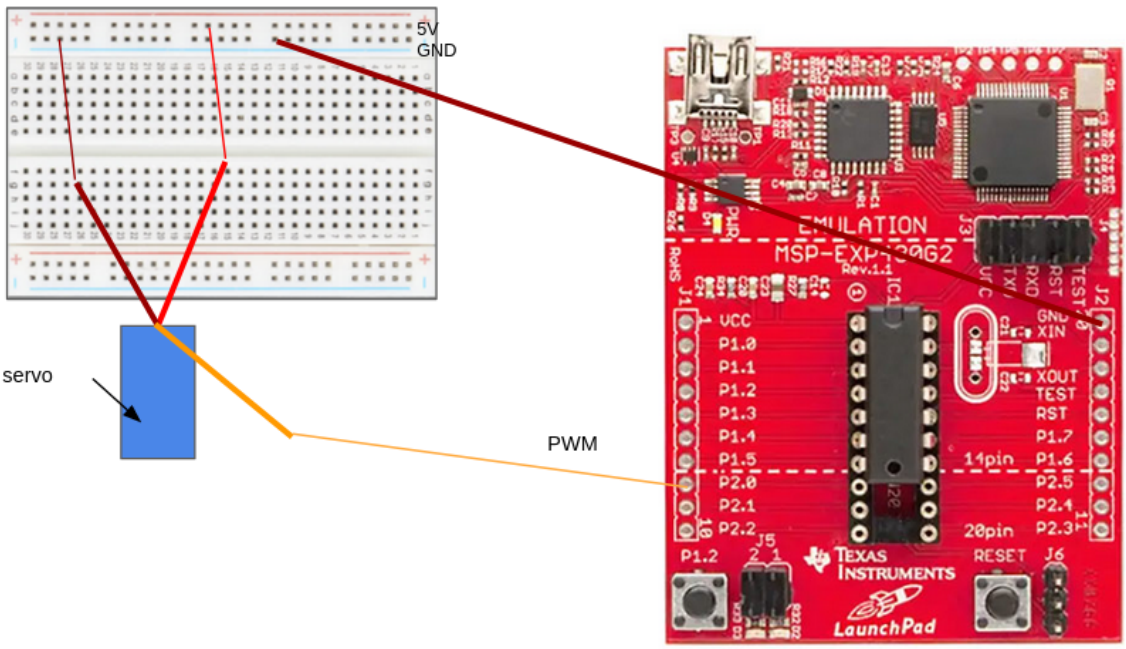
Apparatus

- SG90 Micro-servos (3x)
- 15 cm plastic rulers (2x)
- Small Bull Clip
- Pen
- MSP430 Launchpad with serial cable (Note that we are using a full U-Bridge, unlike the one used in the images in this report)
- Host Computer
- Jumper cables
- Breadboard with power supply
- Super glue or any effective plastic-plastic bonding adhesive
- Metal bar
- Tape (electrical or otherwise)
- Mini phillips screwdriver
- Knife/hacksaw
- Pliers
- Heat source + thin metal rod OR 2mm drill

Before Beginning Assembly

We need to set our servo deflections to maximum.

1. Assemble the following circuit:



2. Write the following program in Energia IDE:

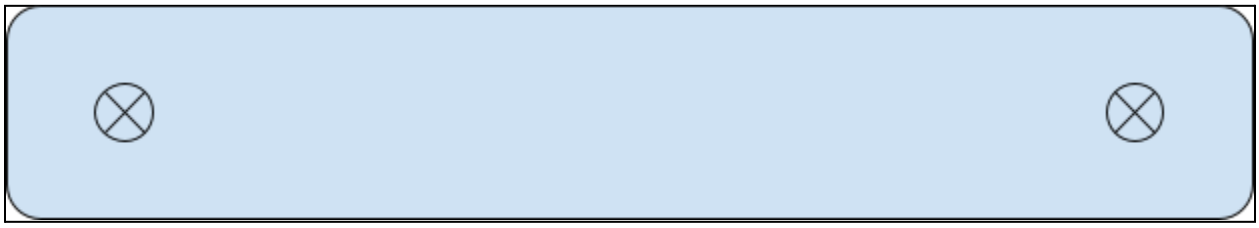
```
#include <Servo.h>

Servo servo;
void setup()
{
 servo.attach(P2_0); // attach servo PWM to P2.0
}
void loop(){
 servo.write(180);   // set maximum deflection
}
```

3. In the top menu in Energia, go to ‘Tools -> Boards’ and select ‘MSP430EXPG2 with MSP430G2553’ to load the correct drivers. On the keyboard, press CTRL-U to compile and upload the sketch to the Launchpad.
4. Attach each servo you wish to use in the manner shown in the circuit diagram above, each time turning the circuit off and on between servo change. This should set each servo to maximum deflection.

