

MEEN 652 Ball-Plate Balancer Manual

The System

The system for the course project is a ball-plate balancer, as shown in Figure 1. The system utilizes a webcam, MATLAB/Simulink, an Arduino, and two servo motors to balance a ball-like object or have it follow a reference. MATLAB/Simulink are used to 1) measure the ball's position through image processing, 2) design and implement a controller to actuate the two servo motors, and 3) send the servo motor control signals over a serial connection to the Arduino.

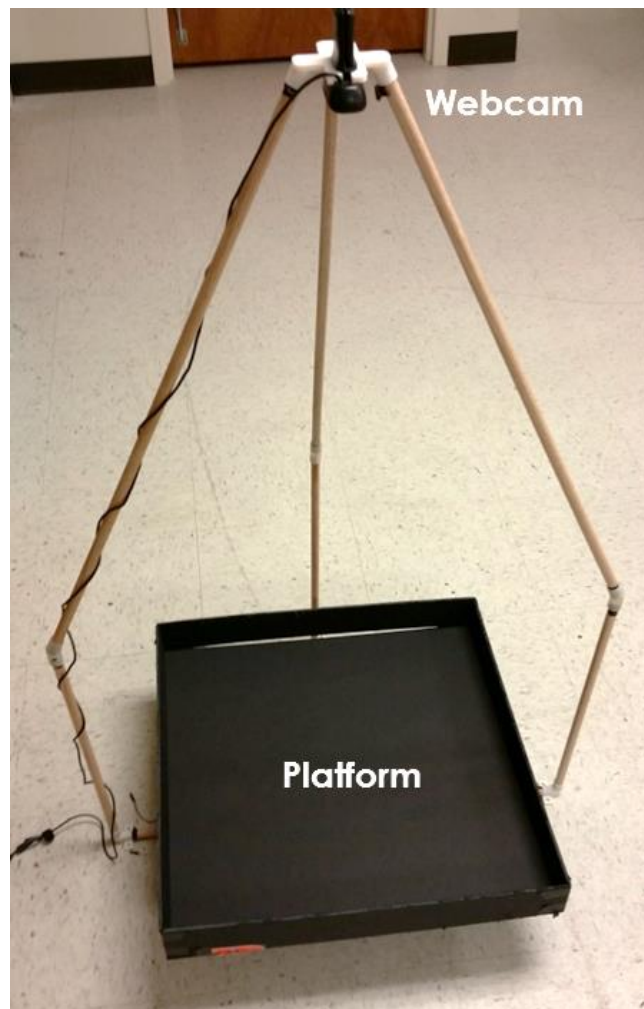


Figure 1 - Ball-plate balancer system

The parts list is as follows:

- Arduino Due
- Micro USB cable
- 5V DC power supply – 2.1mm barrel jack
- Barrel jack to screw terminal adapter
- Bread board
- 10 jumper wires
- 2 Turnigy 9g hobby servo motors (TG9e)
- Logitech USB Webcam (C310)

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- Hardwood dowels cut to length
- Misc. hardware to assemble structure
- 3D printed parts for structure
- Platform for ball to roll on (not to exceed 20"x20", without changing the length of dowels)
- Ball-like object to control

Everything but the platform for the ball and the ball itself is being provided by the department. It is up to you to decide on and make a platform. The easiest way to attach the platform to the structure is with double-sided tape (see Figure 2), though if this is not substantial enough, something else can be figured out. Additionally, you want to choose the color of the platform so that there is a strong contrast between the platform and the ball, so it can be easily identified.

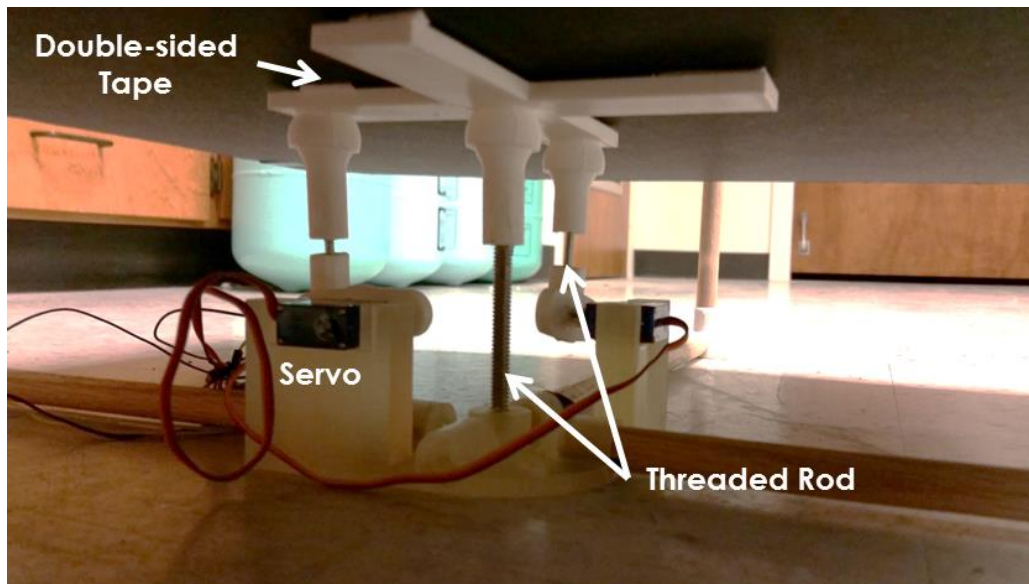


Figure 2 - View of actuation and support of plate

Software

You will be provided with a Simulink program that will provide image processing to determine the balls position and communication lines to send control signals to the Arduino. The communication lines to the Arduino have some limits on the parameters due to hardware limitations of the servo motors. The signal you are sending is a value in microseconds, ranging from 1000 to 1900. This range provides full-range of motion for the servo motors (180 degrees), with a little buffer built in on each side as to not torque out the motors. You should use MATLAB r2014a, or newer.

To use the provided Simulink program, webcam, and real-time synchronization block, you will need a few required drivers. The webcam driver for the Logitech c310 webcam can be found at <http://support.logitech.com/product/hd-webcam-c310#download>. Within your MATLAB installation, you will need to install a generic webcam capture driver by following the instructions at this link: <http://www.mathworks.com/help/imaq/installing-the-support-packages-for-image-acquisition-toolbox->

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[adaptors.html](#). When asked for which adaptor to install, select “winvideo”. Lastly, you will need to follow the directions at this link for the real-time synchronization block:

<http://www.mathworks.com/help/rtwin/ug/real-time-windows-target-kernel.html>. If the command “sldrtkernel” is undefined, then replace it with the command “rtwintgt”, which has been replaced by “sldrtkernel” in newer versions of MATLAB.

In addition to the Simulink program, you will be given code to be uploaded to the Arduino Due for receiving serial information from Simulink. To upload this software, you will need the Arduino IDE, which can be found here: <http://arduino.cc/en/Main/Software>. Install the software, connect the Arduino Due using its programming port (see Figure 3), and then open the IDE.

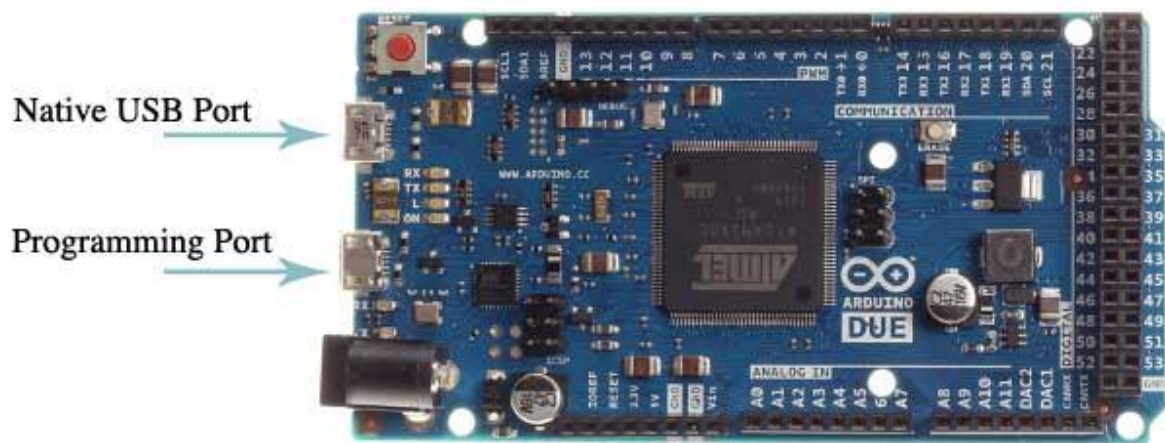


Figure 3 - Arduino Due

Navigate to the *Tools>Board* menu and select the *Arduino Due (Programming Port)*.

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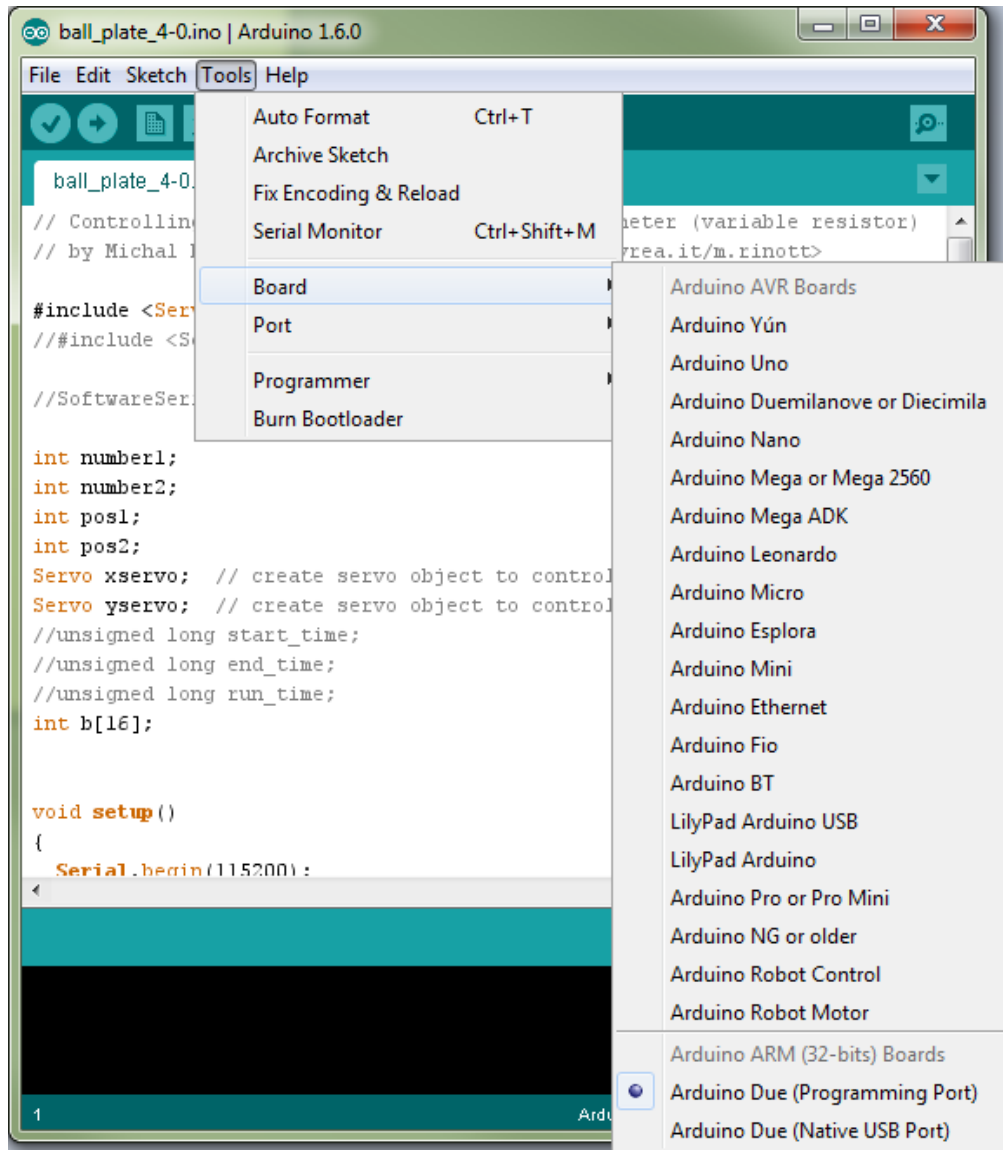


Figure 4 - Arduino IDE board selection

Next, navigate to the *Tools>Port* menu and, if the drivers for the Arduino Due installed correctly, you should see a COM port listed. Select the COM port that matches with the Arduino Due. If more than one are visible, unplug the Arduino Due, take note of the port numbers available, and then plug it back in. The new port number is associated with the Arduino Due.

