# Building an Arduino-powered underwater ROV

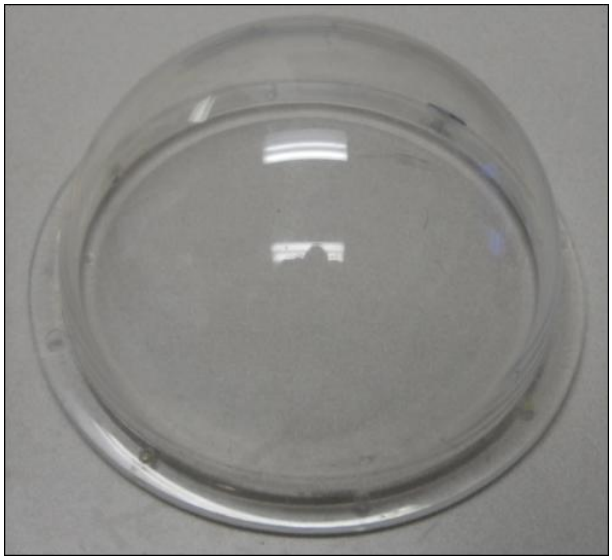
An ROV offers an entirely different way to use Arduino to explore a new world. This project is a bit different in two ways. First, there is quite a bit of mechanical work to do, and second, it is almost impossible to send wireless signals through water. So, you are going to use a tethered control line to give your robot direction.

## Building an ROV

There are several possible approaches to building your ROV. Although controlled by a different processor, the mechanical design at openrov.com/page/openrov-2-0 is quite elegant, and you could certainly build the HW yourself and then integrate your Arduino. At openrov.com/page/open-rov-designs-1 is a simpler yet similar design that incorporates Arduino. Another design that is very different from the first one is available at www.instructables.com/id/Underwater-ROV/. Both could certainly use Arduino as the motor control.

My physical design is based more on the latter design that mostly uses plastic piping, as shown in the following image:

One of the most important components of your ROV is the clear plastic casing, as you need to be able to use a camera to see the world underwater. The following is an image of the one I used:

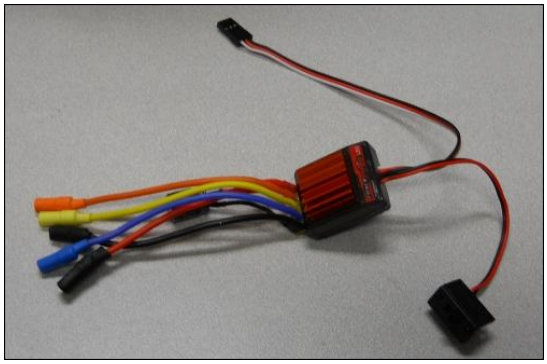


This came from a company called EZ Tops and can be ordered online at www.eztopsworldwide.com/smalldomes.htm. I put this on the other end of my ROV, assembled with a gasket and some small bolts. Whether you use a round design or a more traditional square design, you'll want a clear plastic so that you can get a good view of the underwater world.

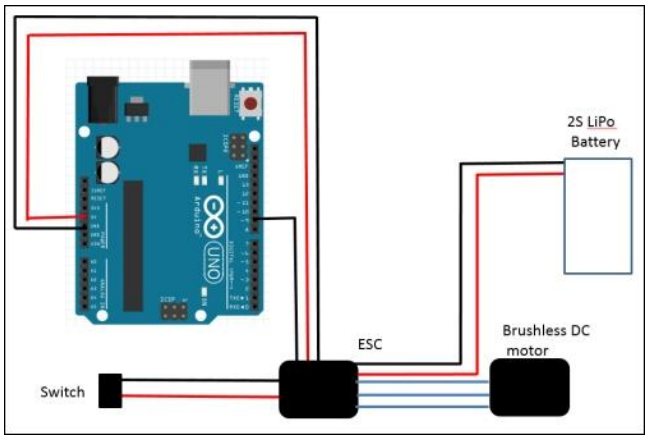
## Controlling brushless DC motors with Arduino

Whatever physical design you choose, you'll need to control the motors, and Arduino is well suited for this task. In this case, I chose fairly standard brushless DC motors and then fitted them with RC boat propellers. These motors work just fine underwater and are easy to control with RC **electronic speed controllers** (**ESCs**).

