ME 511 Mechatronics @ UIC

Programming and interfacing Arduino microcontrollers in hardware
This lab is to be done individually, but in the lab.

1 Prelab (To be done before you come to the lab)

1.1 Motivation

The goal of this lab is to introduce you to a hobby grade open-source microprocessor called the Arduino Uno made by the company Arduino. You will extensively use this micro-processor for the hardware project in this course.

1.2 Assigned Reading

This part of the lab needs to be done before you come to the lab. Assigned reading is listed below

1. A general introduction to microprocessors made by Arduino is here:
   http://arduino.cc/en/Guide/Introduction

2. You will be using the **Arduino UNO Rev3** for the hardware project. More information about this board is here: https://store-usa.arduino.cc/products/arduino-uno-rev3. Here is a webpage that explains the various pins on the Arduino UNO:
   https://www.circuito.io/blog/arduino-uno-pinout/

3. Arduino code is called a sketch. Every code involves the functions, the setup() and the loop(). More information on these function is given here:
   Setup(): http://arduino.cc/en/Reference/Setup
   Loop(): http://arduino.cc/en/Reference/Loop

4. We will write code for the Arduino in C and/or C++. Here is a list of various functions/loops/structures that are available in the language reference manual:
   https://www.arduino.cc/reference/en/. You can skim through some of them. Read about the following functions: pinMode(), digitalWrite(), digitalRead(), analogRead(), analogWrite().

1.3 Questions based on reading (not graded)

Answering the following questions will help assess your comprehension of the assigned reading. Since the labs are short, only 2 hours, it is important that you come prepared for the lab before hand. Note that there is a 20 point penalty for not completing the lab on time. .

1. The correct method of supplying power to the Arduino UNO Rev 3 are:

   (a) Connecting a USB from a computer to the Arduino UNO

   (b) Connecting a 7-12 V external power supply to pin Vin.

   (c) Connecting a 13-20 V external power supply to pin Vin.

   (d) Connecting a 5 V external power supply to pin 5V.

2. Which of the following are true for Arduino UNO Rev 3

    (a) It uses an ATmega brand of microcontrollers
    (b) It has a 32 KB of flash memory.
    (c) It has a clock speed of 16 MHz.
    (d) It has 14 digital input/output pins and 6 analog input pins.

3. Which of the following statements are TRUE for setup() and loop()

    (a) setup() function runs once during start up and this is where you can initialize the variables.
    (b) setup() function is optional and can be skipped.
    (c) loop() function runs every clock cycle.
    (d) loop() function is optional function and can be skipped.

4. Which of the following are TRUE for the pins on the Arduino UNO Rev3

    (a) PWM pins are only for output.
    (b) Digital pins can be used for input and output.
    (c) Analog pins can be used only for input.
    (d) There is built-in LED connected to digital pin 13.

5. Consider the following Arduino code:
   int ledPin = 13; void setup()
   {
   pinMode(ledPin, OUTPUT);
   }
   void loop()
   {
   digitalWrite(ledPin, HIGH);
   delay(500);
   digitalWrite(ledPin, LOW);
   delay(500);
   }
   Which of the following statements is TRUE about the above code

    (a) The above code blinks an LED once per second.
    (b) The above code blinks an LED once per 500 seconds.
    (c) The part of the code that starts with // is a comment and ignored by the compiler.
    (d) In order to make the LED blink faster, replace delay (500) with delay(1000).

Answers:
1 a, b. Dont do (c) or (d). It will damage the Arduino.
2 a,b,c,d.
3 a,b,c
4 a,b,c,d
5 a, c

2 Labwork (graded)

2.1 Equipment list

1. Arduino UNO Rev 3 and USB A to B cable (commonly used on printers).

2. 1 resistor of value $200\Omega, 10k\Omega$ (the resistors should be in the same ball park, exact values not needed).

3. 1 LED.

4. 1 switch (the kit has a button switch).