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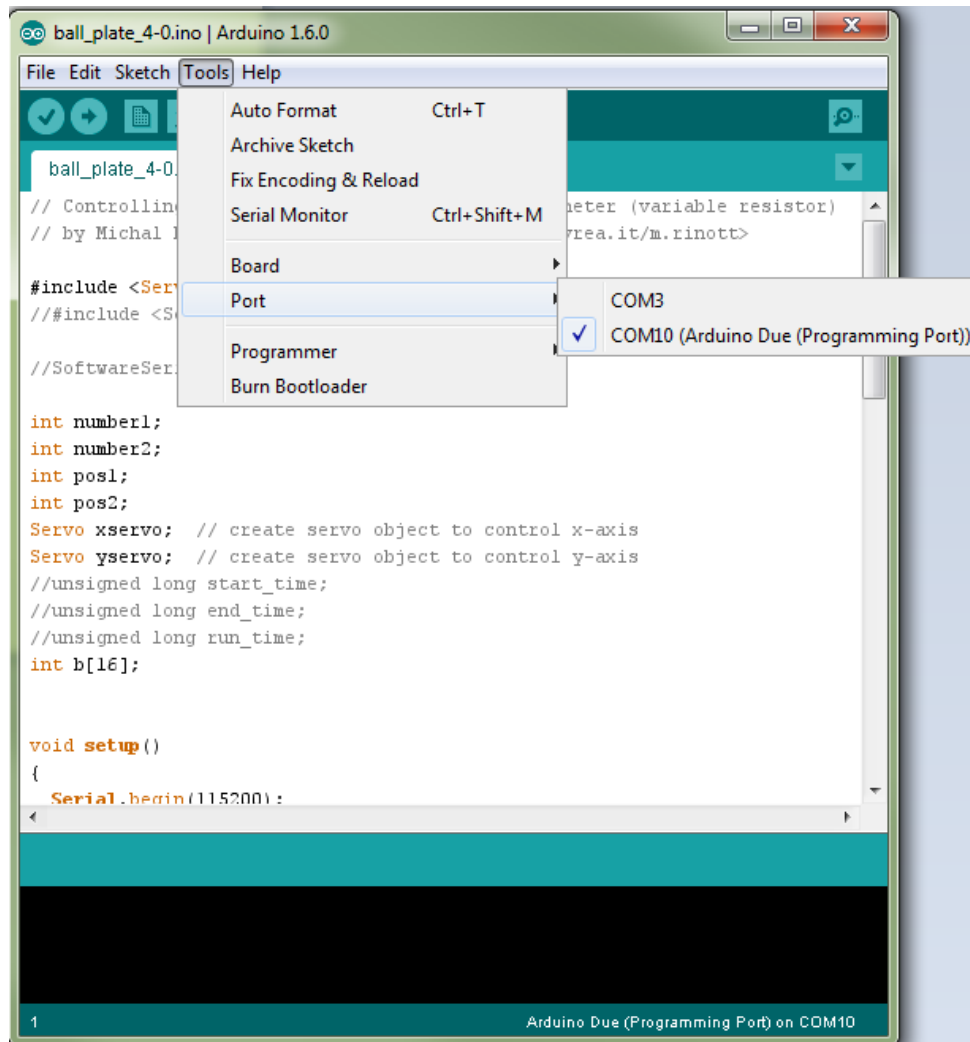


Figure 5 - Arduino IDE port selection

Once you have the correct board and port selected, you can upload the code by clicking the upload button in the top left corner, highlighted in red below.

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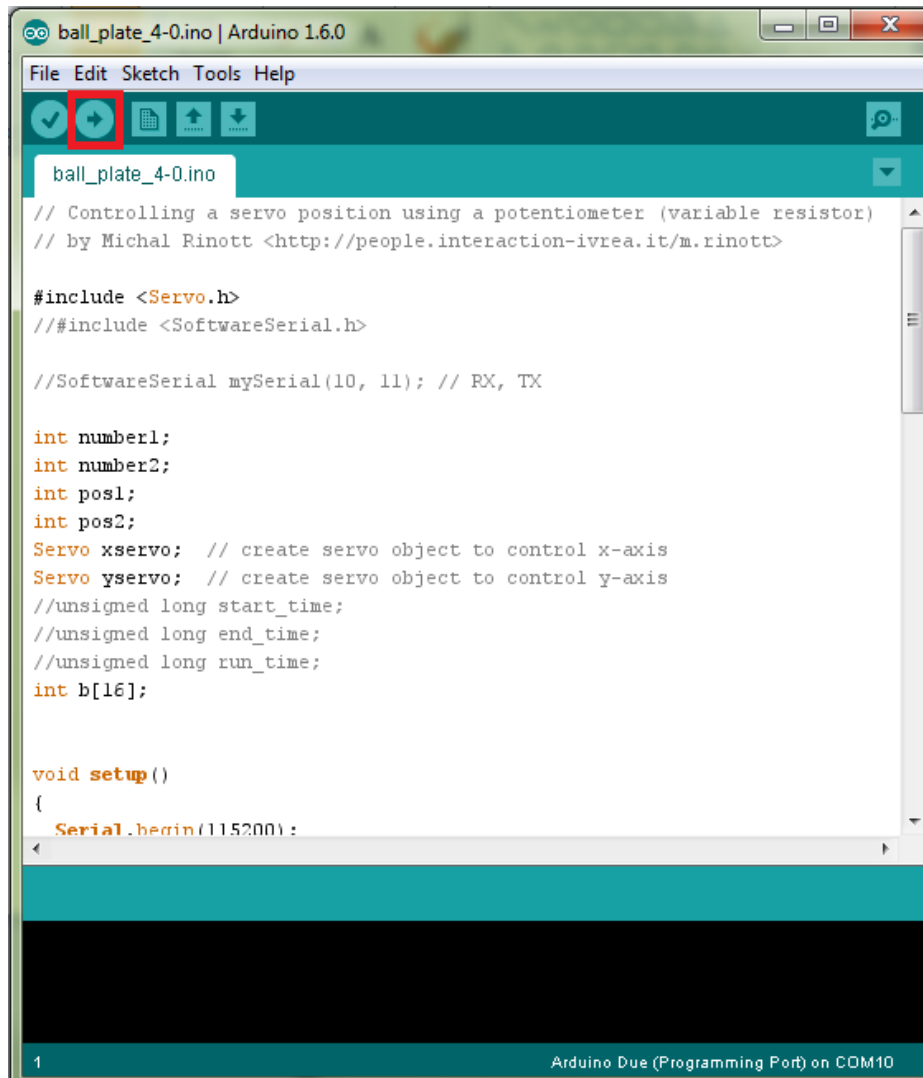


Figure 6 - Arduino IDE upload button

Now you will want to physically change ports on the Arduino Due to the Native USB Port, see Figure 3. Using the Arduino IDE, select the Native USB port options under the *Board* and *Port* menus. Take note of the port number, as we will need this for the Simulink configuration.

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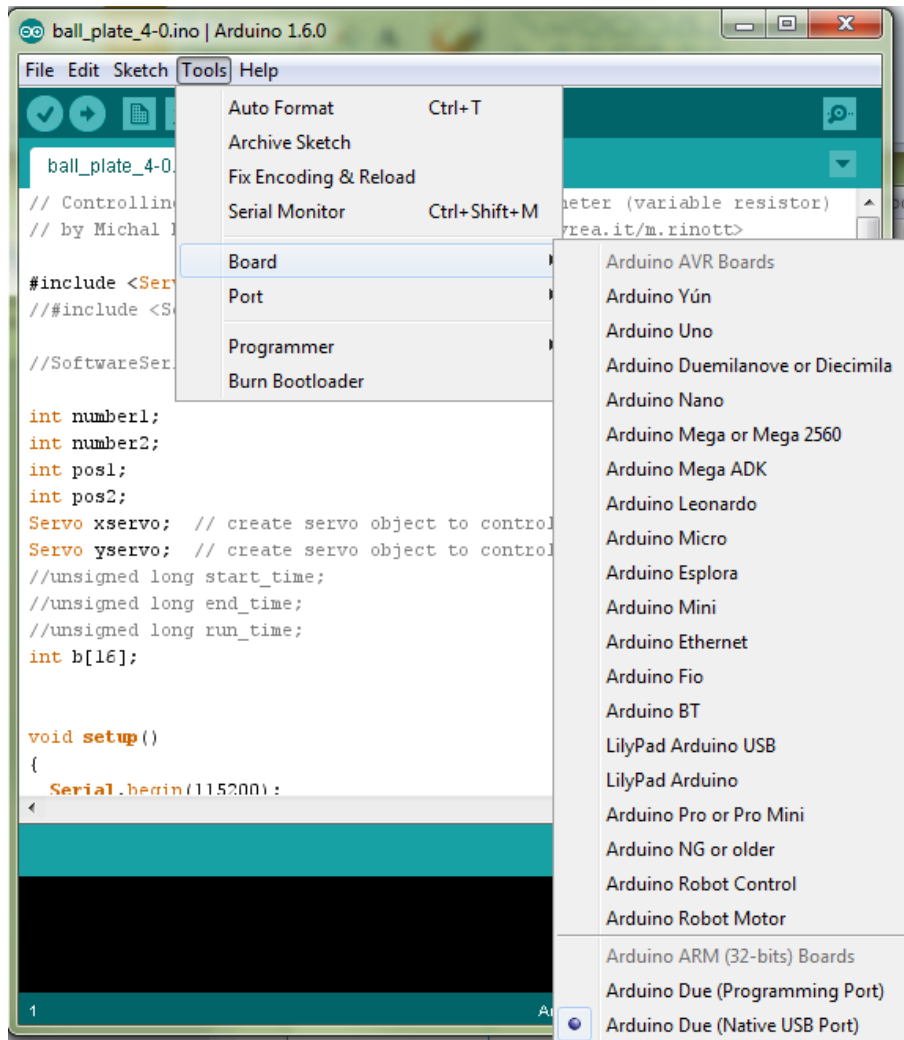