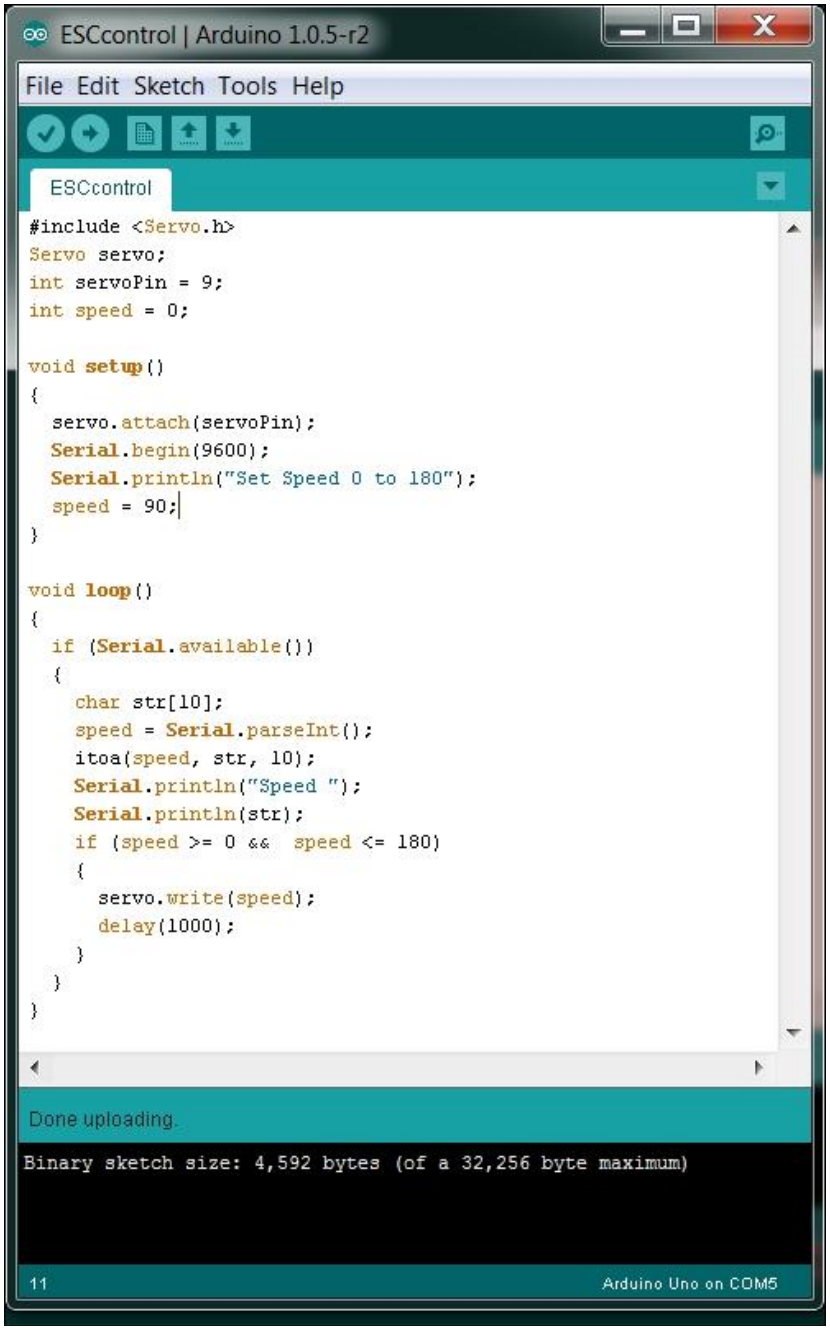
For this project, you'll need four brushless DC motors and four ESC controllers. You'll need to make sure that the ESCs will be able to control the motors to go both forward and backward. The following is an image of one such unit:



This particular unit is a Turnigy Trackstart 25A ESC, made normally for an RC car and available at many RC outlets, both retail and online. The connections on this unit are straightforward. The red and black wires with plugs go to an RC battery, in this case, a 2S 7.4 volt LiPo RC battery. The other three plugs go to the motor. This particular ESC comes with a switch; you won't use it in this particular project. The last connection is a three-wire connector, similar to a servo connection. You'll connect this to Arduino. The following diagram shows the connections:




For details on the connection between the ESC and brushless DC motor, check your ESC documentation. Now that you've connected your motor, a simple sketch to control the motor is shown in the following screenshot:




Note that you will use the servo control process to control the speed of your motor. With these ESCs, `0` will be full speed backward, `180` will be full speed forward, and `90` will stop the motor. The `setup()` function sets the initial speed to `90`, just so that your motors won't take off right from the start.

Now, open the **Serial Monitor** tab and enter a `speed` value close to `90`; you'll see the following screenshot:


The motor should spin both forward and backward. You don't necessarily need to do so, but ESCs can also be programmed. I won't cover that in this chapter; check your ESC documentation for the additional HW required. The ESC may also want to be calibrated. The procedure will change based on your particular ESC, but the basic steps are as follows:

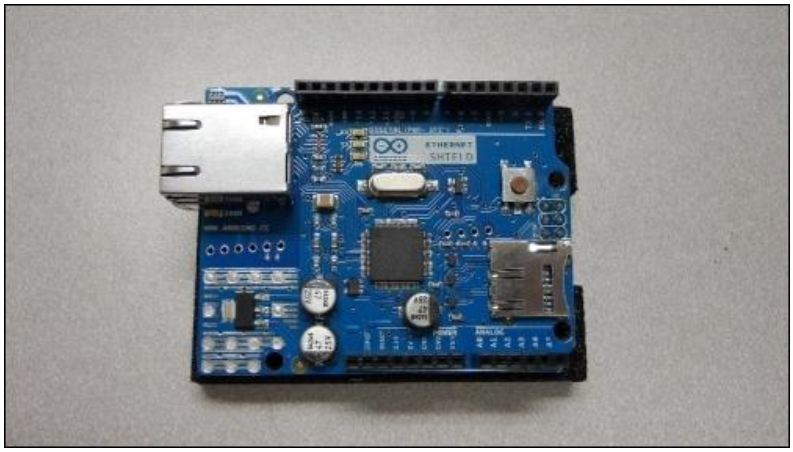
1. Disconnect your motor.
2. Power up the ESC by applying maximum forward throttle; in this case, `speed = 180`.
3. You'll hear a tone and some beeps. Then, after a few seconds, you will hear a confirmation tone, and the LED will blink a few times. This means that the ESC has calibrated maximum throttle.
4. Now, apply minimum throttle, or `speed = 0`. The unit should emit some tones, and the LED will blink. Now, minimum throttle has been calibrated.
5. Now, go to the middle throttle, or `speed = 90` in this case, and the unit will emit some tones and blink. Your unit is now calibrated.

