The prelab portion of this lab has to be completed at home and presented to a TA at the BEGINNING of your lab section. The prelab may contain written assignments and/or assignments to implement on your own Arduino kit. Before starting each lab, present your work papers and/or your working implementations to a TA and get their signature and keep this sheet for your records. Prelabs are individual assignments. The lab portions may be worked on in groups of two.

Lab 3 – Prelab/Home Portion

1) Explain the purpose of the `map()` function and provide an example of its use.

2) Explain the purpose of the `constrain()` function and provide an example of its use.

3) What is a voltage divider? Draw the schematic of a simple voltage divider circuit.

4) Provide an example of when to use a voltage divider.

5) What is an H-bridge and what is it used for? Draw a diagram of how the H-bridge is used to control the direction of a motor.

6) Read the datasheet for the L293D H-bridge (http://www.ti.com/lit/ds/symlink/l293.pdf) and pages 74 – 75 from the textbook

   Explain what the each of the following pins are used for:

   i. Heat Sink/Ground (Pins 4, 5, 12, and 13)
   ii. V_{CC2} (Pin 8)
   iii. V_{CC1} (Pin 16)
   iv. 1Y and 2Y (Pins 3 and 6)
   v. 1A and 2A (Pins 2 and 7)
   vi. 1,2 EN (Pin 1)
   vii. 3Y and 4Y (Pins 11 and 14)
   viii. 3A and 4A (Pins 10 and 15)
   ix. 3,4 EN (Pin 9)

7) What precautions should you take to prevent the H-bridge from accidentally short circuiting?

8) Explain the differences between the bipolar and unipolar stepper motors in terms of torque and speed briefly?

9) Based on the reading of the 28byj -48 unipolar stepper motor datasheet you have in your kit, how many steps per full rotation (360°) in both half-step and full-step modes? (hint: this motor has 64:1 gear reduction) ?

This exercise requires the use of your lab station's power supply. In order to prevent damage to the yourself and your equipment, exercise caution and common sense: turn the power supply off when you need to make modifications, verify that your connections are correct before turning the power on, and turn the power supply off when you are not using it.

Lab #3 Assignment

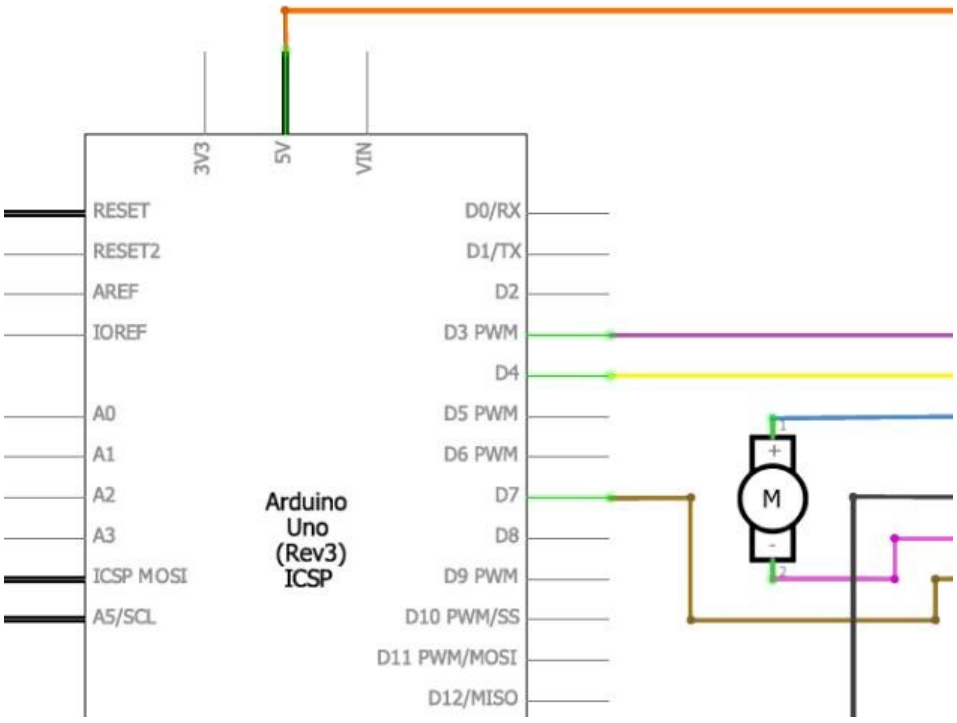
Part 1. Wire up the joystick to your Arduino and write a program to print the joystick position to the serial monitor.

