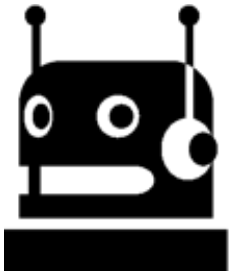
PicassoBot

Robotic Drawing Arm Kit

BUILD INSTRUCTIONS

V 3.4



The Educated Robot

TEACHING WITH ROBOTICS

There are several pieces that make up the full kit. These include:

- The robot parts
- PicassoBot Firmware (software on the robot arm)
- Energia IDE (for editing and loading the firmware)
- PicassoBot Simulator (software for controlling the robot)
- Processing IDE (to run the simulator software on the computer)

All of the software components can be downloaded from the website at:

http://educatedrobot.com/picassobot

PicassoBot Hardware Parts

Let's begin building the PicassoBot. We will start by making sure that we have all of the pieces we need. Open the box and lay all of the parts out. They should be in smaller bags to keep them clean and protected.

The parts list for a robot project, or any other electronics project, is sometimes called a BOM - or bill of materials. This is a list of all of the parts, what they are called, and how many of them.

For this project, you should have the following parts:

- 1 Microcontroller board - a red MSP430 LaunchPad circuit board
- 1 Upper arm - a blue plastic arm with an attached wheel
- 1 Lower arm - a blue plastic arm with a pen lifter attached
- 1 Elbow line feed loop – a metal wire with a loop in the middle.
- 1 USB cable - a black cable to connect the LaunchPad to the computer
- 3 Servos - small motors with a three wire cable connected
- 1 Servo horn - a small white or black piece of plastic that connects to the motor and has several holes in it
- 3 Servo horn screws - small silver screw to connect the servos
- 4 Servo mounting screws - slightly larger screw
- 4 Servo mounting washers - black circles to hold screws (some kits do not have these due to different servos)
- 1 Servo extension cable - a black, red, and white cable, 15cm long
- 1 Power bus cable - a short two wire cable with ten pins on one end
- 1 Wrist lifting cable - a clear thread like cable
- 1+ Elastic bands - bands to hold the pen in place
- 2+ Crimp beads - small copper tubes
- 2 Glue dots - drops of high tack adhesive glue
- 2 Velcro pieces
- 1 Base platform - tan clip board
- 1 Felt tip pen
- 1 Screwdriver

The servo motors need to be calibrated before mounting them up and should **NEVER** be turned manually. It is very tempting to position the arm with your hand after the kit is built. **RESIST THIS TEMPTATION** or your PicassoBot may not work correctly!

Depending on the options you purchased, there may also be parts for a capacitive touch pad, a Bluetooth module, a WiFi module and connecting wires in separate bags.

Processing IDE

The Processing IDE is used to run the PicassoBot Simulator code on the computer to control and send commands to PicassoBot.
Download the software at:

https://processing.org/download/?processing

Unzip the files, install, and run the IDE.

Energia IDE

The Energia IDE is an integrated development environment for programming the MSP430 microcontroller board that is used. This IDE will help us to put the firmware code into the microcontroller.

We are using the Energia IDE because:

- Based on C/C++ programming language
- Simplified program set
- Easy compile/upload/run
- Can be extended with libraries
- Compatible with Arduino code - Energia is based on the open-source Arduino(TM) IDE (see http://arduino.cc/en/Guide/Environment) and can run most of the sample Arduino programs with little or no modification. Firmware programs, called sketches, developed in the Energia IDE are sent through a USB cable to run on the MSP430 microcontroller board.

Installing Energia on Mac OS X (Skip if using Windows)

To use Energia on a Mac computer you will need to have the LaunchPad drivers installed. The drivers allow your computer to "see" the LaunchPad on a serial COM port when it is connected.

1. Download the LaunchPad drivers for Mac OS X: https://github.com/energia/Energia/raw/gh-pages/files/MSP430LPCDC-1.0.3b.zip
2. Unzip and double click MSP430LPCDC 1.0.3b.pkg
3. Follow the instructions.

Download Energia

The most recent release of Energia can be downloaded from:

http://energia.nu/download

Double click the energia-0101EXXXX-macosx.dmg file and drag the Energia application onto the Application folder.
On OS X 10.8 and 10.9, as Energia isn't a signed package yet, proceed as follow:

- First time you use Energia, press `ctrl` and click on Energia, choose `Open
- A window states Energia isn't signed and asks for confirmation to launch it: confirm and Energia starts.
- This procedure isn't required after.
  If a window pop-ups and claims *"Energia is damaged and can't be opened. You should move it to the Trash"* don't panic! The "damaged" message is a cryptic reminder that Energia isn't signed, thus not trustworthy according to Mac OS X. Proceed as follow:

1. Launch Systems Preferences on the Apple menu
2. Select Security and Privacy
3. Click on the padlock, type your password and confirm
4. Select Authorise the apps downloaded from everywhere and confirm
5. Go back to the folder containing Energia
6. Ctrl-click on Energia and select Open
7. If a message asks you to confirm, confirm
8. Once Energia is running, go back the the Systems Preferences and select the previous setting for Authorize the apps, either Mac App Store or Mac App Store and Identified developers.
9. Next time you double-click on Energia, the application will be launched normally.