You'll use four of the digital I/O pins, one for each motor. Controlling the speed and direction of each of these motors will allow you to move your ROV forward, backward, up, and down, as well as turn your ROV. How much speed you apply will depend on both the size of your ROV and the size of your motors.

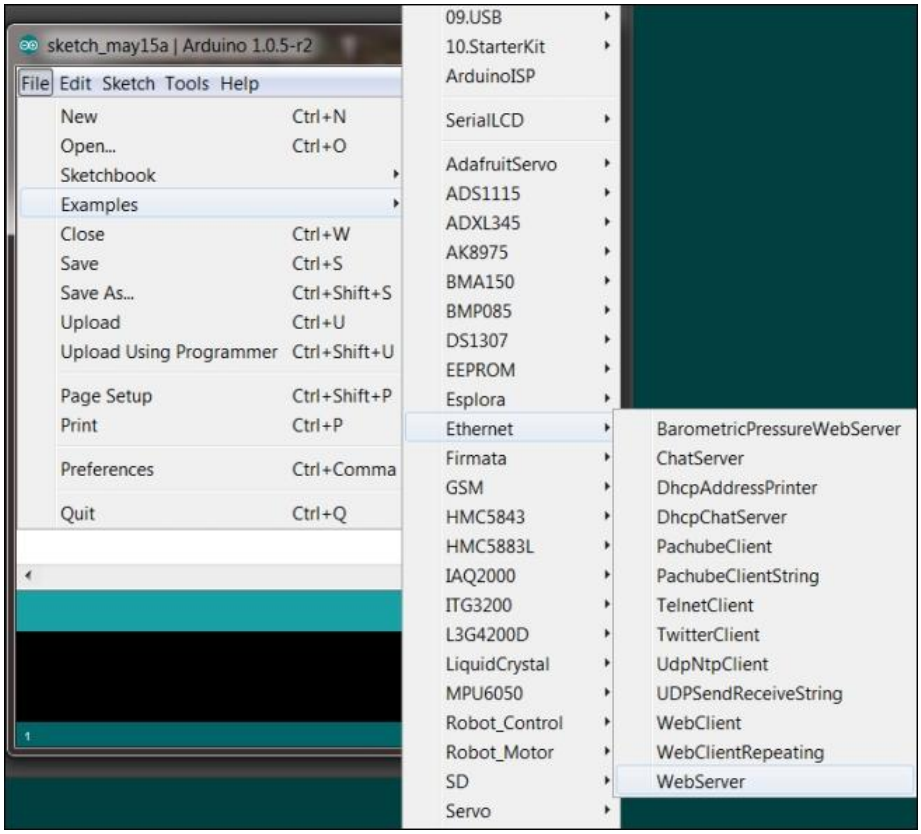
Now, your ROV is maneuverable. To complete your ROV project, you'll need two additional capabilities. The first is a LAN shield for your Arduino so that you can control and communicate with your ROV via the LAN cable that will run from your ROV to the surface. The second is a way to see underwater. Let's tackle the control problem first.

**Connecting a LAN shield to Arduino**

The ROV will be controlled from a computer on the surface through a very long LAN cable. This will require you to add LAN capability to your Arduino, so you will need to add a LAN shield to your project. There are several shields available; the following is an image of a standard Arduino LAN shield available at [arduino.cc](arduino.cc):



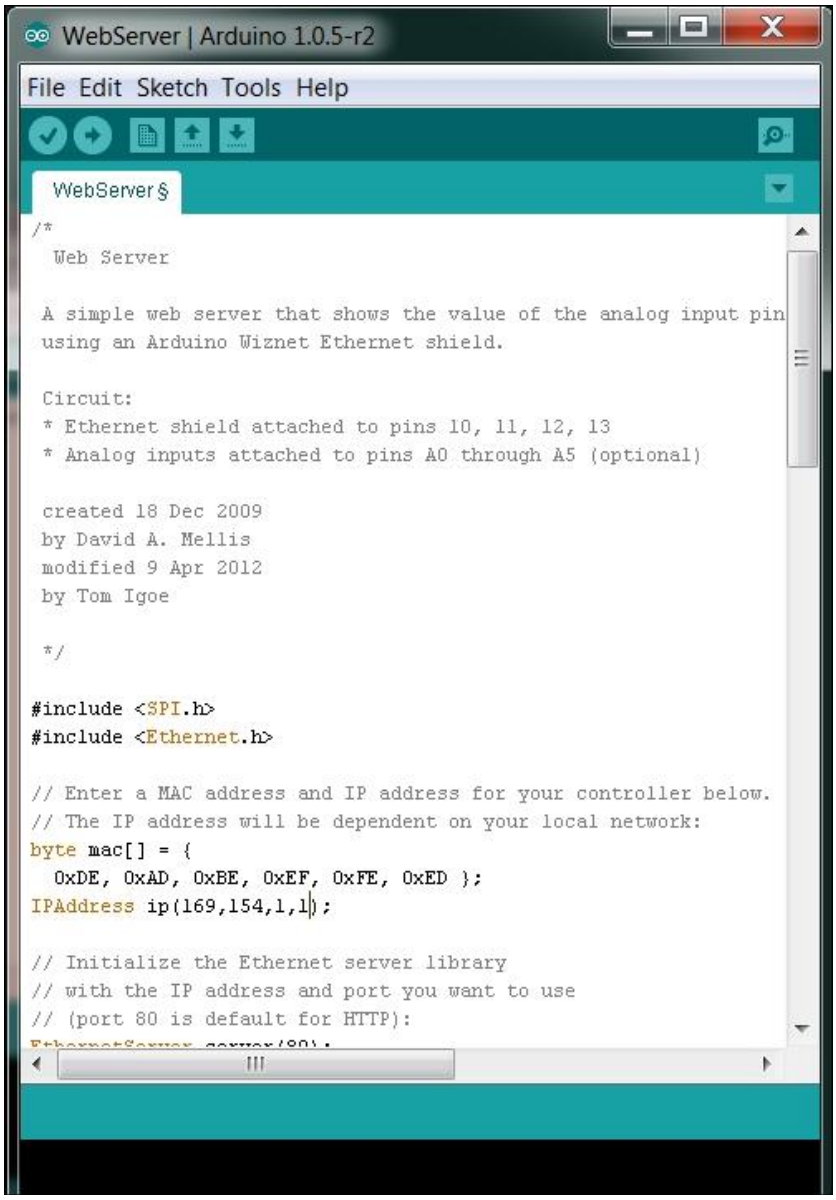
When you have obtained the shield, attach it to the top of your Arduino. Now, you can open the Arduino IDE, and the first example you'll use is a simple web page access of data. To do this, open the **WebServer** example by navigating to **File** | **Examples** | **Ethernet** | **WebServer**, as shown in the following screenshot:



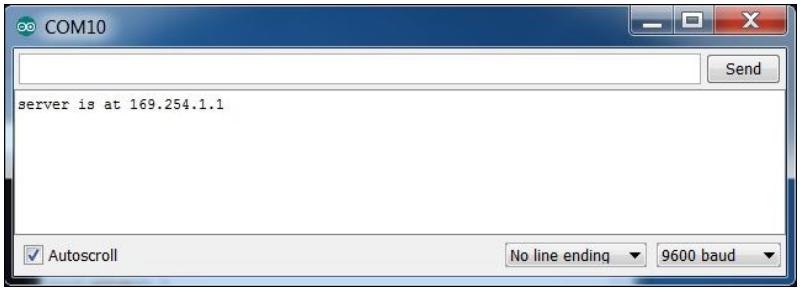

Using a web server will allow you to access your Arduino via the LAN cable that will be connected to your ROV from a web browser on a computer at the surface. To connect with the device, you'll need to set the appropriate address for the Arduino web page.

To do this, run `ipconfig` from the command prompt (under the **Accessories** folder) on your computer. When you run this, you should see something like the following screenshot:

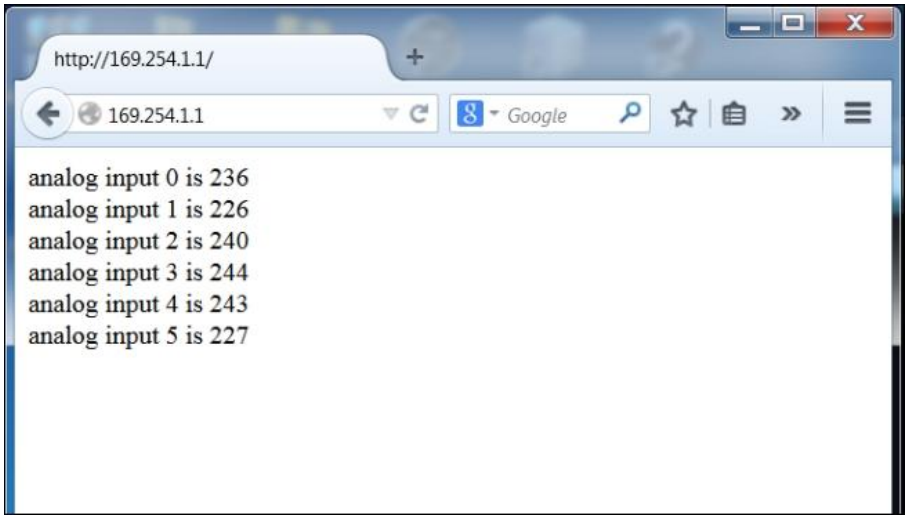
You'll now need to edit the **WebServer** sketch to set a new address that uses the same first two numbers in the address. This is where you'll change the code as follows:




Open the **Serial Monitor** tab and you should see the following screenshot:



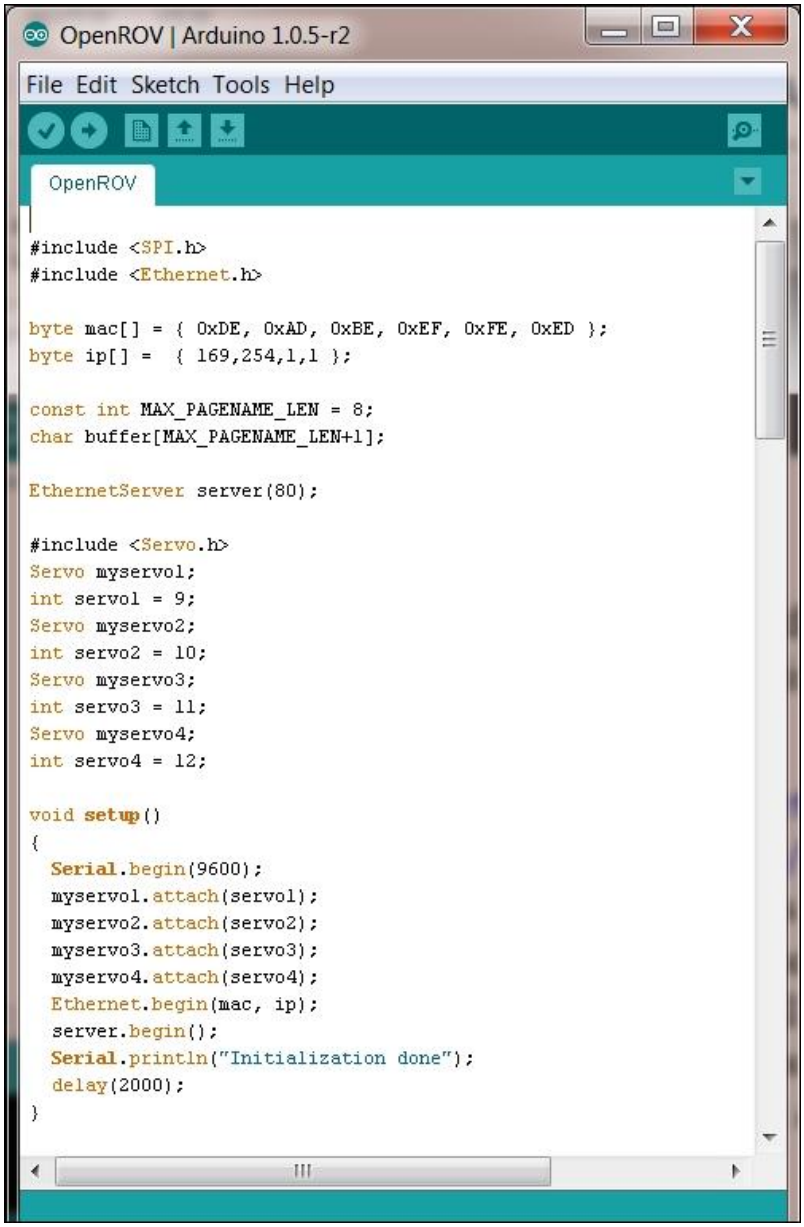

Now, open a web page and type in the IP address you set in the sketch, and you should see the following screenshot:



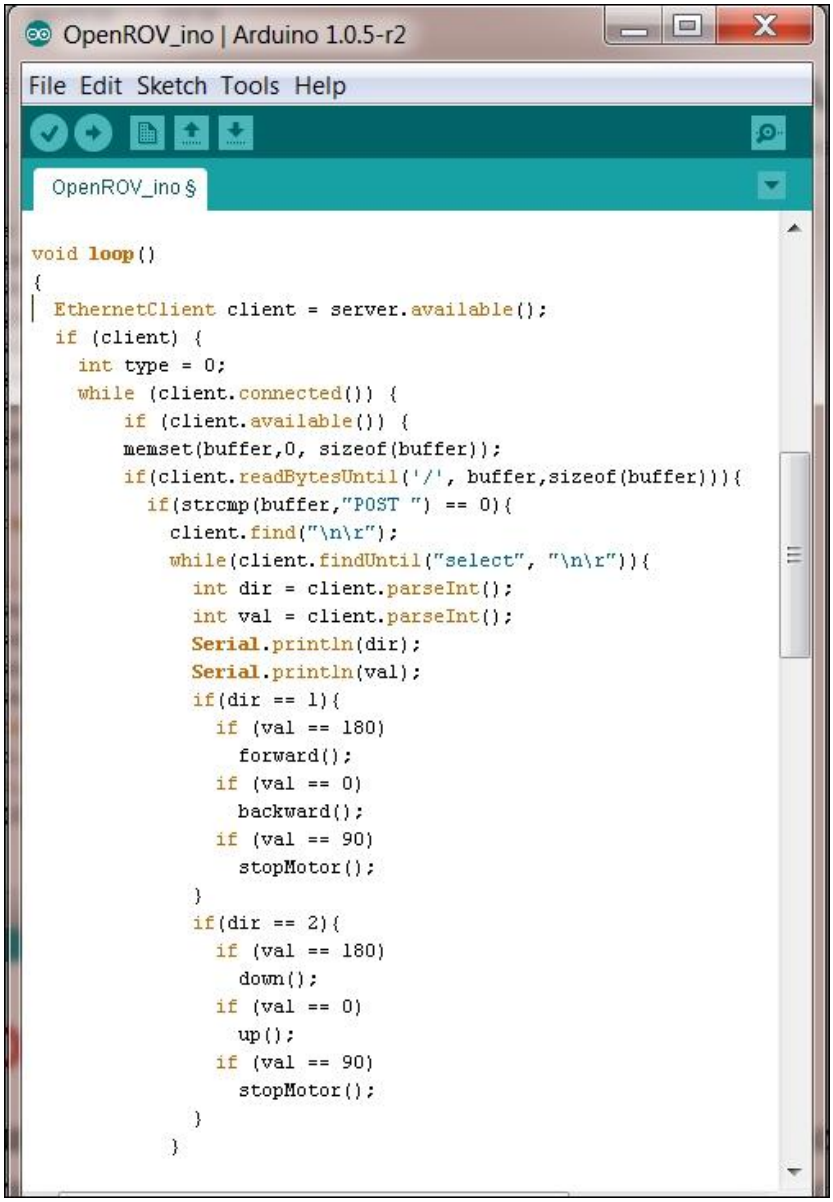

You'll need two additional capabilities to control your ROV. The first is the ability to use the LAN connection to control your motors. You can do this through a web page interface.