5. 1 ON/OFF switch (if you are given a switch by the TA please return it)

6. 1 Potentiometer

7. Breadboard.

8. Multimeter.

9. DC voltage supply (please return this back after the lab is done)

You will find it useful to refer to the **Arduino language reference manual** when you write code for the Arduino. Here is the link. https://www.arduino.cc/reference/en/
In the exercises below we will try to understand the function digitalWrite, digitalRead, analogWrite, and analogRead. These functions are building blocks for more sophisticated code that you will write later on, for this lab and for your hardware project.

2.2 (20 pts) Getting started with the Arduino and using digitalWrite()

Set up Arduino IDE on your computer https://jayconsystems.com/blog/setting-up-arduino-software-on-your-computer.
Run the blink sketch https://jayconsystems.com/blog/run-a-sketch-in-arduino-ide. NOTE: Between step 2 and step 3 connect the Arduino UNO to your computer using the USB cable.

You should have the blink example up and running.

- Read about pinMode(), DigitalWrite() in the language reference manual. Discuss the following with your group members.

    1. Do you absolutely need to call pinMode()? What happens if you skip this function?
    2. Can the pinMode() command be placed in the loop() block instead of the setup() block?
    3. Play with the delay function in the code. Increase and decrease the delay. What does the delay() function do?

- Show that you got the blink code working to the teaching assistant. Show the answers to the above questions to the teaching assistant.

2.3 (20 pts) Using Breadboard with the Arduino and using digitalRead()

Follow the instructions on this web page about using the digitalRead() function,
http://arduino.cc/en/Tutorial/DigitalReadSerial

After completing the above circuit and loading it on the Arduino UNO, open the serial monitor (There is a shortcut on the right top corner or by going to Tool > Serial Monitor). Now press the push-button and note the output on the serial monitor.

- Read about digitalRead() in the language reference manual. Discuss the following questions with your group.

  1. Where does the resistor gets it power from?
  2. What command in your code prints to the serial monitor?
  3. If push-button wire was connected to a different digital pin, say pin 10, instead of pin 2, then what changes in the code will need to be done in order to get the same result as above?

- Show that you got this example up and running to the teaching assistant. Show the answers to the above questions to the teaching assistant.

2.4 (20 pts) Using analogWrite()

Follow the instructions on this web page about using the analogWrite() function,
http://arduino.cc/en/Tutorial/Fade

You can read about the analogWrite() function in the language reference manual.

- Now modify the code in order to make the LED do the following sequence.

  1. Gradually brighten from fully off to fully lit in 5 seconds.
  2. Remain fully bright for 2 seconds.
  3. Finally, turn fully off.
  4. Repeat.

  HINT: (a) You can use the loop structure (e.g., if, else, while, switch) found in the reference manual. (b) One of the issue you will face is that the Arduino code does not provide a timer. You will have to program your own timer to keep a track of time. You can initialize the timer in the setup().

- Demonstrate the experiment to the teaching assistant.

2.5 (20 pts) Using analogRead()

Follow the instructions on this web page about using the analogRead() function,
http://arduino.cc/en/Tutorial/ReadAnalogVoltage

You can read about the analogRead() in the language reference manual. Do the exercise above and

print the output to the serial monitor.

After you complete the experiment, show your work to the teaching assistant.

2.6 (20 pts) Electrical lighting for a house

You have to develop a prototype for electrical wiring for two rooms of a house. You will use the Arduino UNO, the breadboard, the LEDs, the potentiometer, and the ON/OFF switch to develop a prototype wiring solution. Here are the specifications.

1. For the living room, the light bulb will be operated by an ON/OFF switch. When the switch is turned ON, the light bulb should turn on immediately. When the switch is turned OFF, the light bulb should turn off gradually over a period of 5 seconds.

2. For the study room, we need an adjustable light. The user should be able to control the amount of light by turning a potentiometer knob between the fully OFF position (LED off) and the fully ON position (LED fully lit).

HINTS: (a) Use the LEDs in lieu of the light bulb. (b) Circuits for both rooms should be built on the same breadboard and controlled from a single Arduino UNO at the same time. (c) It is recommended that you draw the circuit diagram before you hook up the breadboard.

Show your work to the teaching assistant.