Starting Energia

Double click on the Energia icon in Applications. Energia will start and an empty Sketch window will appear. A Sketch is a firmware program for Arduino compatible circuit boards. The Sketch is the program that will tell the microcontroller what to do and communicate with other parts of the robot and the computer.

Selecting the Serial Port

Select ***Serial Port*** from the ***Tools*** menu to view the available serial ports. ***On Mac OS X make sure to select the /dev/cu.uart-XXXX and NOT the /dev/tty.uart-XXX***. Later, when trying to download firmware code to the microcontroller, try switching to a different COM port if it does not work.

Selecting the Board

The LauchPad board that we are using is the MSP430G2553. Select ***Board*** from the ***Tools*** menu and choose that board (make sure it says msp430g2553 exactly). You can make sure that this is correct by looking at the microcontroller chip itself on the board and reading the number on the back.

Installing Energia on Windows (Skip if using a Mac)

To use Energia on a Windows computer you will need to have the MSP430 LaunchPad drivers installed. The drivers allow your computer to "see" the LaunchPad on a serial COM port when it is connected.

1. Download the LaunchPad CDC drivers for Windows:
   https://github.com/energia/Energia/raw/gh-pages/files/EZ430-UART.zip
2. Unzip and double click DPinst.exe for Windows 32 bit or DPinst64.exe for Windows 64 bit (NOTE: Windows 8.x usually installs Windows 64 bit by default).
3. Follow the installer instructions.

Download Energia

The most recent release of Energia can be downloaded from:
http://energia.nu/download
Double click and extract the energia-0101EXXXX-windows.zip file to a desired location.

Starting Energia

Double click Energia.exe. Energia will start and an empty Sketch window will appear. A Sketch is a firmware program for Arduino compatible circuit boards. The Sketch is the program that will tell the microcontroller what to do and communicate with other parts of the robot and the computer.

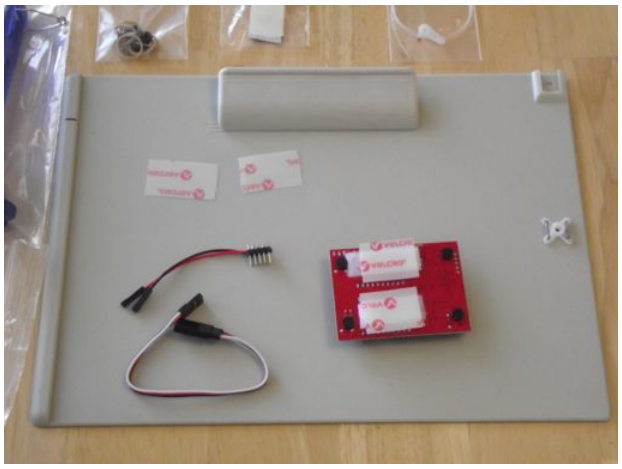
Selecting the Serial Port

Select ***Serial Port*** from the ***Tools*** menu to view the available serial ports. On **Windows,** they will be listed as COMXXX port and usually a higher number is the LaunchPad com port. Later, when trying to download firmware code to the microcontroller, try switching to a different COM port if it does not work. NOTE: Sometimes Windows switches COM ports when the PicassoBot or LaunchPad is disconnected and then reconnected. Although this is rare, it may happen, especially when you have other USB devices such as external hard drives or mice.

Selecting the Board

The LauchPad board that we are using is the MSP430G2553. Select ***Board*** from the ***Tools*** menu and choose that board (make sure it says msp430g2553 exactly). You can make sure that this is correct by looking at the microcontroller chip itself on the board and reading the number on the back.

