Chapter 5 - Robot Navigation

Robots can navigate in a variety of ways. Autonomous robots navigate using programs that allow them to follow GPS coordinates or sensors that respond to their environment. Robots can also be operated using remote control by the user and by following pre-programmed commands. We'll look at several types of robot navigation in this chapter.   We'll also look at two Add-on Packs available for the basic mBot kit for a reasonable price. The mBot Servo Add-On Pack and Interactive Light and Sound Pack have many additional brackets, studs, M4 screws and nuts, beams, additional sensors and RJ25 cables along with a wrench. These items are all handy for many of the projects in this chapter. The Add-on Packs are available on Amazon or the Makeblock website at: www.makeblock.com.

Robot Navigation using Keyboard Commands

Connect your mBot to your laptop or tablet using Bluetooth or 2.4G Serial Wireless and write the following code.

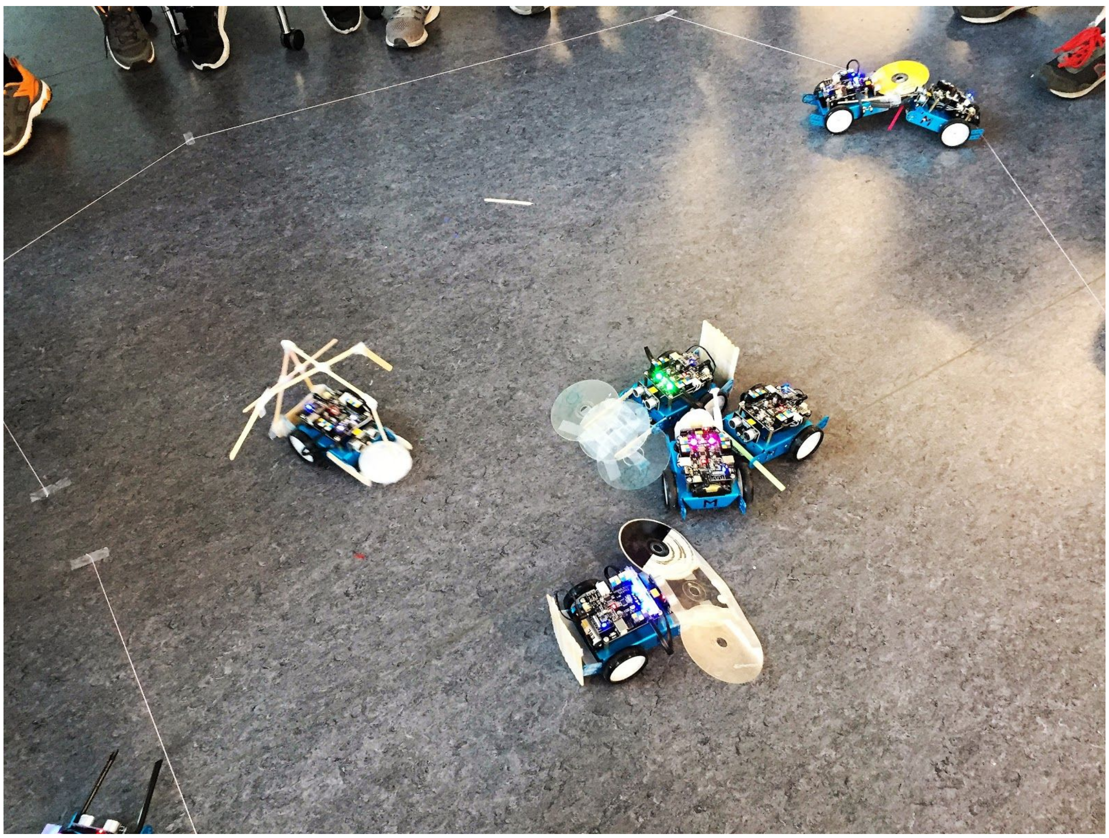
SCRATCH code to control your mBot with the up, down, right and left key on your keyboard. [c05f001.jpg]

With a Bluetooth connection, you can now control your mBot using the arrow keys from across the room. If the robot is moving too fast, drop the bot's peak speed from 255 to 100. But remember -- resistance in the gearing and the weight of the wheel combine so that lower values for Speed often won't be enough to move an assembled mBot. We've found that speeds less than about 70 aren't strong enough to move the mBot from a dead stop, but will keep it moving forward with a small push.