Figure 7 - Arduino IDE board native USB port

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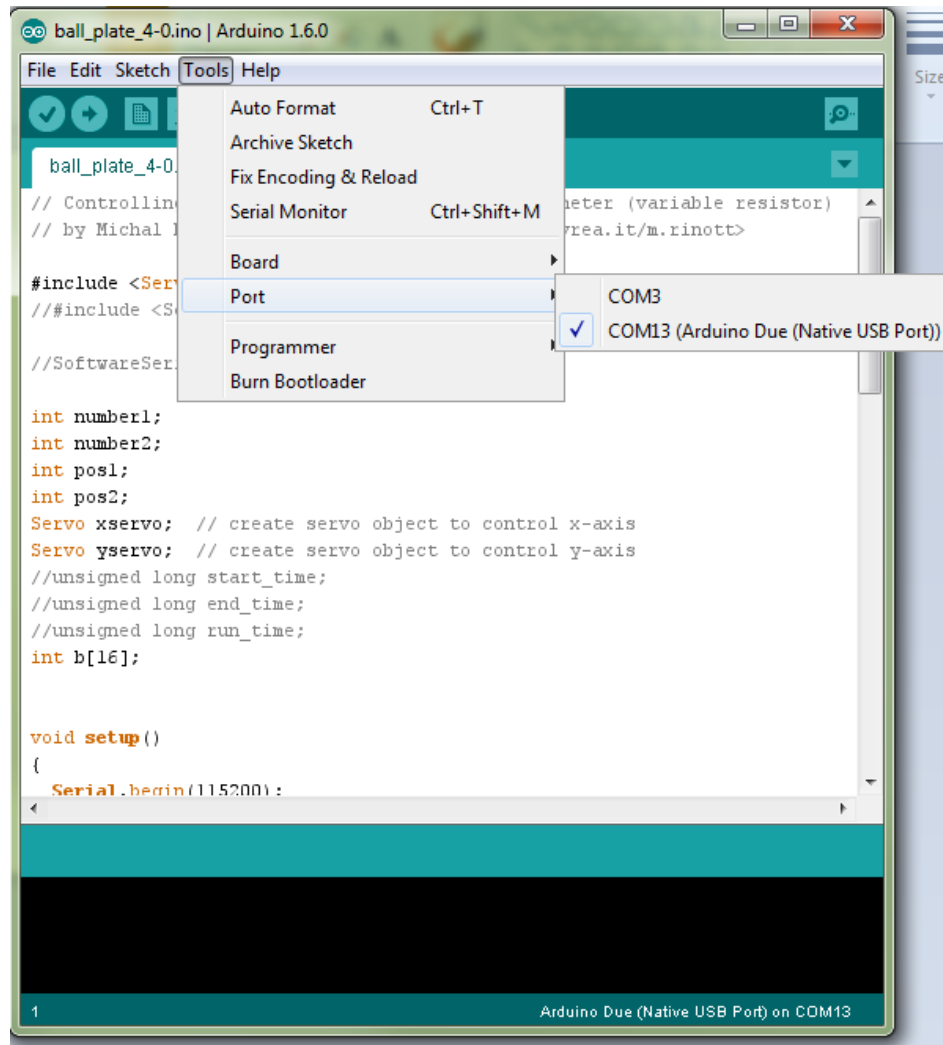


Figure 8 - Arduino IDE native USB port

Now before starting MATLAB and opening the Simulink file, ensure you have the Arduino Due and the Logitech webcam plugged in, or they will not be available in the Simulink environment. Start MATLAB and open the Simulink file. First, select the Logitech C310 webcam by double-clicking on the “From Video Device” block and selecting the webcam from the “Device” drop-down menu.

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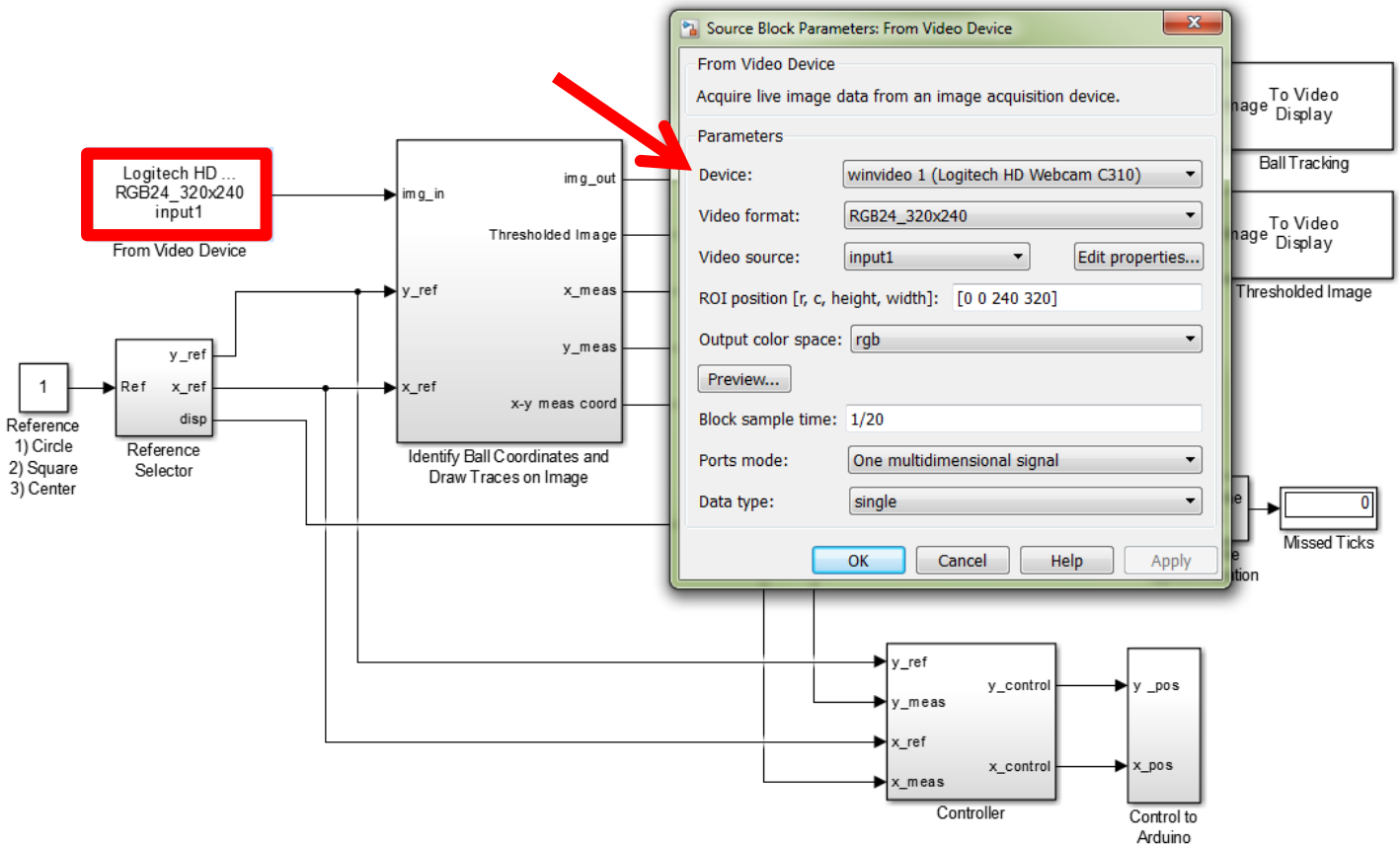


Figure 9 - Select correct video device in Simulink

Click “OK”. Now we will want to set the serial port for the Arduino in Simulink. Double-click on the “Control to Arduino” block. Then double-click on the “Serial Send” block Using the “Communication port” drop-down menu, select the COM port we identified earlier using the Arduino IDE, in this case, COM13.

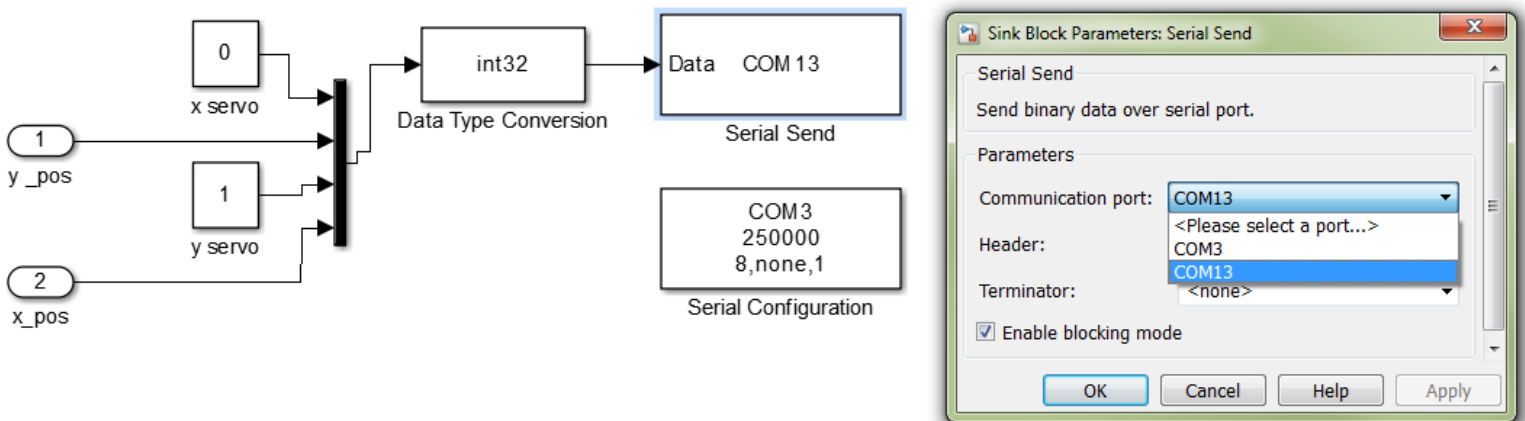


Figure 10 - Selecting the correct COM port for the Arduino

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Simulink may ask if you want to add a “Serial Configuration” block, but click no. We are going to just modify the one that is already there. Double-click on the “Serial Configuration” block and select the same port as you did for the “Serial Send” block.

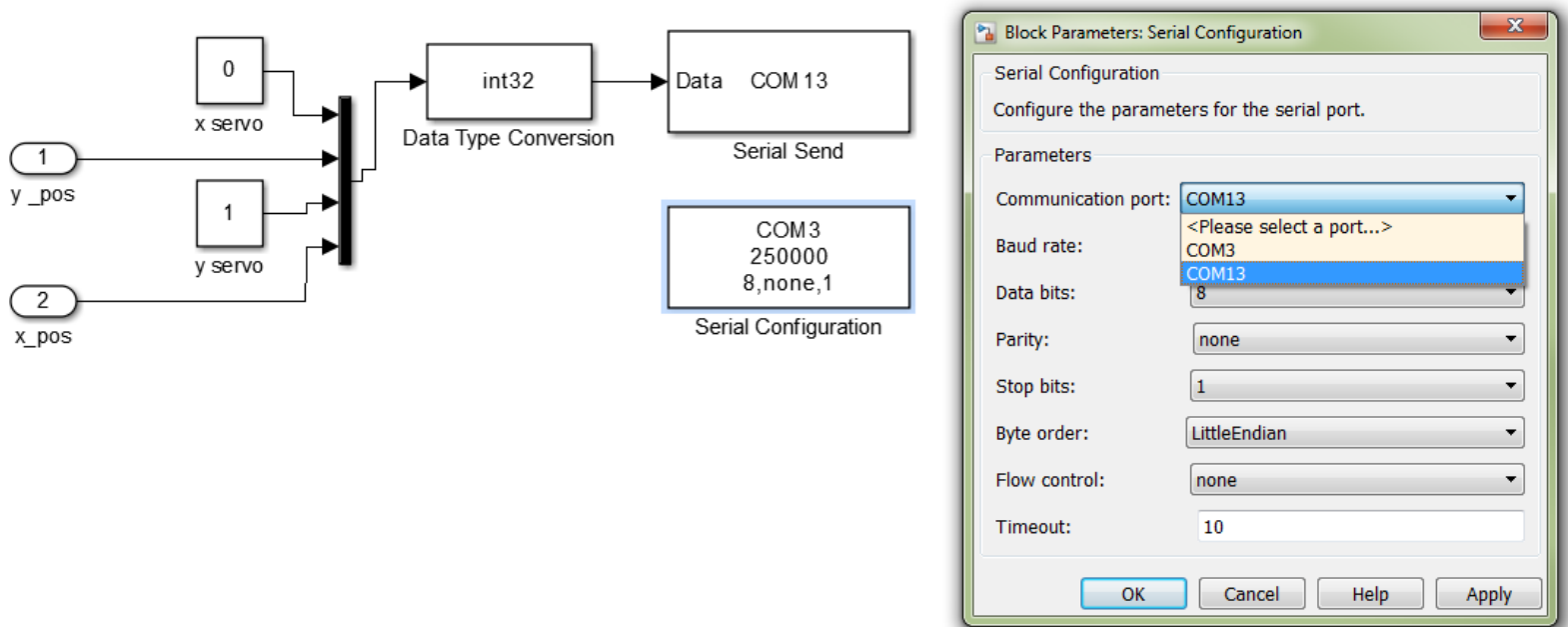


Figure 11 - Selecting the correct COM port for the Serial Configuration

Now you should be ready to go once you have implemented your own controller within the controller block, shown in Figure 12.