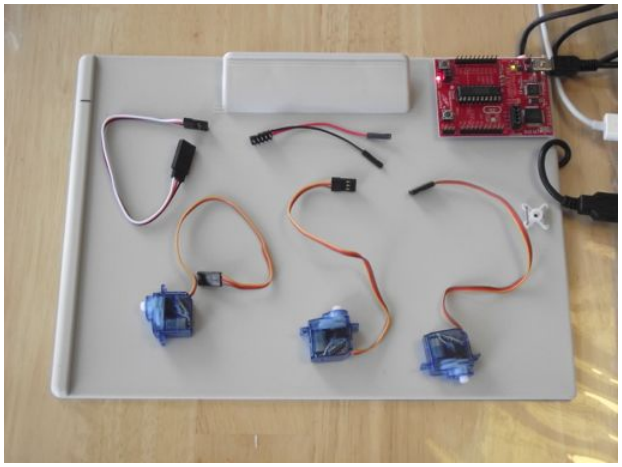
Mounting the LaunchPad to the Base



Please follow the instructions below exactly. Each step is meant to be done in order. Failing to follow the instructions could result in broken robot.

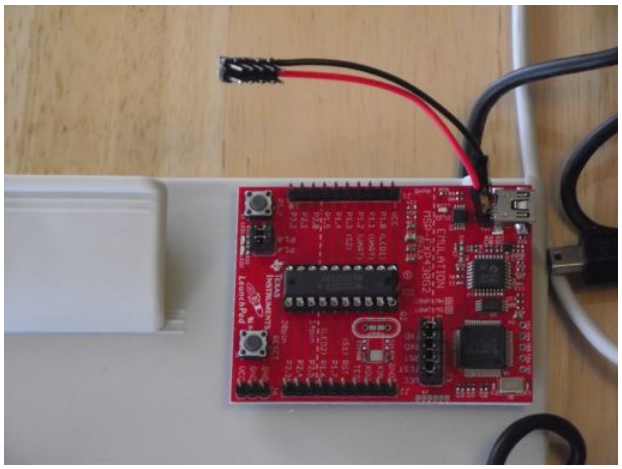
Place the tan clipboard on a flat surface such as a table.

Remove the LaunchPad microcontroller board from its box. Connect the mini USB cable in the box to the LaunchPad. Remove the four Velcro fastener pieces from the adhesives bag. Apply the two softer pieces to the back of the LaunchPad board between the rows of pins by removing the backing tape. Press the loop Velcro pieces onto the applied softer pieces and remove the backing tape from those.



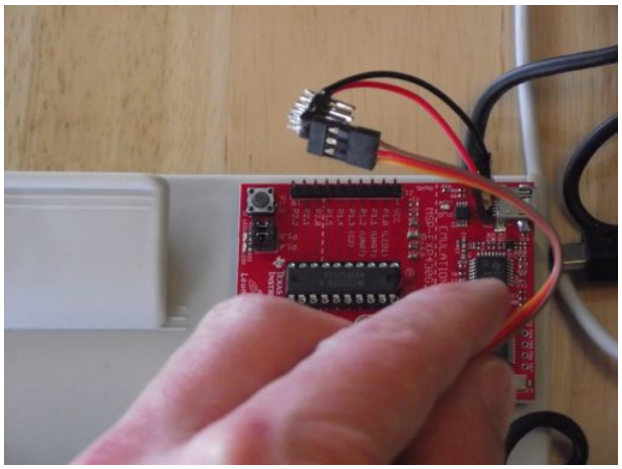
Connect the LaunchPad to the clipboard by placing it in the top right corner of the board. The USB cable should be extending out to the right of the clipboard. The rubber foot of the LaunchPad should be fitting into the recess of the top right corner of the clipboard.

Connecting the Power Bus Cable

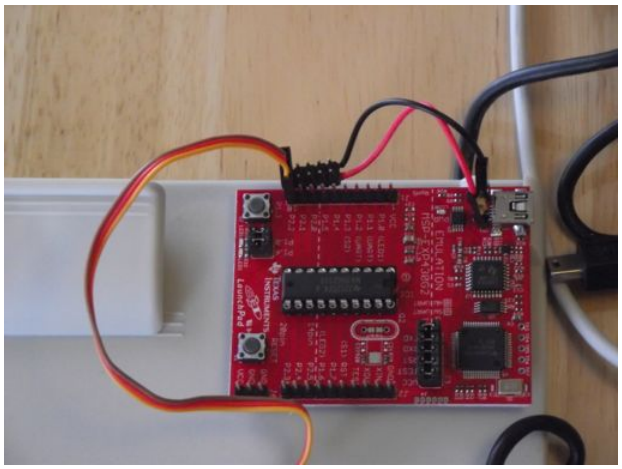


Please follow the instructions below exactly. Each step is meant to be done in order. Failing to follow the instructions could result in broken robot.

