dB point of 1000 Hz; Input the PWM out into this filter; Analog read the filtered signal and plot it
    c. Repeat b with a low pass filter with a 3dB point of 10 Hz
    d. Repeat b with a low pass filter with a 3dB point of 1 Hz
    e. Repeat this for a sine wave generated with AnalogWrite.
3. Repeat #2 but for high pass filters. Same 3 dB points

Homework #5: Sensing light

Due Friday

1. Make a distance sensor using LEDs and photocell
    a. Relate the LED-photocell distance to measured signal for the red, green, and IR LED by taking data and making a graph
    b. Does it make a difference if you do it in the dark?
    c. Is there a difference between red, green, and IR light in the sensitivity of the photocell?
        i. Make sure if you are trying to compare them that you control for the luminosity/brightness of each LED.
    d. Is there an angular orientation dependence for the LED and photocell?
2. Does this work for scattered light? (i.e. have the LED and detector facing outward and in the same direction, and block any direct transmission of light from the LED to the detector.) Can you detect objects that are close by through sensing of light scattering off of them? Can you get the range of these objects from the detector?
3. Repeat the above experiments using the phototransistor.

Write up your circuit diagram, a description of your Arduino sketch, and your findings, specifically addressing the questions and points above as well as any observations you have.
(Upload as “Writeup #5.1”)

Homework #6: More Sensing (HAD TROUBLE GETTING THE LOAD CELL TO WORK)

Due Wednesday

1. Temperature with a thermistor and a voltage divider
    a. What is your measurement resolution of the input voltage? (This is not a thermistor-specific or voltage divider-specific question, it's an Arduino-specific question.)
    b. Find an expression of V_{out} of the voltage divider versus thermistor resistance
        - Find the sensitivity of V_{out} on thermistor resistance
    c. Write an expression for Temperature as a function of thermistor resistance
        - Find the sensitivity of thermistor resistance on temperature
    d. Combine the sensitivities from b and c to get the sensitivity of V_{out} on temperature
    e. Combine d with part a to get the measurement resolution of temperature near 25C.
    f. Wire up the thermistor in a voltage divider and print/plot the temperature using the serial monitor. Do these values match e? Why or why not?
    g. Put a 10x (or more) amplifier on the voltage divider output. Plot the measured temperature.
2. Connect the load cell to a differential amplifier. You choose the gain and the specifics of the amplifier. Clamp one end of the load cell to the edge of a table, with the other end hanging off the edge. (Or if you don't have a clamp, put a heavy weight on one end.) Now hang a weight from the suspended end (or put something on top of it.) What is the smallest load you can measure?

Upload write up as "Writeup #6.1"

Homework #7: IR distance sensor with two stage amplification

Due Friday

You'll use both op-amps on your dual op-amp chip for this.

In HW 5 you made an LED distance sensor- can an amplifier give you greater range?

Make a light sensor for scattered IR light using the phototransistor.

a. Experiment with different resistor values. Find which ones give you the greatest sensitivity, and which give the least. Choose a value for which the output gives you a good response for close objects, but goes to zero for objects further away.
b. Create a non-inverting amplifier with a gain of 11. Take the output of the light sensor and input it into the amplifier, and send the output to the Arduino.
c. Create a second non-inverting amplifier with a gain of 11. Take the amplified output from part b and input it into the second amplifier, and send the output to the Arduino.
d. If you have the un-amplified output connected to A0, the 11x output connected to A1, and the 121x output connected to A2, plot A0, A1, and A2 as a function of object distance.
   For a reflective object, this may be tough since you'll have to have the orientation just right for far distances. So do this for a reflective object as well as something non-reflective, like cloth.
e. What is the farthest distance you can detect?
f. Draw a circuit diagram for your project.

Upload write up as "Writeup #7.1"

Homework #8

Due Wednesday

1. Modify the plotter program we made in class so that you can click a button to change the plotted function from sin to $\sin^2$. Add sliders that allow you to change the frequency and amplitude of the plotted function.
2. Take the program from problem #1 and instead of plotting sin, plot a random number between 0 and a value set by a slider. For this program, plot an N-point moving average on top of this data. (An N point moving average is the average of the last N points of data, and continuously updates as new data points are added.) Change N in the moving average using another slider.

Upload as “Program#8.1”

Homework #9: Arduino + Processing

Due Friday

1. Make a Pong game with Arduino/Processing in which the pong paddles are controlled by two potentiometers connected to your Arduino. Press a button to serve the ball. (“Program #9.1”)

Homework #10

Due Wednesday

1. Servo: How fast can the servo react? Turn it from 0 to 180- how long does it take? If you want the servo to fully go from 0 to 180 to 0 over and over again continuously, how do you do it?
2. Stepper motors
    a. How many steps per rotation in the stepper motor? Find this empirically.
    b. Are you able to make the stepper motor go backwards?
        i. Write a function that allows you to turn the stepper motor by X degrees forward or backwards
    c. Try modifying your code so you can do half steps.
3. Revisit your IR LED/phototransistor project with two stage amplification, but now mount the LED and phototransistor on the servo or stepper motor and collect the data as the servo or stepper is scanned from 0 to 180 degrees and back again repeatedly. (IR LED and detector are mounted on servo arm and swept) Feed the sensor data to Processing and make a graphical display that looks like a radar screen. Set up some objects near the servo and see if you can locate them in the dark.

Make a writeup (“Writeup#10.1”). Give your answer for #1, your answer for 2a, the function for 2b, and the code for 2c. Describe the function of your device in #3.

Homework #11: I2C temperature measurement using the MCP 9808

Due Wednesday

1. Read the temperature over I2C using the MCP 9808. Also measure using a thermistor and Analog Input.
    a. What is your resolution with the MCP 9808 and the thermistor?
    b. How fast can you measure the temperature using both of these methods? Compare measurements made with a 10 ms delay, 100 ms delay, and 1000 ms delay.
        i. Change the chip temperature resolution to 0.5C and repeat
2. MCP 9808 only. Set the chip alarm temperatures to 3 degrees above and below room temperature. Read the alert pin with the Arduino to know if the alarm happens. Have the Arduino ask the chip if the alert temperature is below the lower alarm temperature or above the alarm temperature. If it is below, make your RGB LED blue. If it is above, make it red. If it is in the non-alarm range, make the RGB LED green. Don't forget that the alert output needs a pullup resistor (p 30 spec sheet). Upload your code.

Put all into "Writeup #11.1"

FT Homework

Due Wednesday

1. Acquire 8192 (or more) points of data from your thermistor/light sensor over one minute; one hour; one day
    a. Plot each set of data and Fourier Analyze it
    b. Annotate any events seen in the data
2. Acquire data from your microphone while speaking into it; Fourier analyze it
3. Make a Dynamic Fourier Transform plot in Processing
    a. Continuously acquire data from your microphone and plot the amplitude of the FT as a 1D plot with the color of the pixel reflecting the amplitude; as time goes forward make another 1D plot right next to it.
    b. Do this as you play music/sing into the mic