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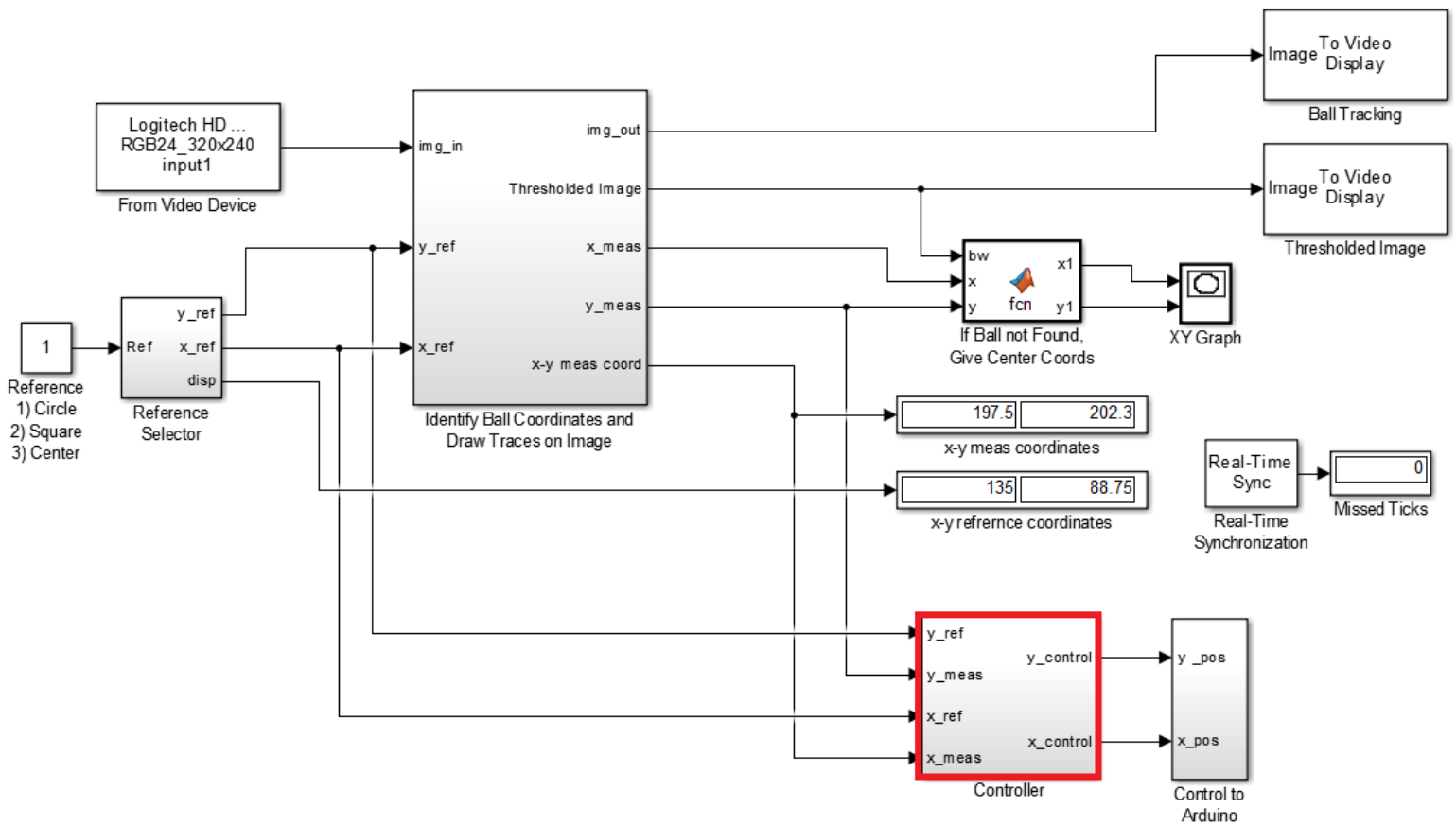
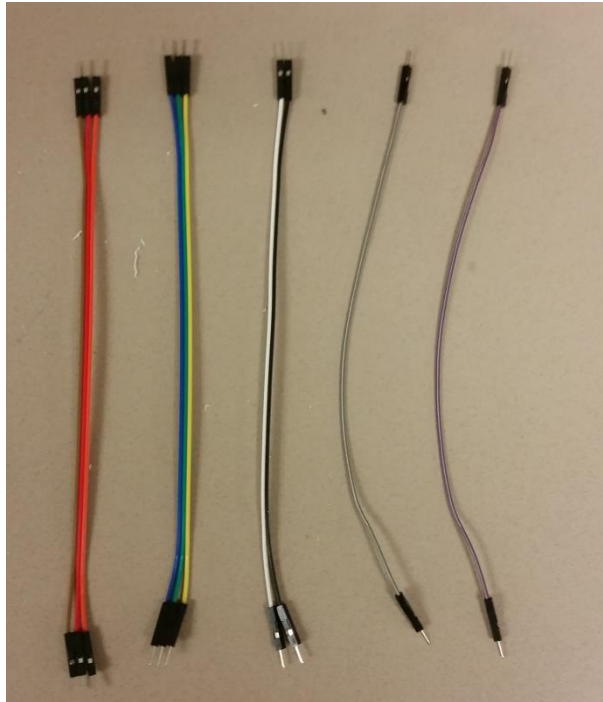


Figure 12 - Simulink code

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Electrical Connections

First, separate your wires into the following groups: 2, 3, 3, 1, and 1.

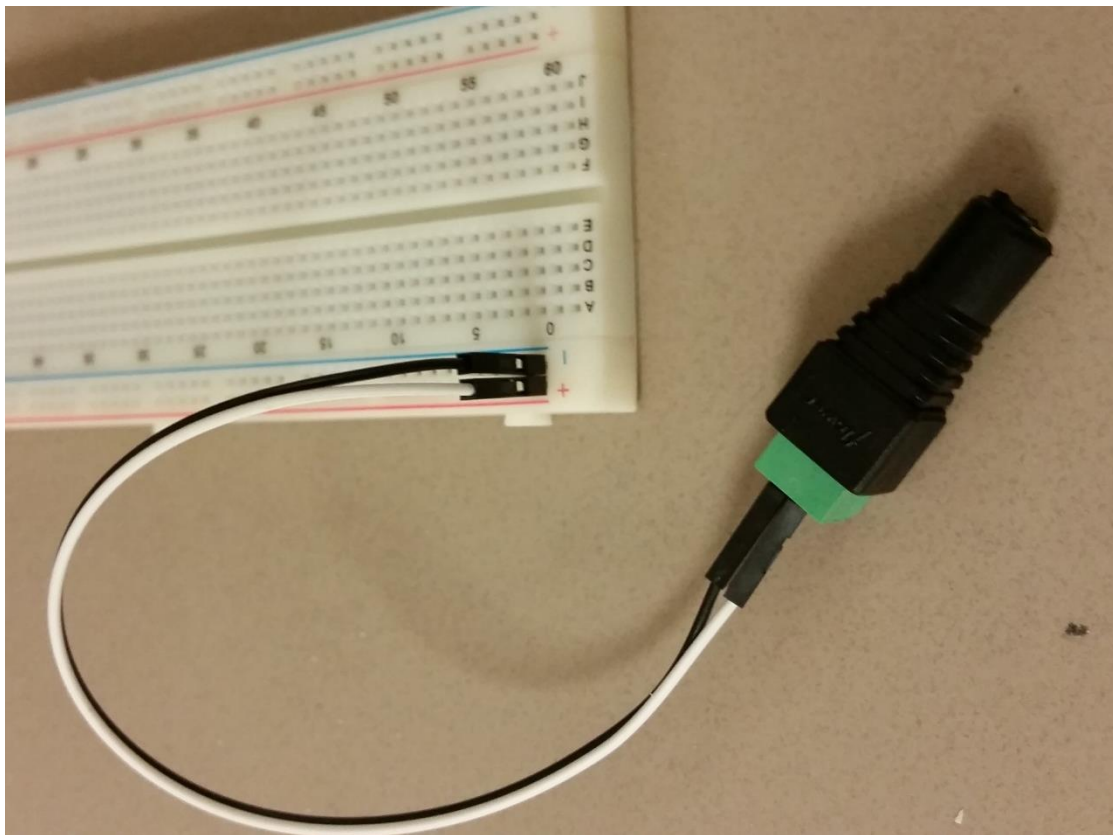
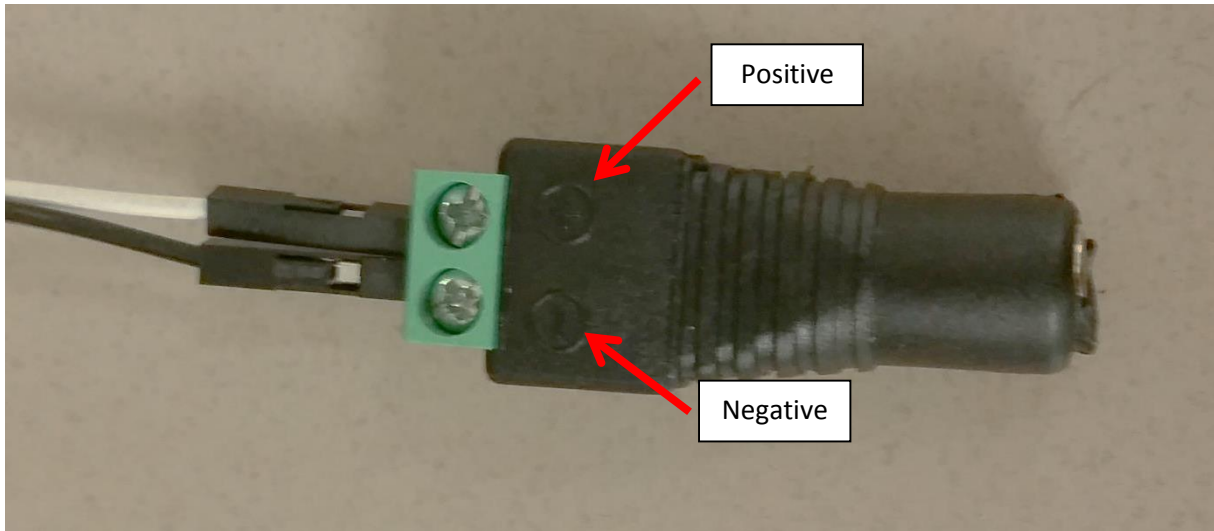


Using the 2-wire segment and a small screw driver, secure the ends of the wire in the screw terminals of the barrel-jack adaptor.