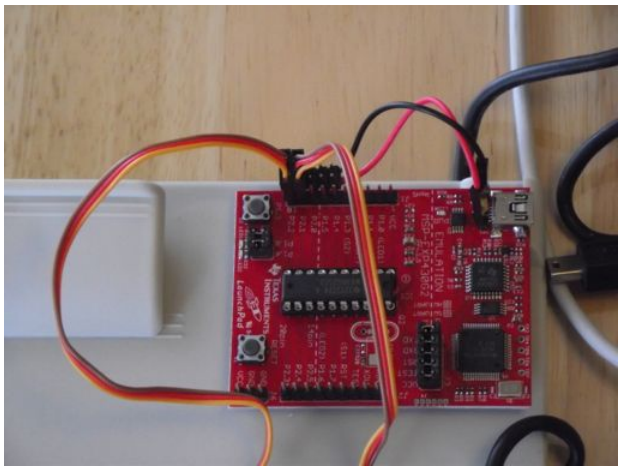
Connect the servo power cord (two wires connected to 10 pins) to the LaunchPad. This is done by connecting the two wires to the two pins located closest to the micro USB connector on the LaunchPad. The pin closest to the edge of the board is ground (negative or -) and the other one is +5V (positive or +). The kits may contain different colored wires, but black, blue, green, grey, and brown are all ground and the red, orange, yellow, white, or purple wires are +5V.



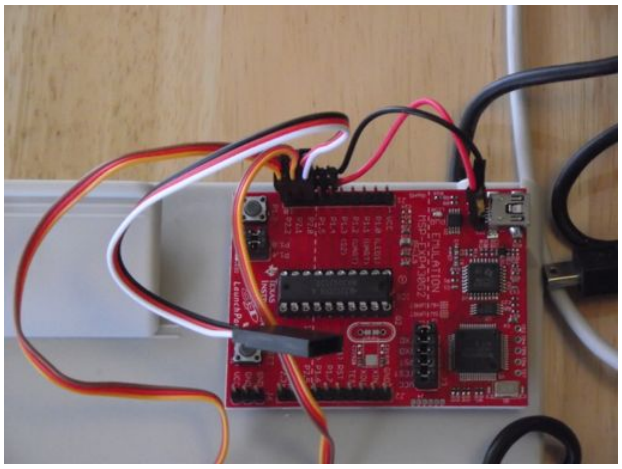
Lay the 10 pin connector to the side of the LaunchPad so that two rows of pins line up with board pins labeled P1.4 through P2.2. You should now note that the top row of pins are all connected to the wire that connects to ground and that the row of pins closest to the LaunchPad connect to +5V on the LaunchPad.



Connect the servos to the LaunchPad. Remove the three servo motors from the bag and connect them by first connecting them to the servo power cord and then to the LaunchPad. Each servo has three wires connected to it, either orange/red/brown or white/red/black. Connect one servo to the end two pins of the servo power cord by matching the brown or black servo wire with the ground pin and the red wire to the +5V pin. Then connect the orange/white wire of the servo to the LaunchPad pin labeled P2.2.

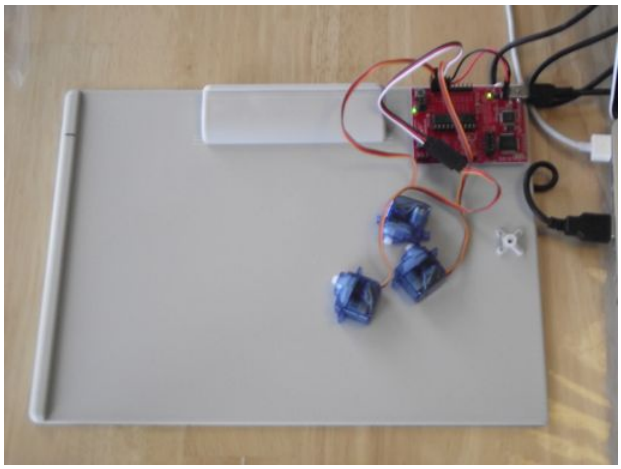


Connect the next servo to the three pins labeled P2.1 (one on the LaunchPad, two on the server power cord).

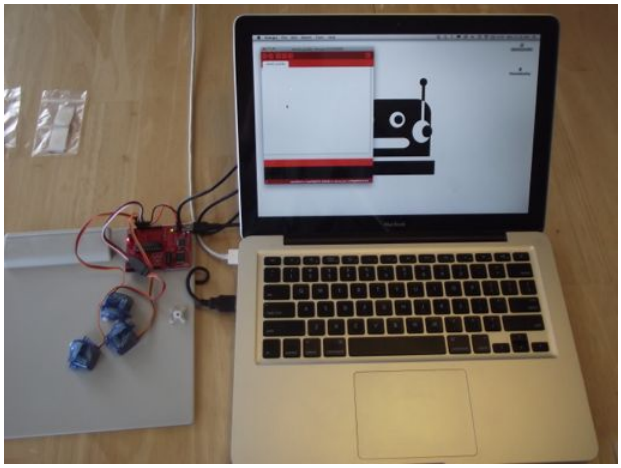


Connect the next servo to the servo extension cord (a three wire cord of white/red/black), and then the other end of the servo extension cord to the three pins labeled P2.0.