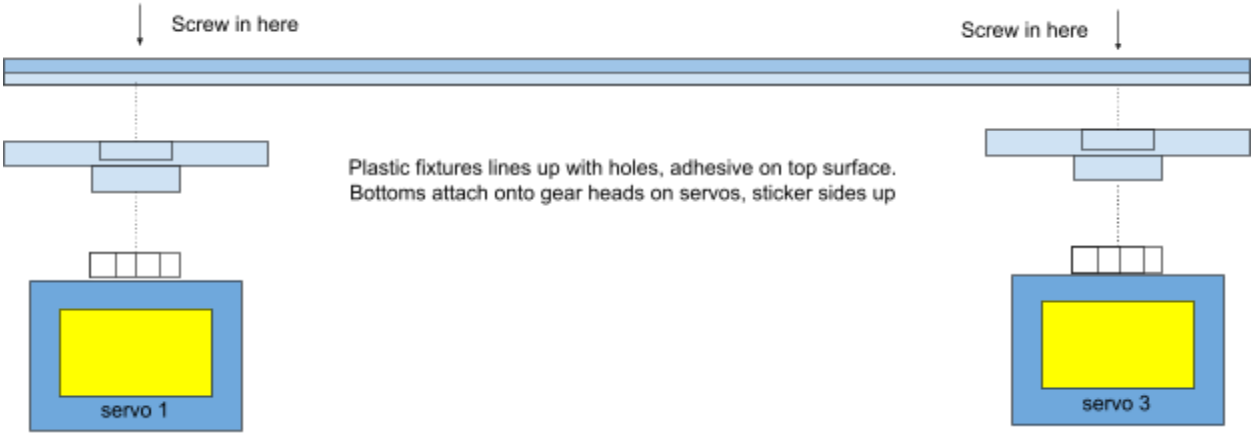
Physical Assembly

NOTE: Do not attach screws until step 8, they are shown in the diagrams for reference.

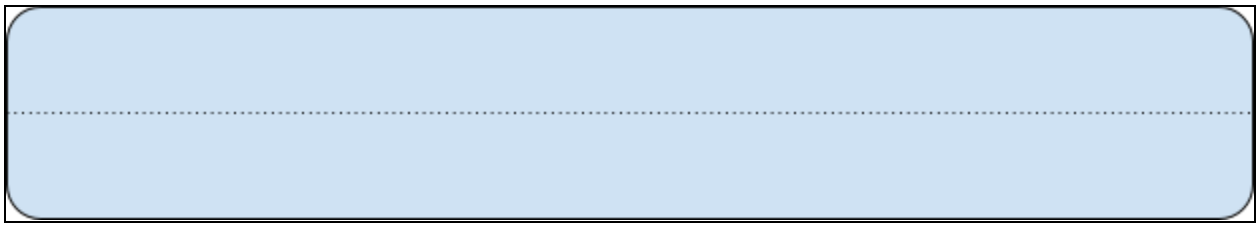
1. Make two crosses in the centerline of one of the 15cm rulers with a pen, with about 1cm of clearance from the edges



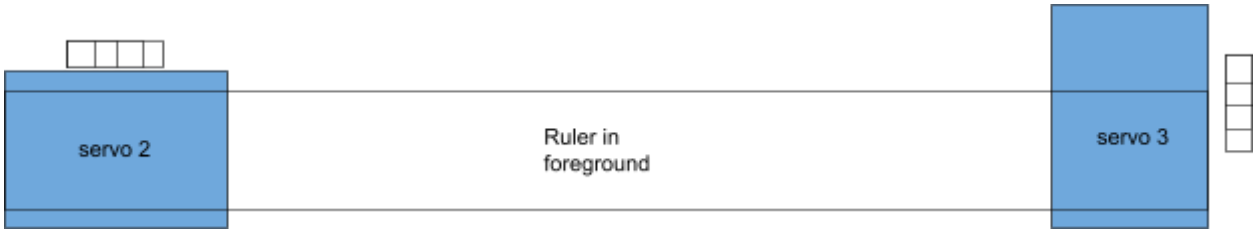
2. Heat the end of a metal rod and press it into the marks made earlier to create holes so that the ruler can be screwed onto the servos. Make sure that the holes are sufficiently large. File off any extraneous plastic.
3. Each servo motor comes with three plastic fixtures as shown in the picture below. Use the largest fixtures from two of the servos (shown circled) in this step. Use a strong adhesive to glue the pieces onto the LOWER surface of the ruler such that they line up with the holes, are perpendicular to the edges of the ruler, and have the FLAT side in contact with the ruler. This is shown in the diagram below.