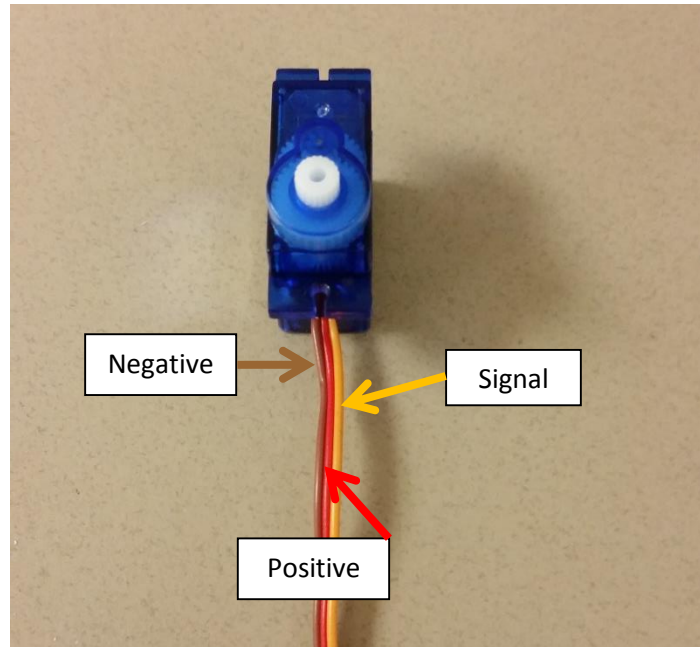
Noting the color of the wire connected to the positive side of the adaptor, plug the same wire into the positive (plus) rail on the breadboard. Plug the ground (negative) wire into the negative rail of the breadboard.

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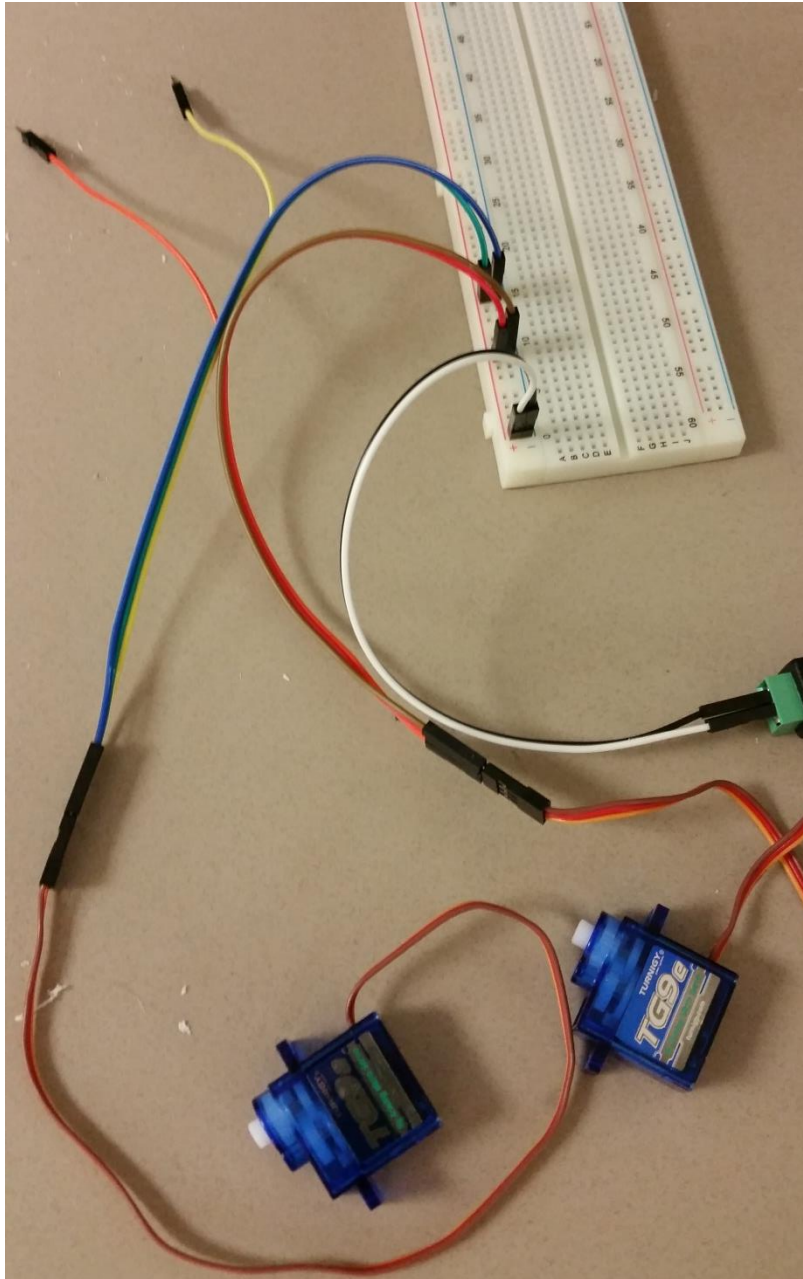
Next, connect the servo motors to breadboard and Arduino. The servos have 3 wires: the brown one is the ground, the red one is the positive, and the orange/yellow one is the signal.

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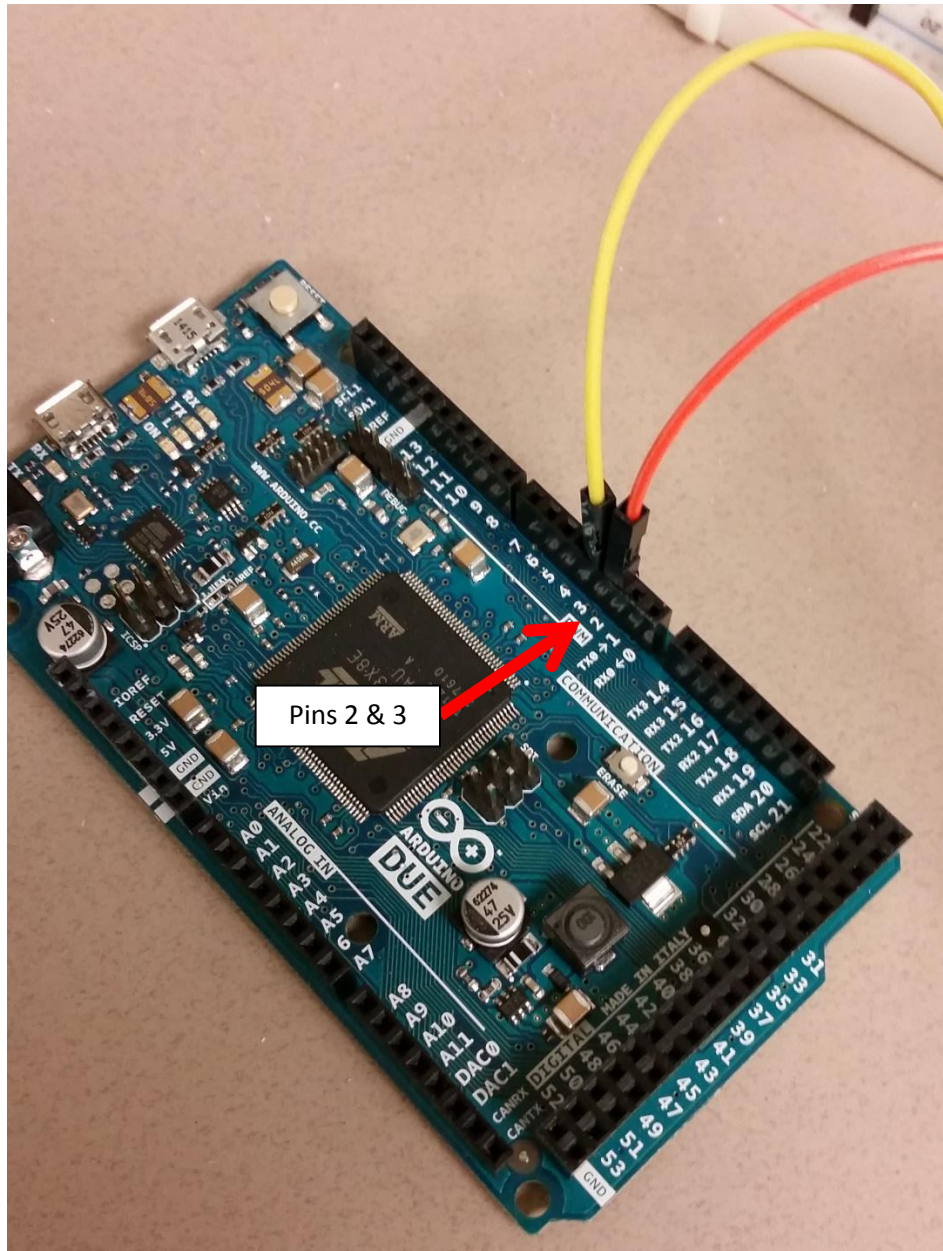
Using the two 3-wire segments, connect the servos to power and ground on the breadboard.

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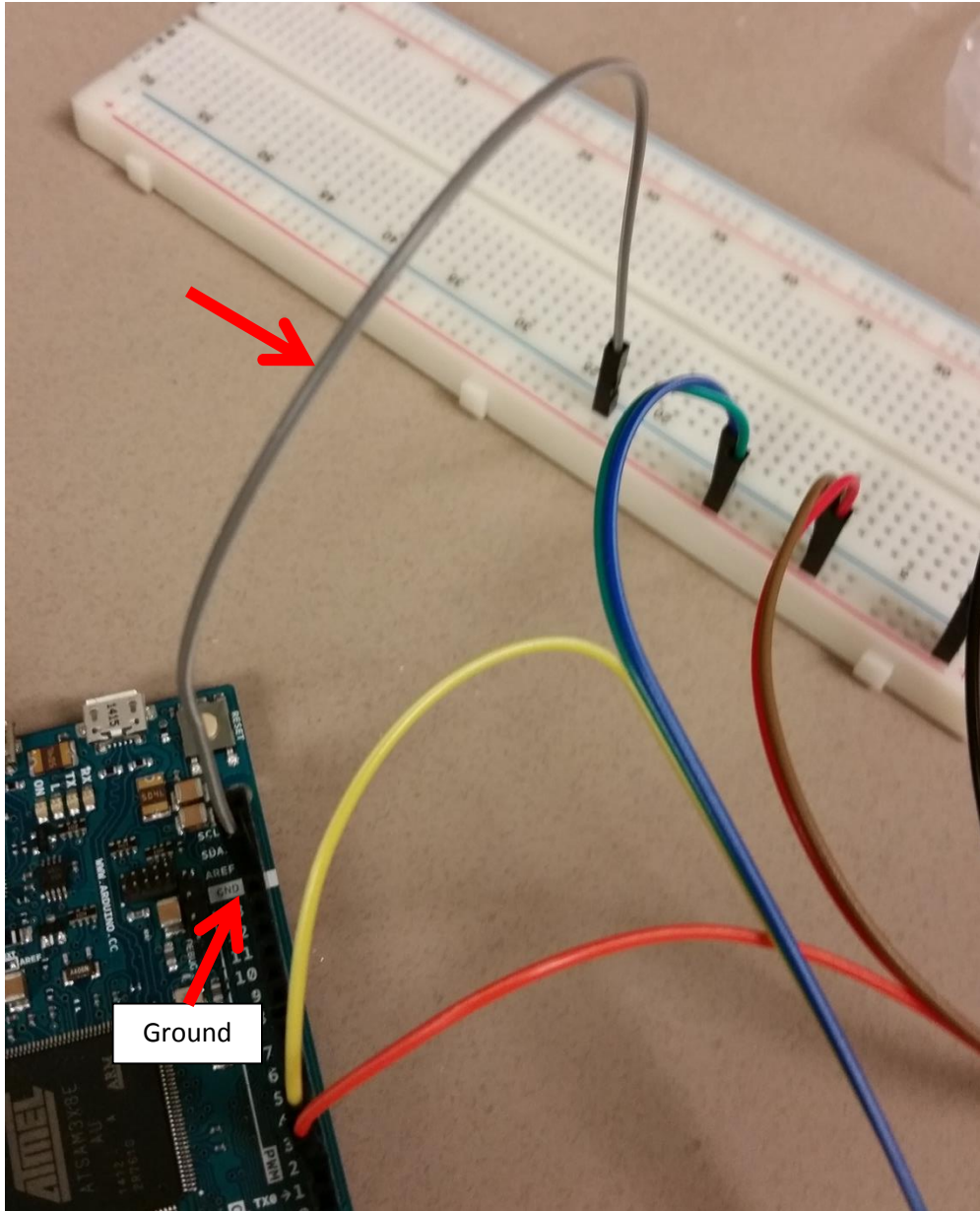
Also connect the signal wires to pins 2 and 3 on the Arduino.