Connect the joystick to the Arduino as follows:

Arduino	Joystick	Meaning
GND	GND	Ground
5V	+5V	Power
A0	VR_y	Y axis pin

Part 2. Create a motor driver that uses a joystick to control speed and direction.

a. First you need to connect the Arduino, H-bridge (L293D) and Motor as the schematics shows below, keep the joystick connected as in part 1:



Before connecting the external power supply to the H-bridge, have a TA check your wiring; incorrectly wiring these components can seriously damage your Arduino, H-bridge or the Motor.

b. Pushing the joystick up will rotate the Motor in forward direction and the speed should be increased by an amount proportional to the offset of the joystick. As pushing the joystick down this will reverse the rotation of the Motor and the speed also should be increased by an amount proportional to the offset of the joystick. If the joystick is within ±10% of its center value, the Motor should be stopped.

c. Show the voltage of the Y axis from joystick and the motor voltage variation using 2 channels of an oscilloscope.

Part 3. Controlling a servo position using the joystick.

a. Connect the servo control wire to a PWM-capable pin and ground wire to a ground pin. Keep the joystick connected as in part 1.

b. Connect the servo's power and ground wires to the lab station's power supply and adjust it to 5V, but do not turn the power on until a TA checks your wiring.

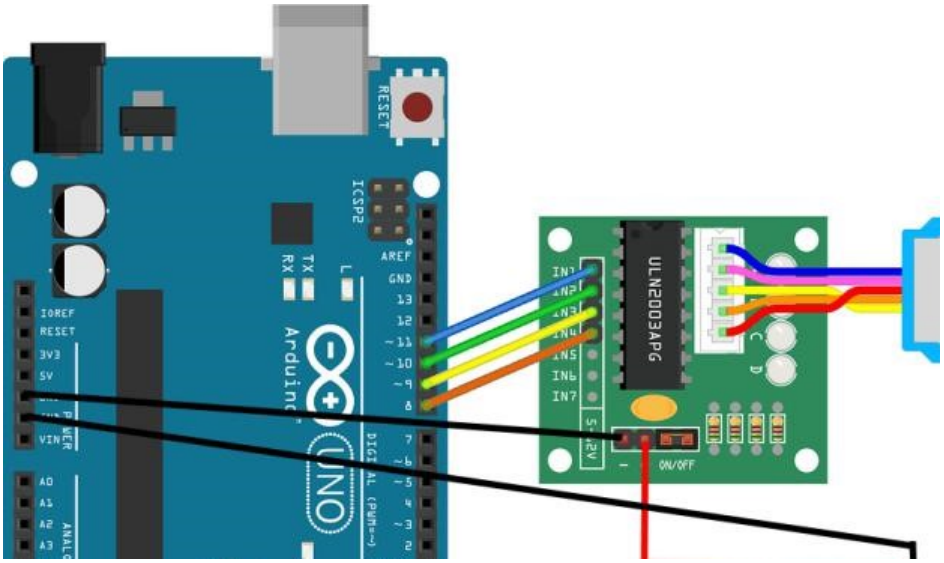
c. Pushing the joystick up will turn the servo counterclockwise by a value that is proportional to the offset of the joystick. As pushing the joystick down this will turn the servo clockwise by a value that is proportional to the offset of the joystick.

d. Show the servo signal on an oscilloscope.

Part 4. Create a motor driver to control speed, acceleration, and direction

Using the, complete the **half step** code below to do these two Parts:

a. First, you need to connect the Arduino, ULN2003 driver, the stepper motor, and a 9V battery as shown below:



b. Edit the code below to implement :

1- Rotate the motor 180° clockwise with 500 (step/second) speed.
2- Rotate the motor 180° counterclockwise with 500 (step/second) speed.

Note: please go to Tools -> Manage Libraries -> search for AccelStepper.h -> install it.

```
// Include the AccelStepper
library: #include <AccelStepper.h>
// Motor pin definitions:
#define motorPin1 11 // IN1 on the ULN2003 driver
#define motorPin2 10 // IN2 on the ULN2003 driver
#define motorPin3 9 // IN3 on the ULN2003 driver
#define motorPin4 8 // IN4 on the ULN2003 driver
// Define the AccelStepper interface type; 4 wire motor in half step
mode: #define MotorInterfaceType 8
// Initialize with pin sequence IN1-IN3-IN2-IN4 for using the AccelStepper library with
28BYJ-//48 stepper motor:
AccelStepper stepper = AccelStepper(MotorInterfaceType, motorPin1, motorPin3,
motorPin2, motorPin4);



void setup() {

        // Set the maximum steps per second:
        stepper.setMaxSpeed(1000);

}
void loop() {

        // write code 1

        here Delay(500);

        // write code 2

        here Delay(500);


}
```

Question) Do you notice any error in the position (does it accumulate)? _____

c. Edit the same code in B to implement:

1) Rotate the motor 180° clockwise with 200 (step/second^2) acceleration.
2) Rotate the motor 180° counterclockwise with 200 (step/second^2) acceleration.