Once you're able to navigate using your arrow keys, you can devise all kinds of challenges with other mBots. The signals to each robot won't interfere with each other, because Bluetooth connections are unique to each mBot. You can continue to use the keyboard driving command code listed above in SCRATCH, but then add code for other sensors to trigger actions. This way you can drive your mBot using the up, down, left and right keys while your bot does other things.

Robotic Game Challenges

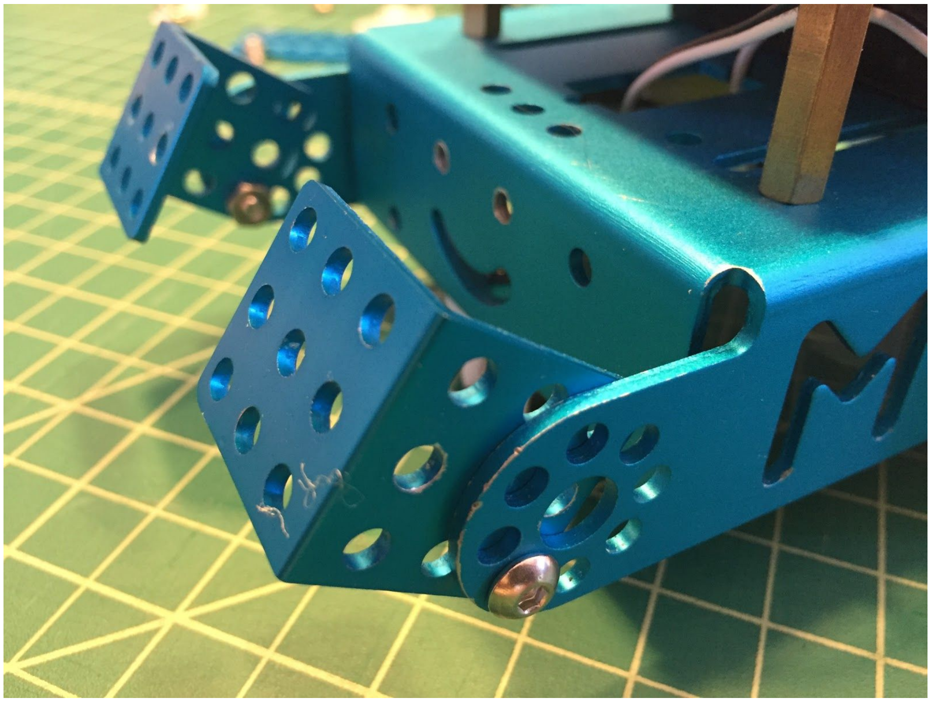
Once you are able to navigate your mBot using the arrow keys, you can begin creating your own Battle Bots! A popular game is Sumo-Bots where two or more bots battle it out inside a ring marked on the floor in tape. The last bot inside the ring wins! My students came up with a great design using old CD's to "scoop" their opponent out of the ring. We'll start off with a few Sumo-Bot defense and attack ideas.



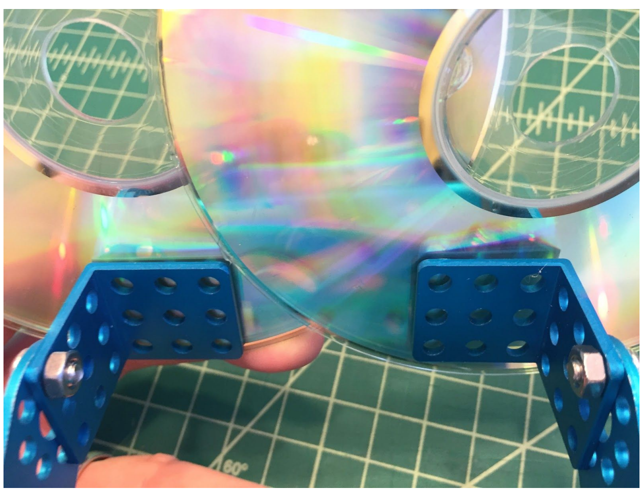
Middle school student's creative take on a Sumo-bot challenge. [c05f002.jpg]

CD Scoop

A CD scoop on the front of the bot just can be done by attaching old CD's onto the front of the mBot just off the ground to scoop your opponent out of the arena. I'm trying to move my students beyond using gobs of tape for everything, so the directions below show the CD's being sturdily attached with drilled holes and screws.