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The last connection that needs to be made is connecting the grounds of the servo power supply. Using one of the 1-wire segments, plug it into the ground rail on the breadboard and then one of the several grounds on the Arduino, any will work.

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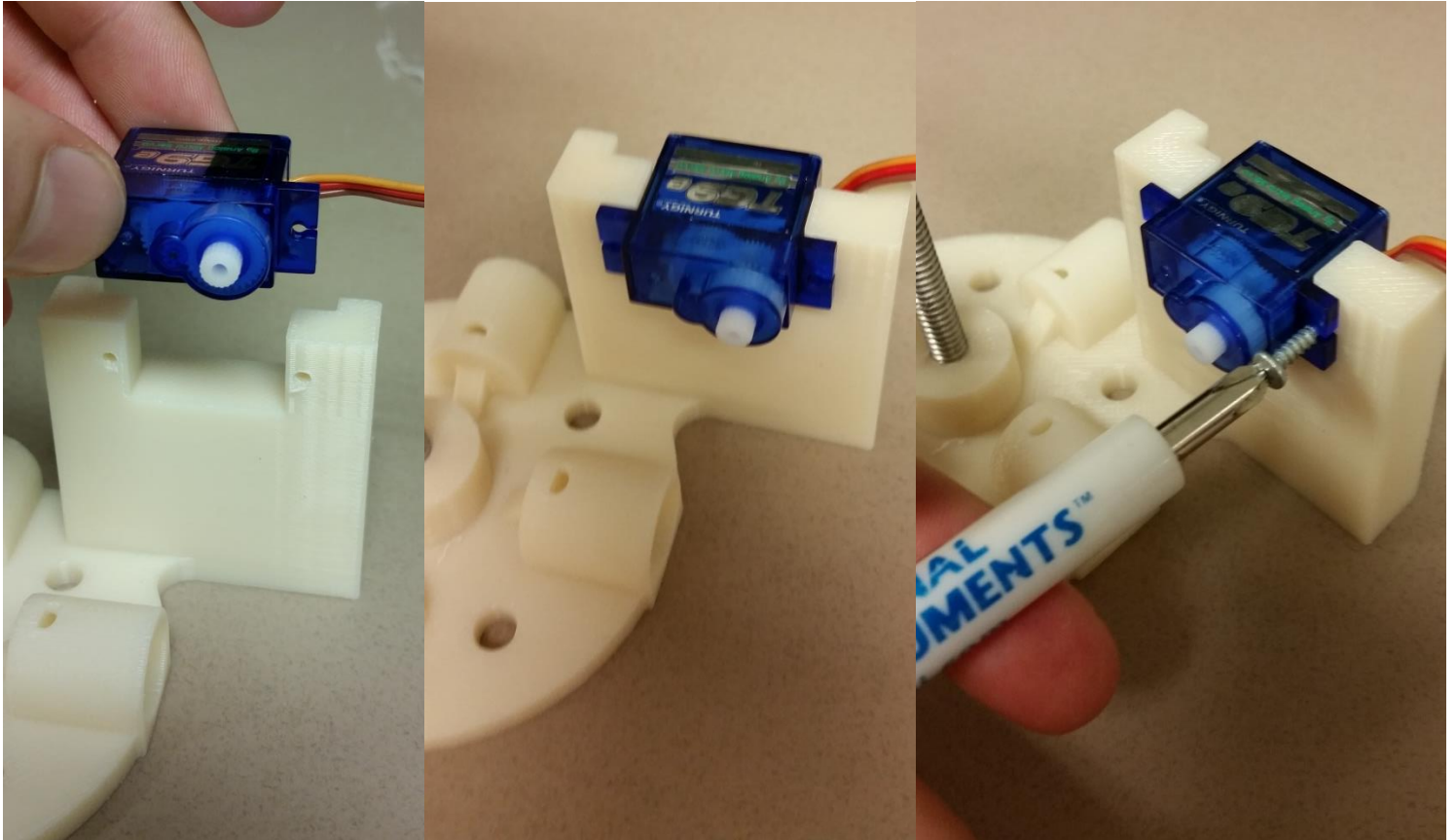


When you are ready to start controlling the motors, you can plug in the power supply.

Structure Assembly

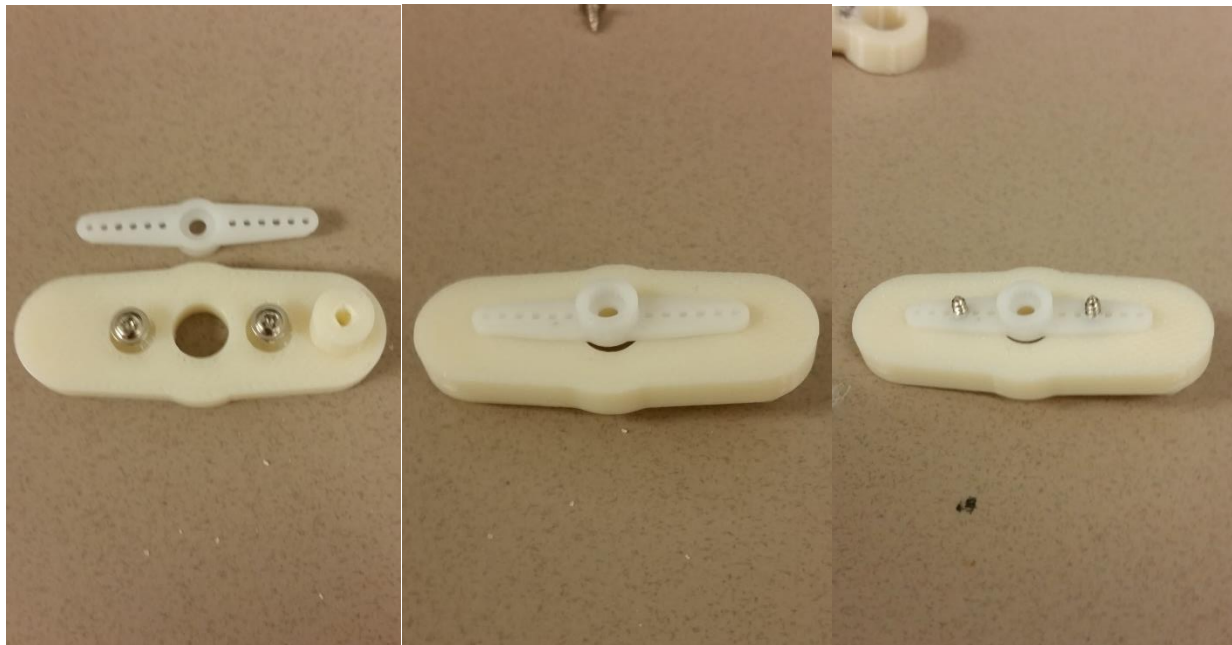
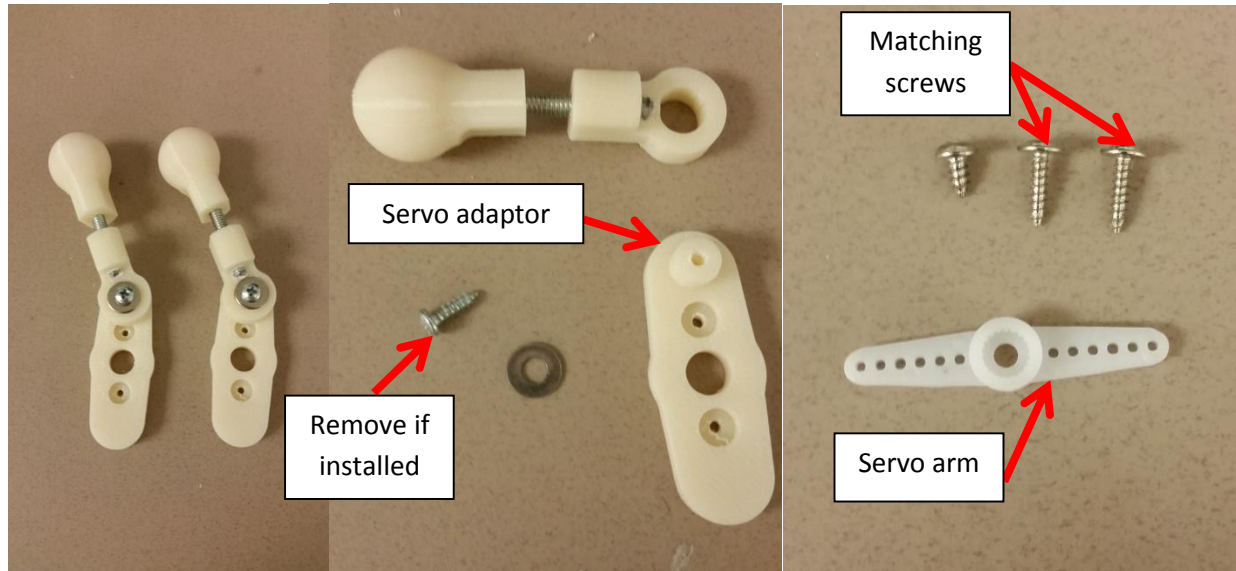
First, begin by attaching the servo motors to the main base assembly. Make sure that the output of the servo is farther away from the center of the base.