Servo Calibration



Connect the USB cable to your computer. The power LED on the LaunchPad should be lit. The default program that in the LaunchPad and will begin running and blink the LED.



Run Energia. Energia will start and an empty Sketch window will appear.

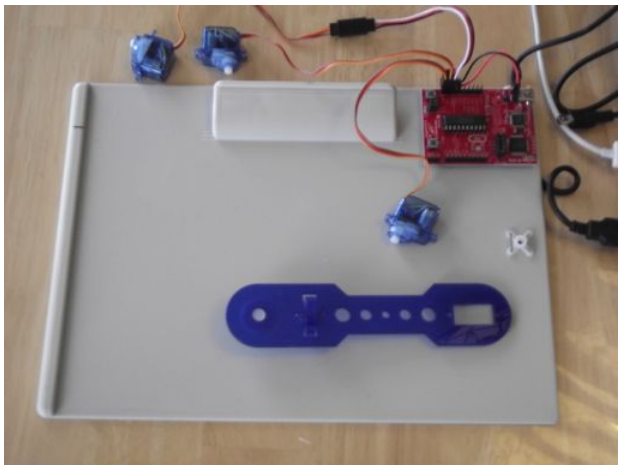
Choose File then Open from the Energia menu. Load the PicassoBotFW.ino sketch (firmwarenprogram) that was downloaded from the website in PicassobotFW_3_4.zip. Be sure that the files are extracted from the zip file and that the file PicassoBotFW.ino is located in its PicassoBotFW directory. You will get an error if the directory is not named the same as the main file.

Upload the PicassoBotFW to the LaunchPad by clicking the Upload button.

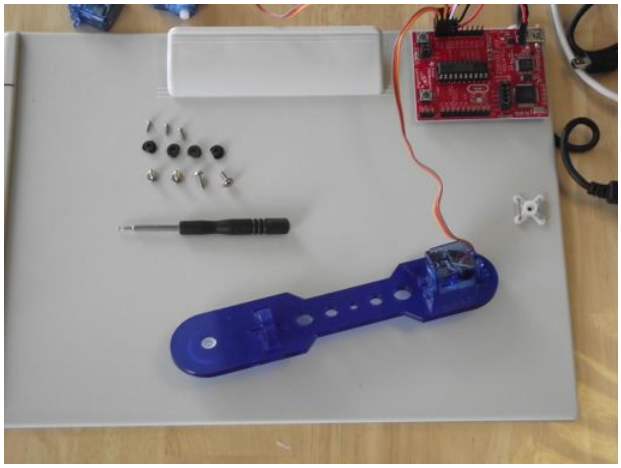
If all goes well, you should hear the servos move and the green LED should begin blinking. The servos are now set to the calibrated positions. If it failed to upload you may have not installed the drivers correctly. Go to http://energia.nu/guide for more information.

Unplug the USB cable from the computer. The LaunchPad LEDs will turn off.

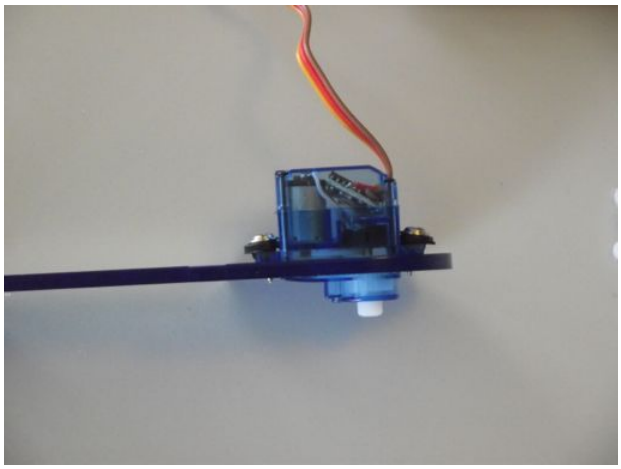
Building the Upper Arm



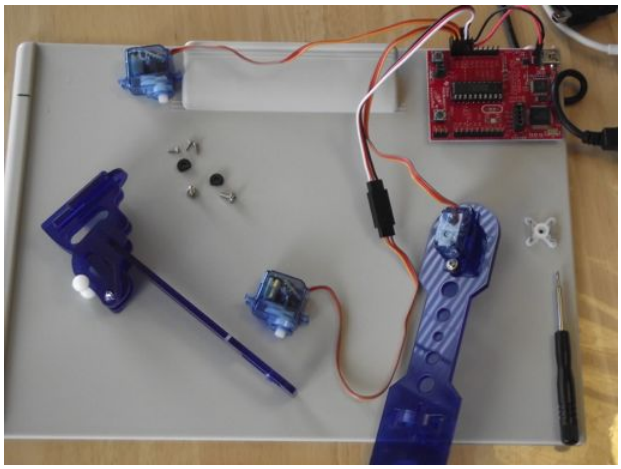
Now that you have the servos calibrated, place the upper arm piece on the board with the top of the arm piece facing up. The top of the upper arm should be all blue, the bottom has the servo horn (white or black) glued on.