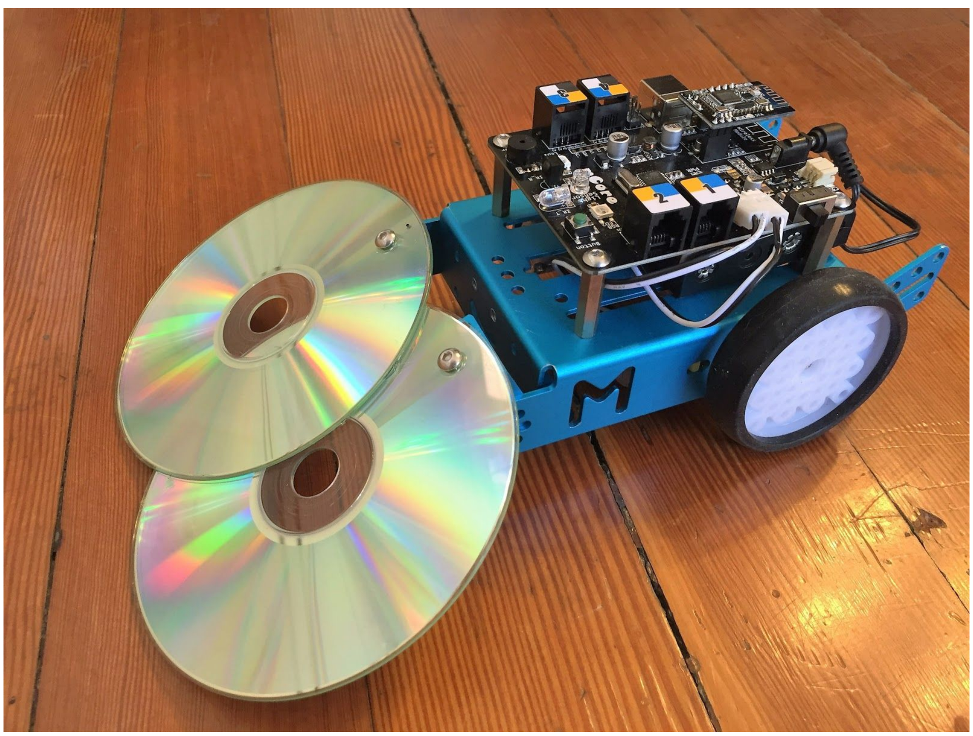


Start off by attaching two right angle “L” brackets to the front of your mBot using a 4M x 8 screw and nut. [c05f003.jpg]



Glue two old CD’s together with a hot glue gun then flip the mBot over and mark where you’ll drill a hole to attach them to the “L” brackets. [c05f004.jpg]

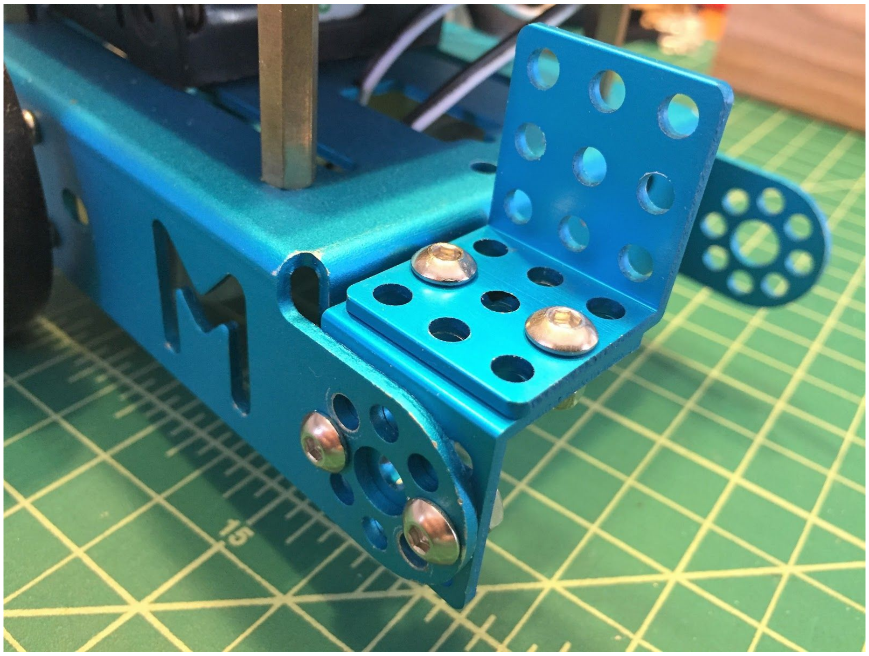
Drill through the CD’s where you marked the holes using a piece of scrap wood under the CD’s. [c05f005.jpg]