The tutorials at startingelectronics.com/tutorials/arduino/ethernet-shield-web-server-tutorial/ and www.instructables.com/id/Arduino-Ethernet-Shield-Tutorial/ provide lots of details on how to access your Arduino via a web page, and www.power7.net/arduinoethernet.html shows how to incorporate even more examples of control using a web page.

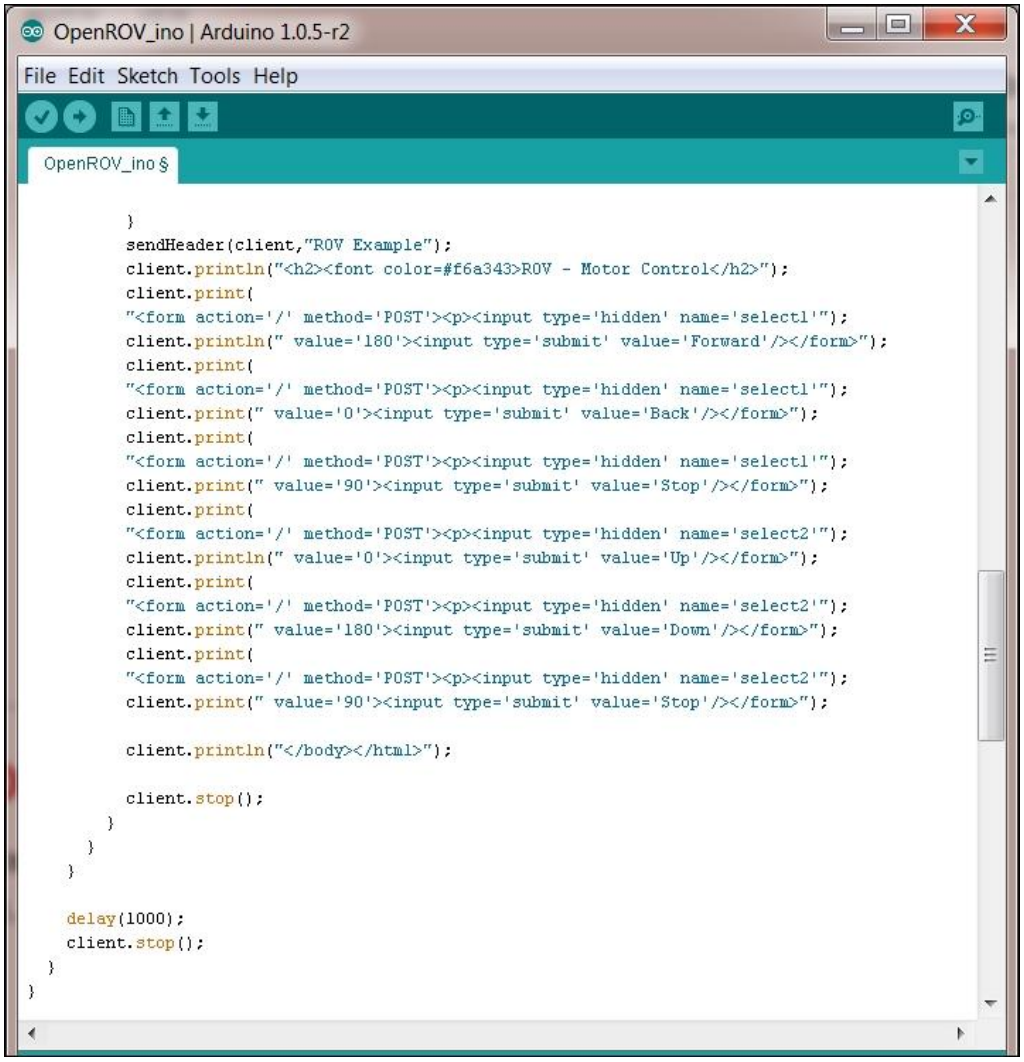
In this example, you'll use some simple code to control the speed of the four motors: two to move the ROV forward and backward and two to move the ROV up and down. The following screenshot shows the first part of the Arduino sketch, the initialization part:



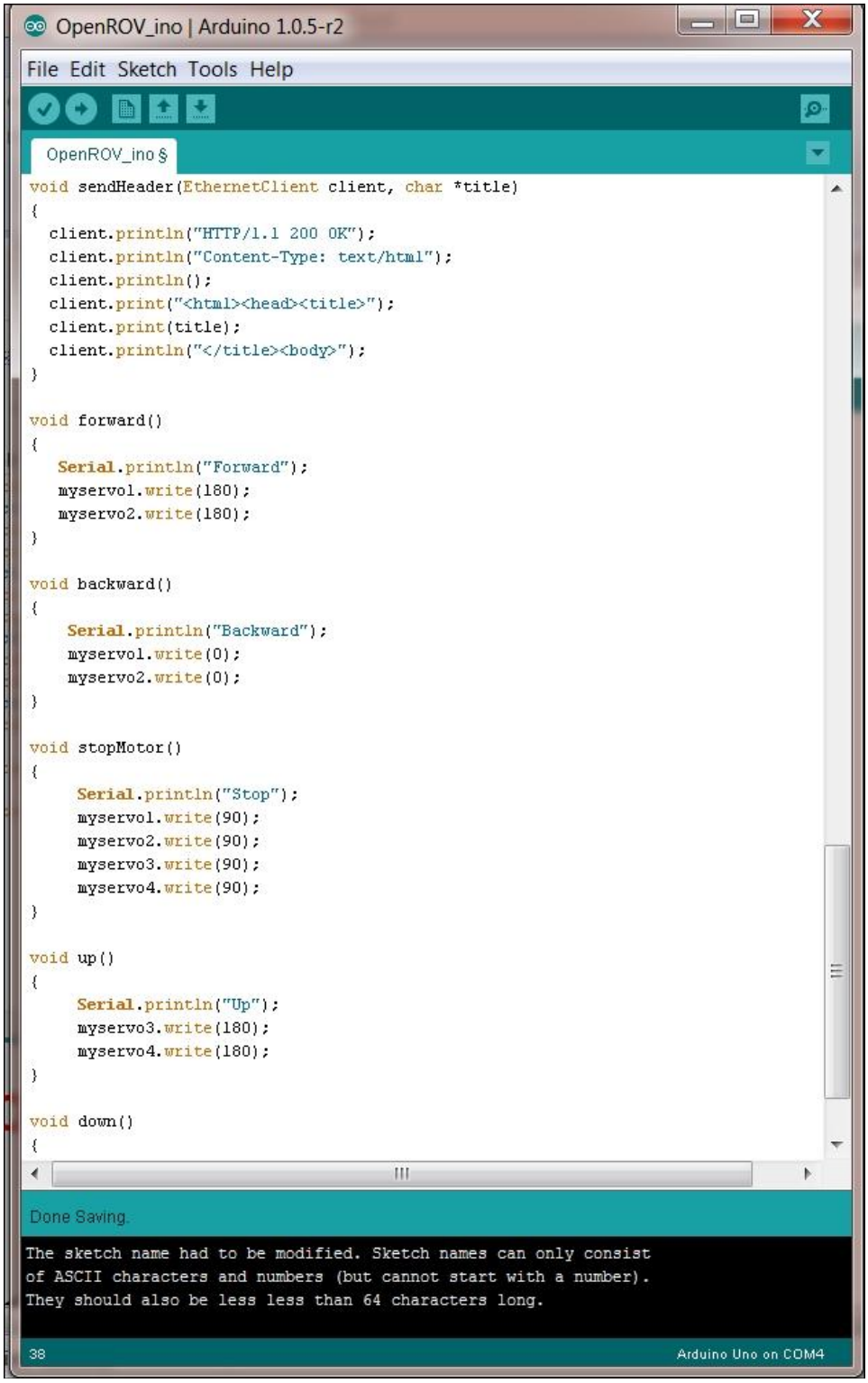

This sets up the web configuration and declares all of your servos to control the four motors. The next part is the web server part of the code in the `loop()` function, as shown in the following screenshot:



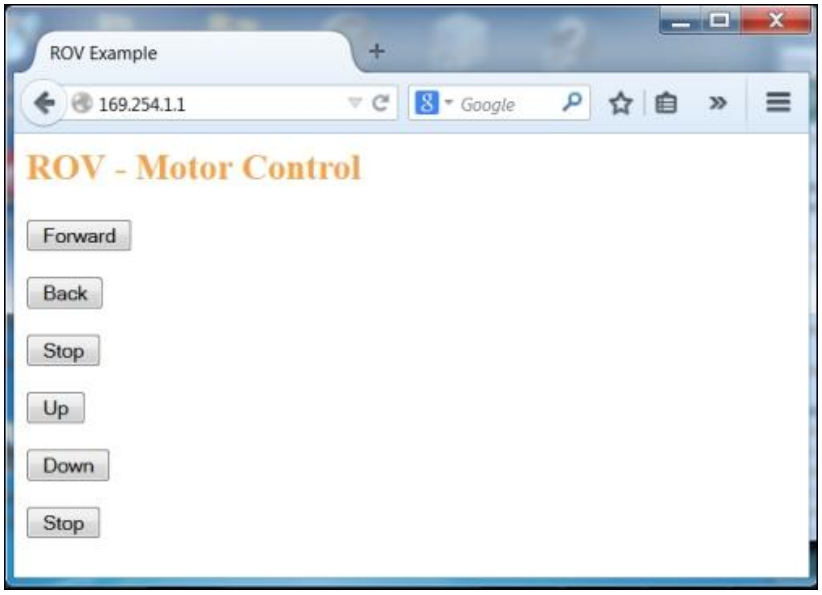

This part parses the input from the web page and calls the functions that cause your ROV to go forward, backward, up, down, or stop. The final part of the loop creates these controls, as shown in the following screenshot:



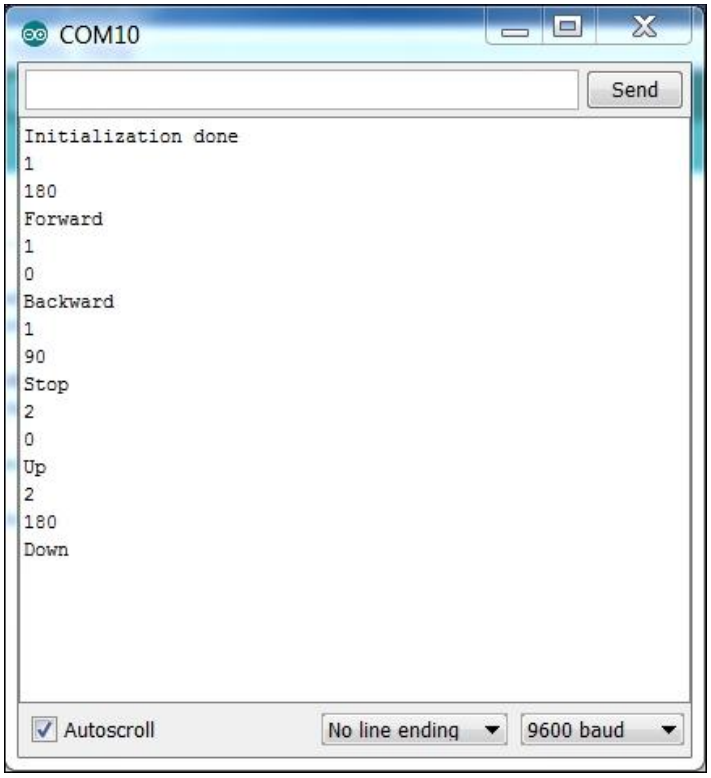

The final part of the sketch is a function to create the header for the web page and the functions to control the motor, as shown in the following screenshot:




You can now run this sketch by first opening the **Serial Monitor** tab and then opening a web page and typing the address at the top of the web page. You should then see the following interface to control the ROV:




In the **Serial Monitor** tab, you should see the commands come through, as shown in the following screenshot:




If your motors are connected to the control pins, as covered earlier in the chapter, your motors should be ready to drive your ROV up, down, backward, forward, or stop all motors. You may have to adjust the settings based on the direction of your motors' spin and also the desired speed.

**Accessing a camera for your project**

Now that you have established connection via a LAN connection, the second capability you'll need is to access a camera to see where you are going. One of the most significant questions is whether or not connecting a camera to Arduino will work in this application. There are several cameras that can be accessed either through a standard UART RX/TX or I2C interface. The following is an image of one such unit, available from RadioShack:

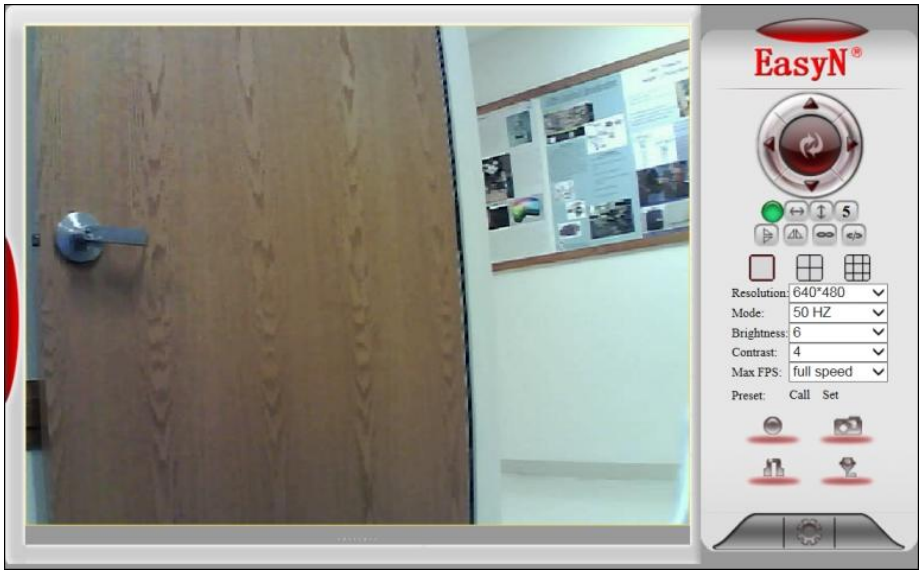
There are two ways to connect the camera. The first is through a UART interface, the other is through an I2C interface. Connecting the camera and getting it to write the images to the SD card interface is a bit daunting, but there is an example sketch available at www.radioshack.com. There is also a tutorial that looks promising at http://makezine.com/projects/crittergram-capture-cam/. Be forewarned that getting this to work is not easy; there is a significant amount of configuration required.

You will also find that the refresh rate on any Arduino-based camera system will be marginal at best. The challenge is that there is no high-speed bus between the camera and Arduino, and you'll be saving the pictures on the SD card for later transmission.

For this application, I chose a different solution: I purchased an IP camera that I could connect to the LAN cable. The following is an image of the unit:


I chose this particular camera because it is inexpensive, less expensive than camera shields available for Arduino, and its small size made it easy to mount on the ROV. With this particular unit, you can issue commands to turn it from side to side and up and down, and turn on LED lighting, which would make it a good choice for dark situations. If you go with this choice, you will have to add a switch to your ROV so that both the motor control and the camera can connect to the LAN cable from the surface.

Your surface computer will now have two web pages, one to access and control the camera and the web page you just created to control the motors. The following is an image of the motor control web page:




Note that you can change the direction of the camera right from the web page, and you can also turn on the lights. You're now ready to go underwater. Just a word of advice: be prepared to add significant weight to your ROV. I had to add 25 pounds of lead to mine to get it to do anything but bob on top of the surface!