Insert the servo that is connected to pin P2.2 into the top of the square hole in the arm. The servo should have the wires closest to the end of the arm as shown.

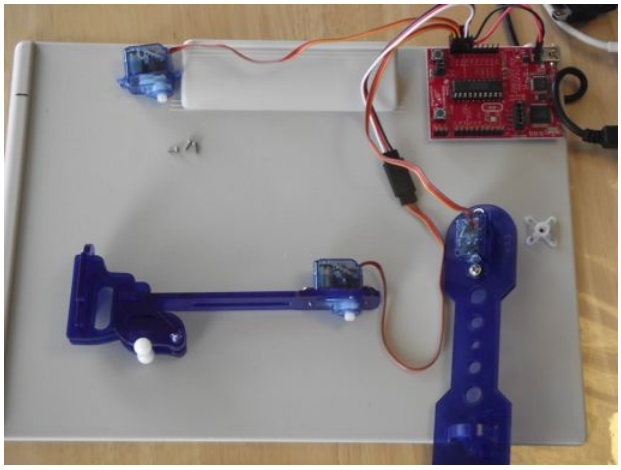


Take two of the four mounting screws and attach the servo to the arm. If mounting washers or rubber grommets are provided, first put the washer on the screw before attaching the servo to the arm.

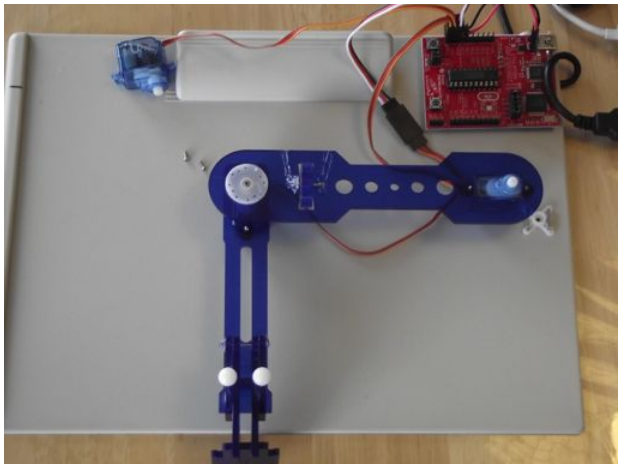


If the screws are still loose and do not seem to grab, cut and insert one of the extra elastic bands into the hole first to provide a tighter grip. This is due to the tolerance changes during laser cutting sometimes.

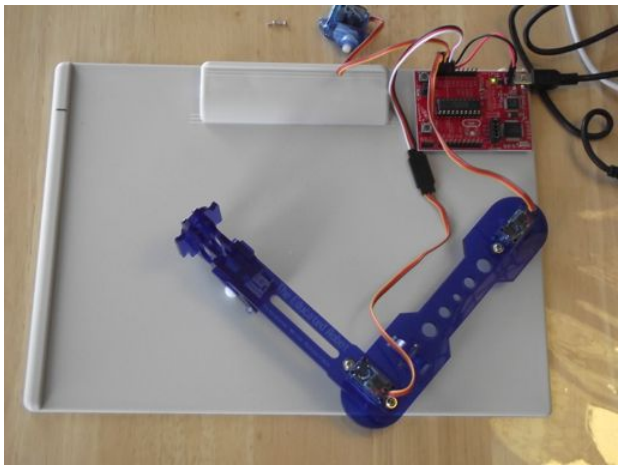
Building the Lower Arm



Place the lower arm piece with the top facing up on the board. Place the servo connected to P2.0 into the square hole on the lower arm. Use two of the four mounting screws to attach the servo to the arm. If mounting washers or rubber grommets are provided, first put the washer on the screw before attaching the servo to the arm. Make sure that the wires on the servo are closest to the end of the arm.