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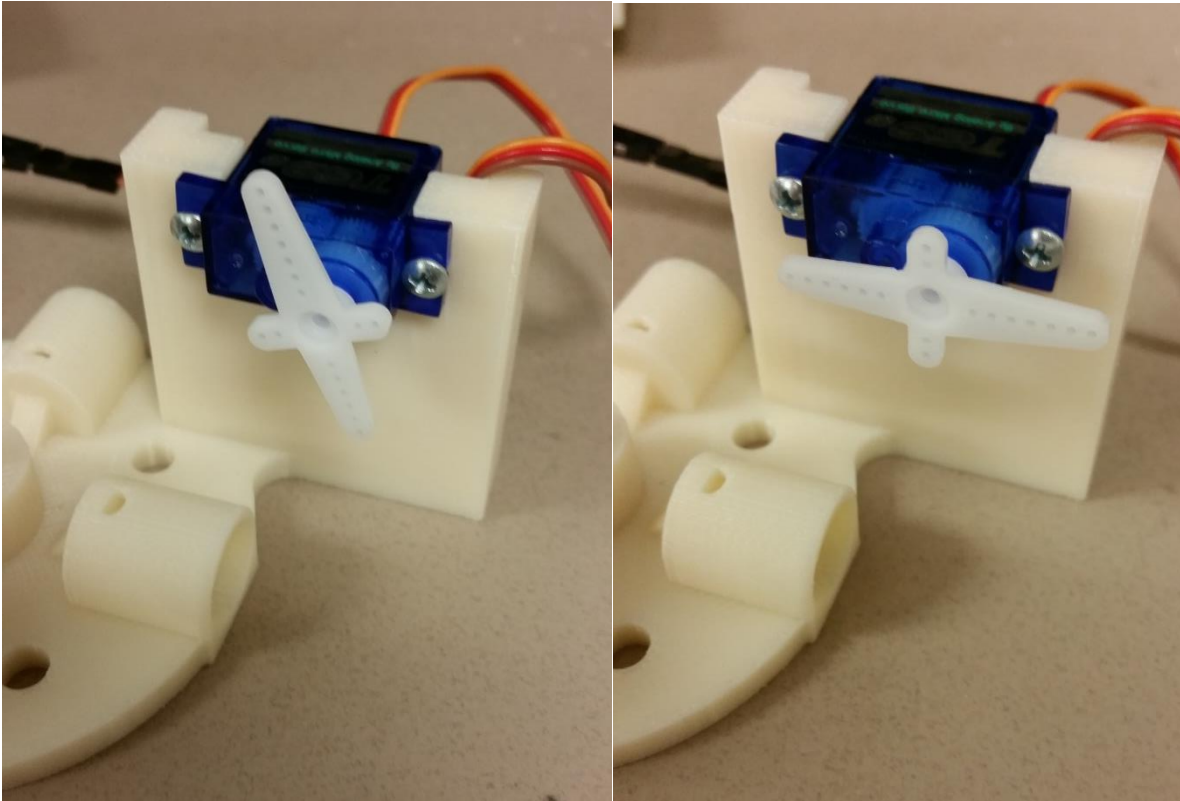
Next, remove the screw/washer from the servo adaptor (if installed) and using the two small matching screws from the servo bag, attach the servo arm to the servo adaptor. Make sure the servo arm is centered on the servo adaptor with the geared sleeve pointing away from the servo adaptor. Be careful installing these smaller screws, as they can strip easily. Be sure to get the servo arm pulled down tight against the servo adaptor.

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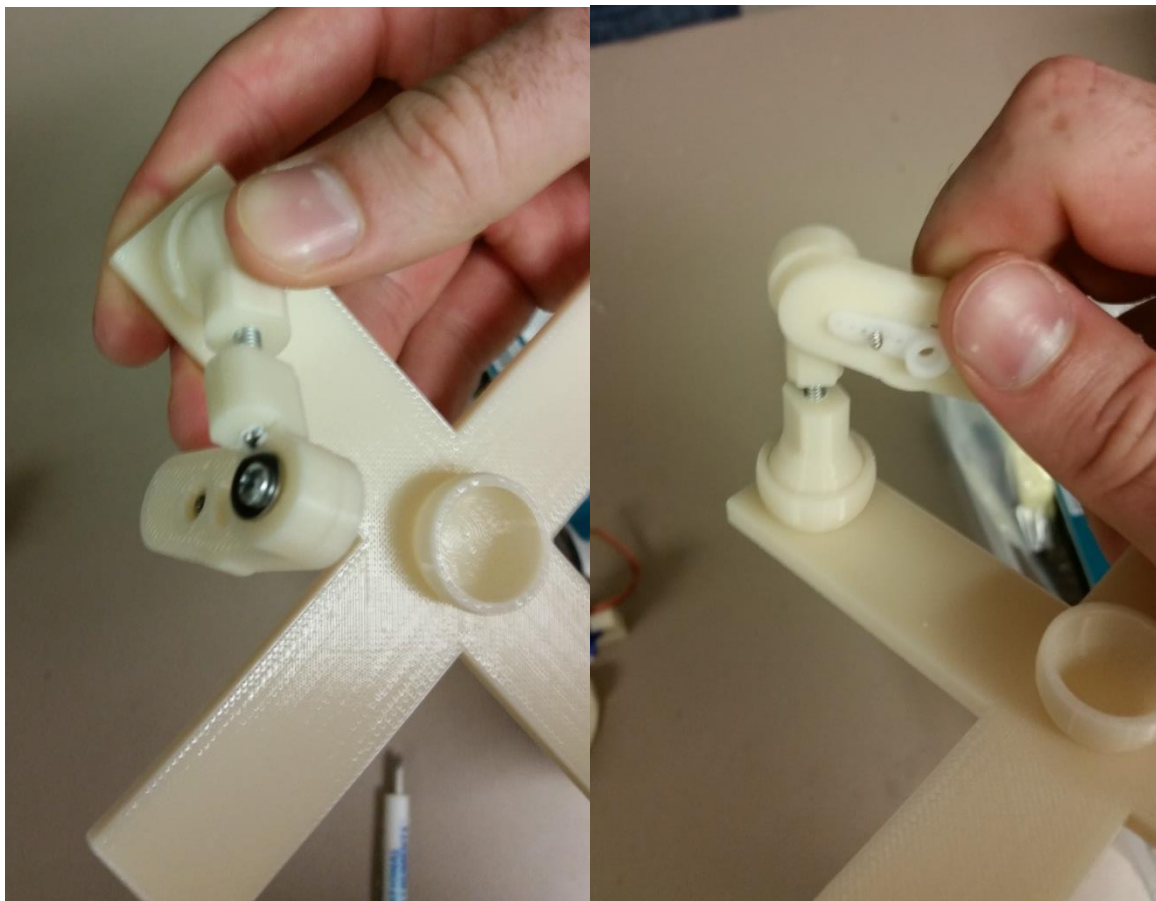
Using a spare servo arm from the pack, ensure your motors are in the middle position. You can do this by pressing the servo arm onto the motor and rotating it to find the extremes. Reattach the servo arm so that at one of the extremes, the servo arm position is a little past vertical. Then rotate the servo arm back to horizontal.

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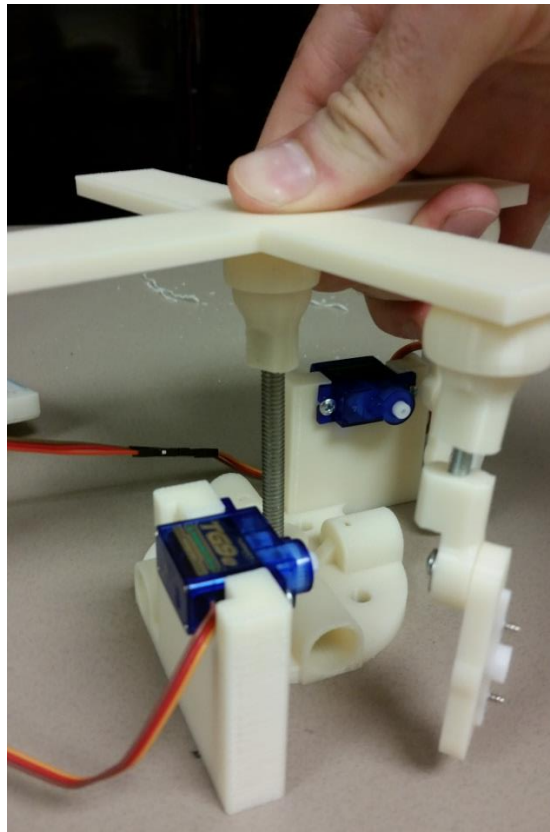
Reassemble the servo adapter and servo link. Push the servo links into the plate support until they pop into place.

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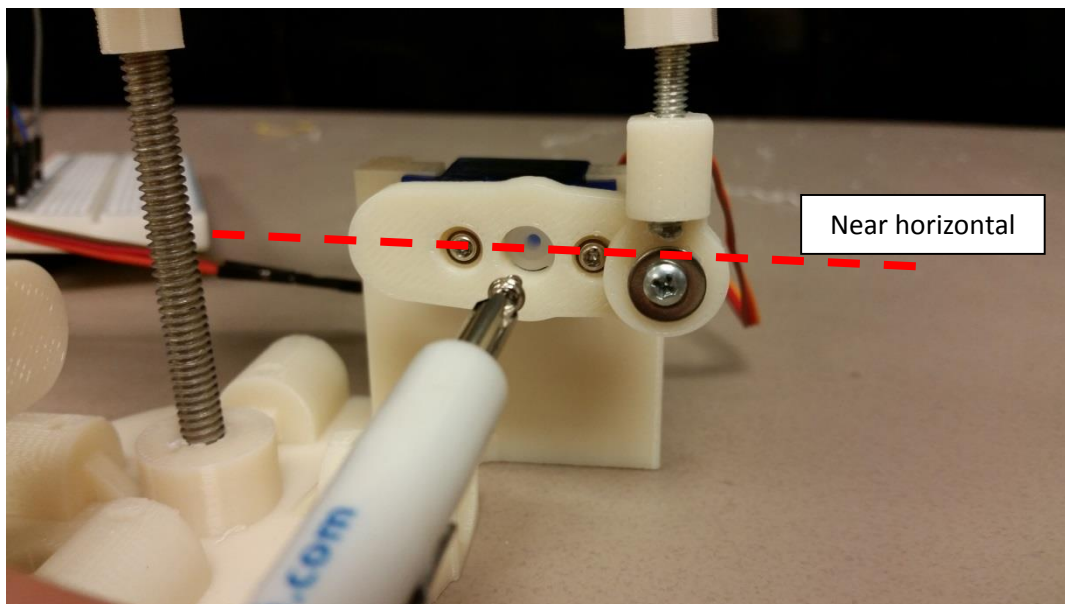


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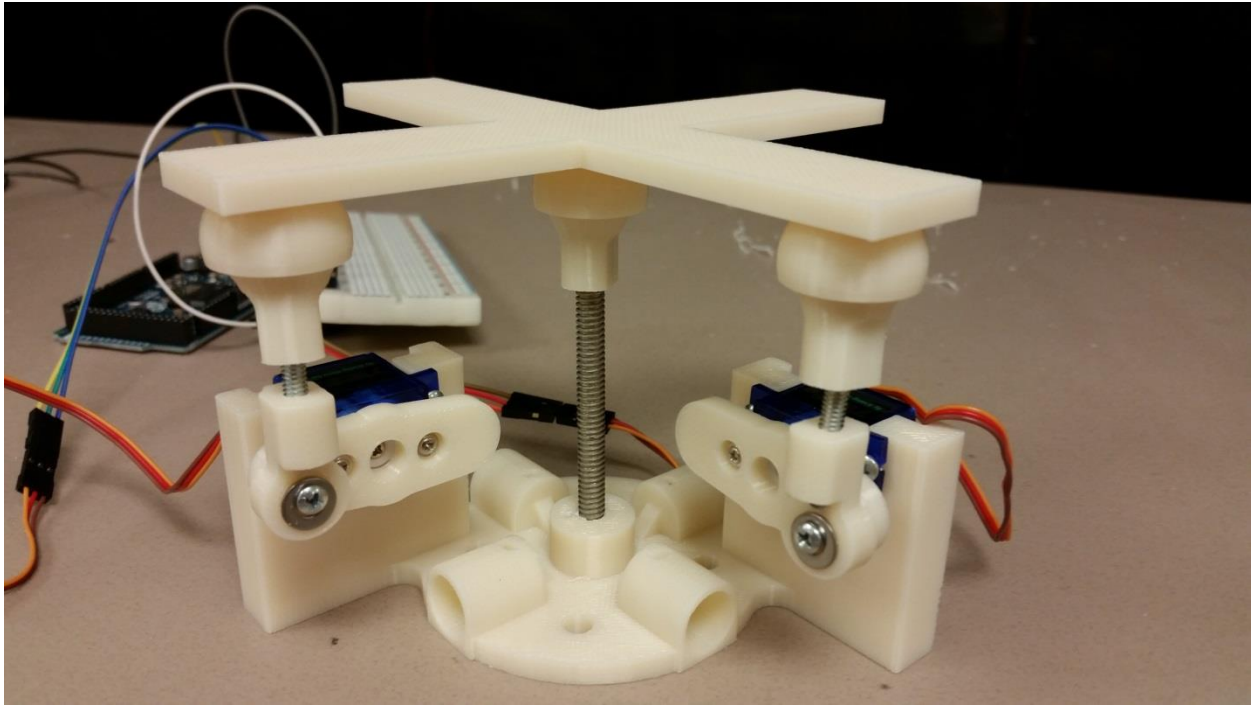
Attach your plate to the plate support (double-sided tape works great). Next, press the plate support onto the main base support ball until it snaps into place.