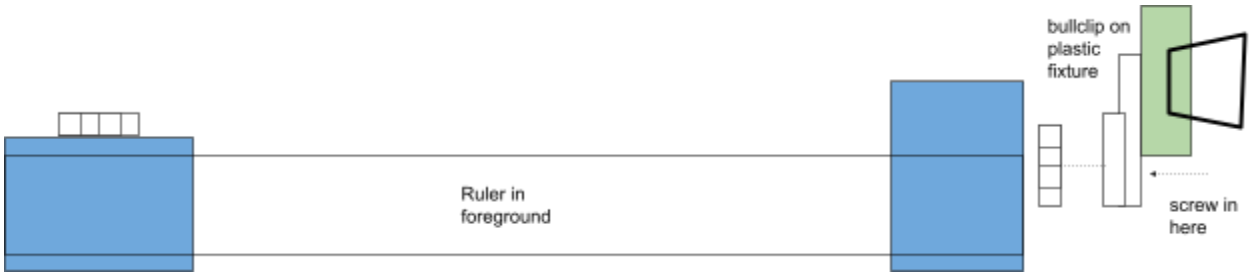
4. Due to the narrow heights of the servos, the second ruler needs to be halved along the short edge i.e. along the dotted line as shown below. Use a pen to make this mark on the top of the ruler, and use a sharp cutting tool to scratch along this line deeply. Use a pair of pliers to break the ruler at this point by clamping onto one of the halves and twisting.



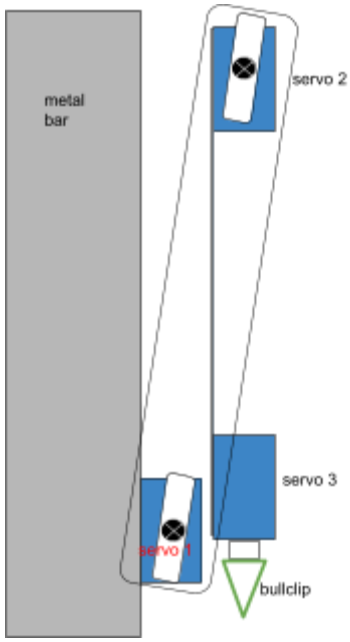
5. Glue servo 2 and 3(with the unstickered side in contact with the bottom of the ruler) as shown below. Note that the bottom surfaces of the servos are flush with the horizontal. This is vital to prevent horizontal loads on the servos.



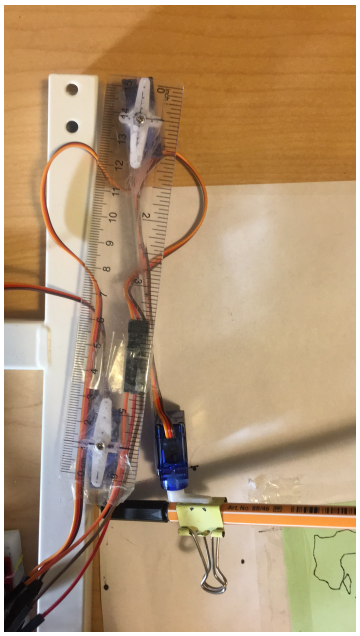
6. Glue a small bull clip onto one of the flat side of another of the plastic fixtures, and then screw the fixture onto servo 3, as shown below.