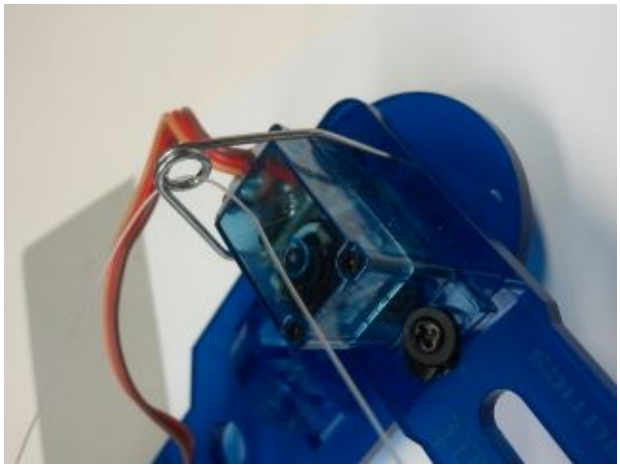
Turn the two arm pieces over and connect the servo of the lower arm into the servo horn of the upper arm as shown. The arm should form a 90 degree angle. Although it may not be exactly square, try and get the two arms to meet at as closely a right angle as possible. Press the servo connection into the horn to make a good tight fit.
REMEMBER: Don't turn the servo motor gears!
Use one of the three small servo horn screws to connect the upper arm horn to the lower arm servo. Turn the arm back over so that the top is facing up.



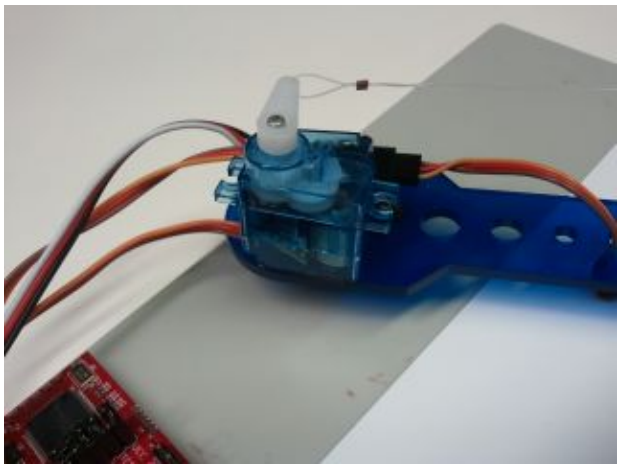
Place the arm so that the upper arm servo (the shoulder) is above the servo horn on the clipboard and the elbow (lower arm servo) is as close to the edge of the clipboard as possible. Press the shoulder servo into the clipboard servo horn to make a snug fit.

Turn the clipboard over and use the second servo horn screw to mount the arm to the clipboard.

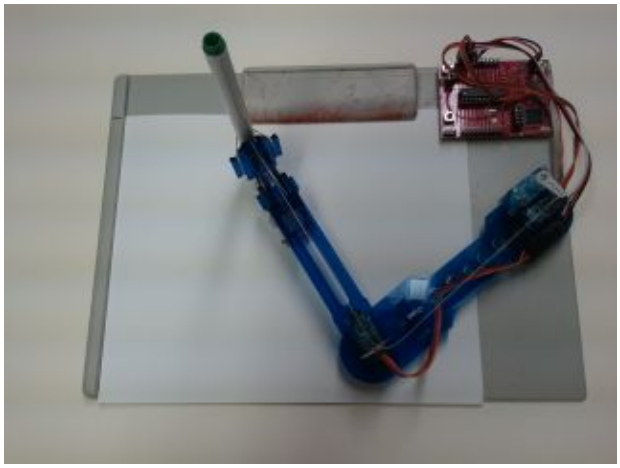
Wrist



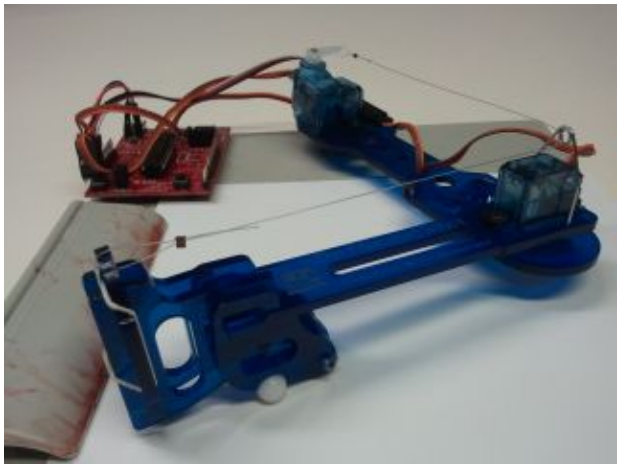
If not already attached, connect the line feed loop to the elbow of PicassoBot. This part is a stiff metal wire with two ends and a single loop in the middle. There are two holes, one on each side of the elbow servo motor to connect the line feed loop into.