Attach the servo arms to the servos using the other small screw from the servo bag, making sure the servo adaptors are near horizontal.

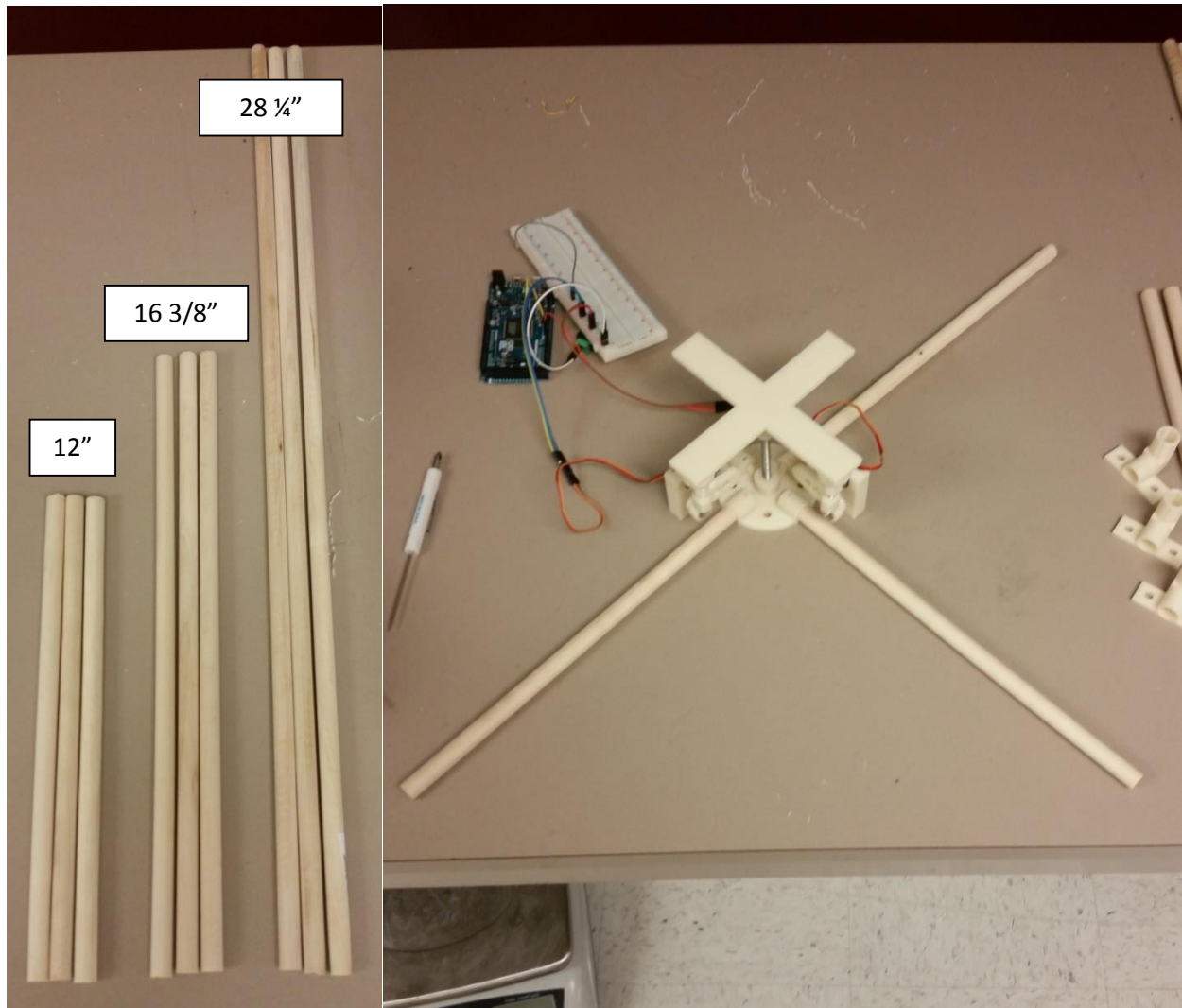


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Now you can assemble the structure to support the camera. Using the 12" segments of wooden dowel, slide them into three of the four holes on the main base assembly.

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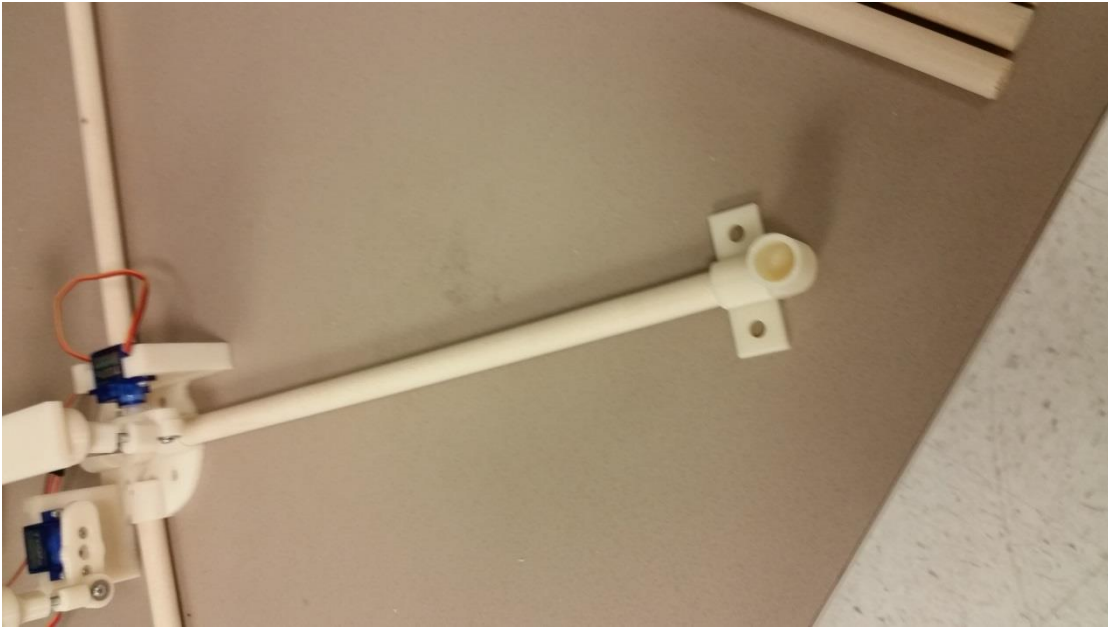


If your wooden dowels do not fit tightly, you can wrap a little bit of duct tape or electrical tape around the end to provide a tight fit.

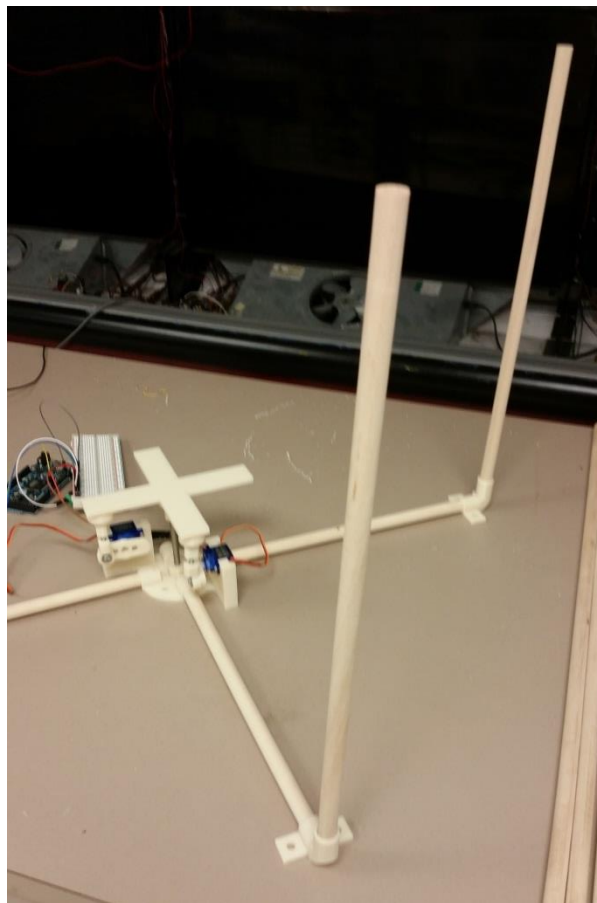


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On the other end of these dowels, slide on the corner pieces.

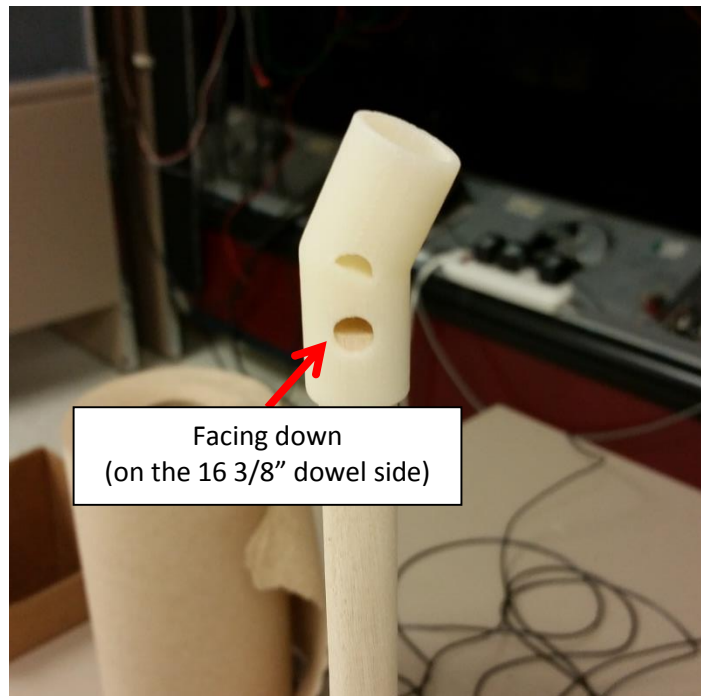


Now slide the 16 3/8" dowels into the corners pieces.



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On the top of these dowels, slide on the angled couplings, with the angle pointing towards the center of your plate. Make sure the round cutout is facing down.



Slide in the 28 1/4" dowels into the angle couplings, and insert the other ends into the camera holder.



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You can simply slide the camera into the camera holder. The fitment allows some minor adjustment of the camera, which may be necessary to center your plate. Your kit is now assembled.