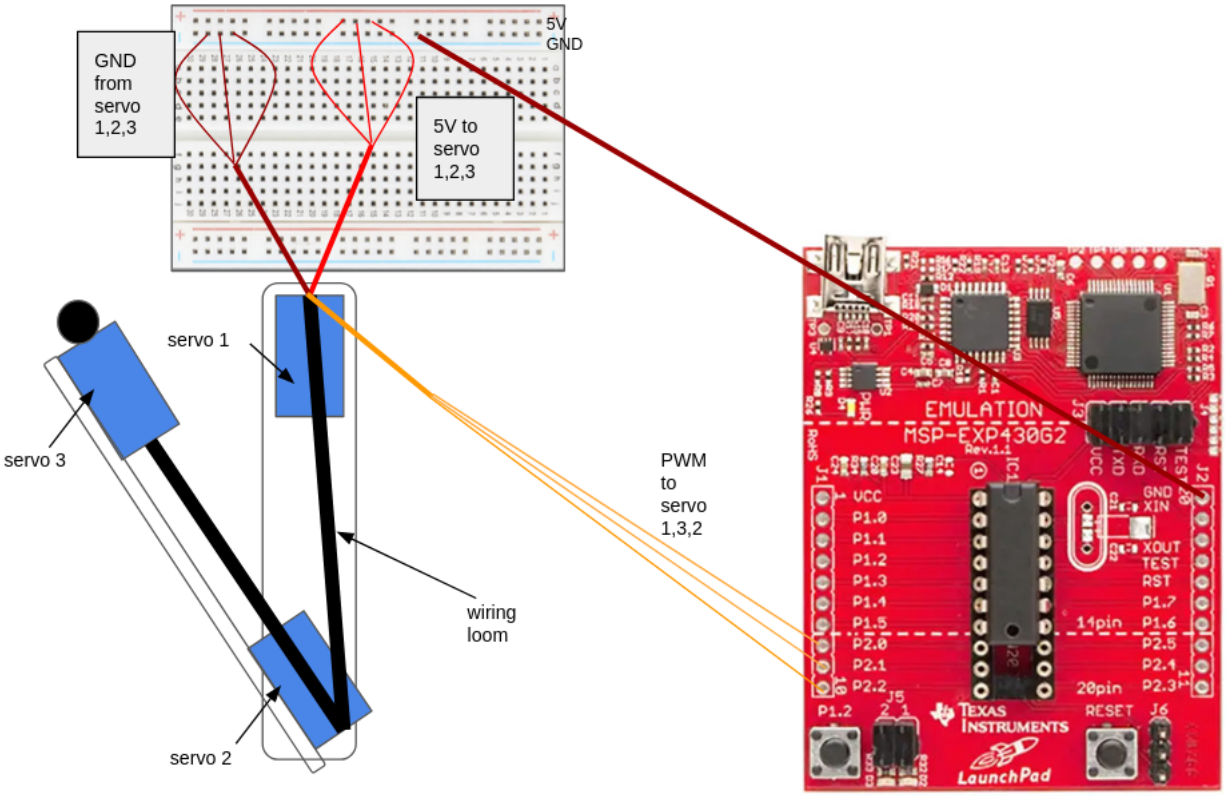
7. Glue the unstickered side of servo 1 onto the metal bar. This will act as the base for the robot. Ensure the servo is flush with the horizontal.
8. Assemble the servos in the manner shown in the top view schematic below, and attach the screws gently. All servos have their stickered sides on the right as seen from above:

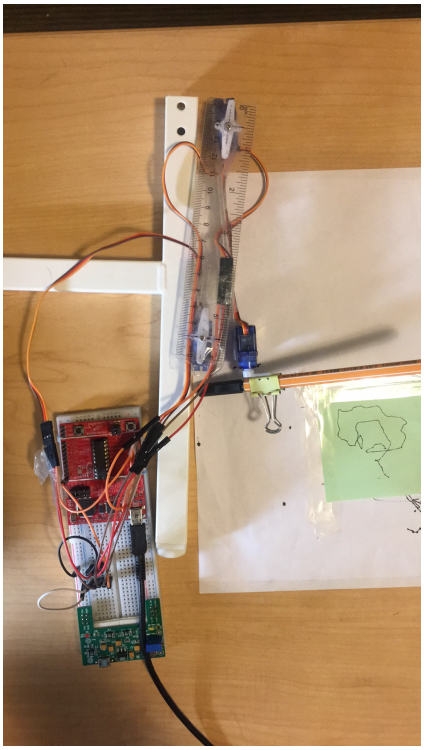


9. Using tape, attach the wires to the rulers in an organised manner, such that they do not hamper movement or cause tension. Use jumper cables as needed to make extensions. I have already attached the pen in the picture below



10. Complete the circuit assembly, using the diagram shown below as a guide. I just so happened to switch the pins on ports P1.2 and P1.1, so I have carried this over into my circuit diagram to coincide with the code.:


GND
from
servo
1,2,3
5V
GND
5V to
servo
1,2,3
servo 1
servo 3
servo 2
wiring
loom
PWM
to
servo
1,3,2
EMULATION
MSP-EXP430G2
LaunchPad
TEXAS
INSTRUMENTS



Microcontroller Software

All software is available on the Github repo https://github.com/ambhudia/319project
This software provides the API needed for the python programs to communicate with the robot, and must be flashed to the MSP Launchpad first.

1. Open prog/prog.ino in Energia IDE:
2. In the top menu in Energia, go to 'Tools -> Boards' and select 'MSP430EXPG2 with MSP430G2553' to load the correct drivers. On the keyboard, press CTRL-U to compile and upload the sketch to the Launchpad.

Python Software

All software is available on the Github repo https://github.com/ambhudia/319project.
Clone this repository on your local machine to use the following in the root directory:

- The Demo jupyter notebook provides a walkthrough on how to use the picosso.
- calibration.py is used to edit raw data that is then used for scaling
- drawing.py provides functionality for programming a drawing
- inv_kinematics.py transforms the x,y target coordinates into polar angles. The inversions were calculated using high school trigonometry.

Calibration

By comparing the servo angular deviations at rest (180 deg), 135 deg and 90 deg against the real world angles, we can find scaling factors to offset the nonlinear behaviour of the servos.
This is captured in the notebooks/calibration.ipynb jupyter notebook