Attach the white plastic servo horn to the wrist servo with the last small servo horn screw. Be sure that the horn is pointing correctly. If you are looking at the top of the wrist servo with the wire coming out from the left side, the servo horn should be pointing north.



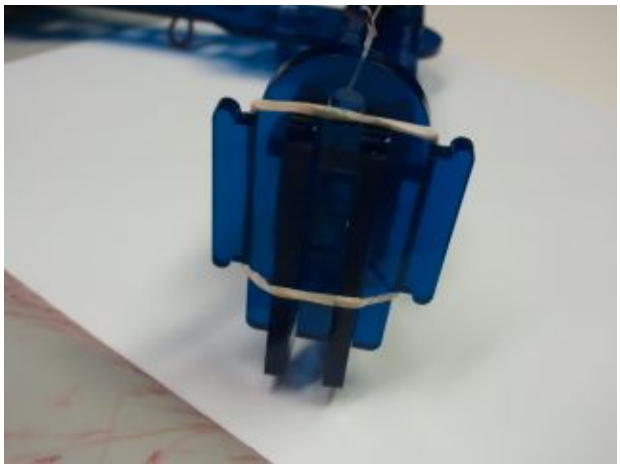
Next, feed the lifting line through one of the two small copper crimping beads, then through end hole of the horn on the wrist servo, then back through the same crimping bead about half an inch. Using needle nose pliers, press the bead tight to hold the line tight. Although it is usually harder to do, a simple knot can be used to connect the lifting line to the servo horn instead.



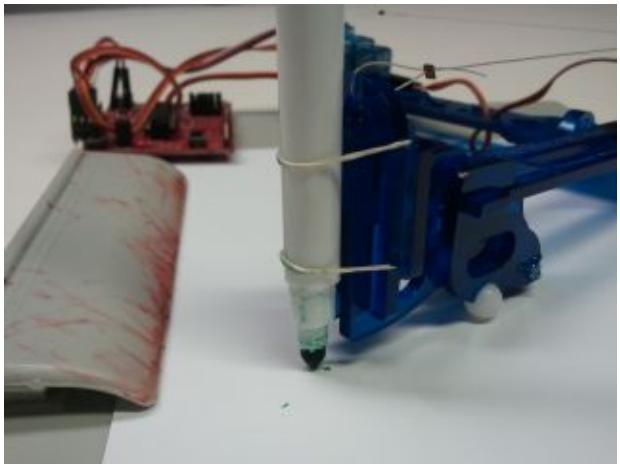
Feed the other end of the lifting line through the line feed loop. Add the second crimping bead to the line and feed the line through the top hole in the wrist. The end of the line then goes back through the crimping bead. Adjust the tension on the line so that the wrist is lifted about halfway up. This will allow the pen on the wrist to be lifted or dropped to write on the paper. When you have the tension just right so that the wrist is about halfway up, carefully crimp the second copper crimping bead to hold the line in place. Cut any excess lifting line off so that it is not in the way.

Insert the paper in the clip board paper holder. Do this by carefully pressing the clip open with one hand and slipping the paper under the PicassoBot arm from the bottom. The top left corner of the paper should be aligned with the black mark on the left side of the clipboard.

You can use a standard 8 ½”x11” paper or cut the paper to 8 ½”x 7” to fit the clipboard (the paper will still extend about 1/4” below the bottom of the clipboard).



Attach on of the elastic bands to the wrist as shown. This will hold the pen in place. Carefully pull the elastic band out and place the pen, with cap removed, in. The pen tip should be just barely above the paper. You may need to adjust the pen height after a test drawing.



The pen will probably need to be removed from the wrist when you are done drawing so that you can cover the pen end to keep it from drying out. Although many pencil and pen types can be used, felt tip pens have been shown to have the best results. The felt tip pen have lasted for up to 16 hours or more of drawing before drying out.

PicassoBot Simulator

The PicassoBot Simulator is a program that runs on the computer and simulates the physical robot arm on the screen. This is the control program that sends commands from the computer to the firmware on the microcontroller board.

Connect the PicassoBot to the computer with the USB cable. Each time it is connected the servos will go to their default start position.

Run the PicassoBot Simulator software. This was the software files in the PicassoBotSimulator_3_4.zip file. Be sue that the files are unzipped and that the directory structure remains intact.

To run the PicassoBot Simulator, double click on the PicassoBotSimulator.pde file. If that does not work, run Processing IDE and Open PicassoBotSimulator.pde.

The Simulator lets you draw images and then turns those images into commands for the robot to move it's arm.

Use the Draw buttons to draw a picture on the virtual paper. When done click the Transmit button and it will take all of the drawing motions that you did and send them as commands to the PicassoBot.

Have fun and draw lots of cool pictures!