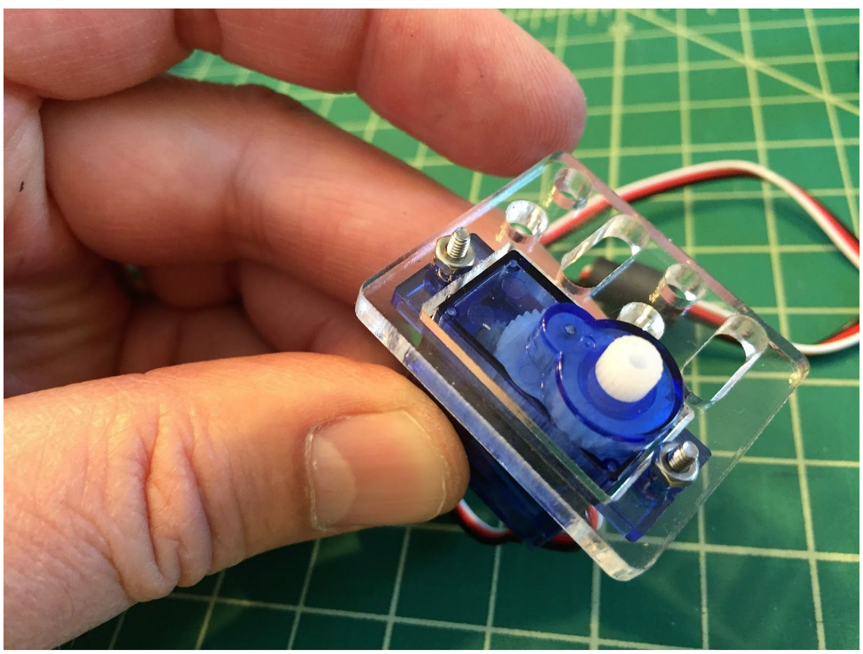
Now put an M4 x 8 bolt and nut through the two CD’s to hold them securely in place. Now you’re ready to scoop your opponent out of the ring! [c05f006.jpg]

Spear-Lowering Servo

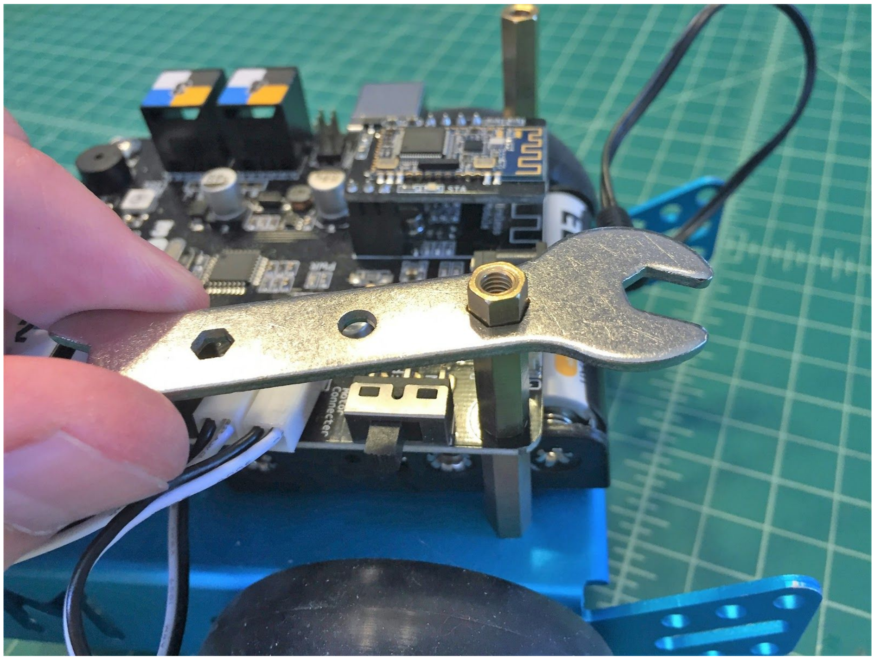
A BBQ skewer lance that lowers using a servo can be added as an attack mechanism. For this you would need a bamboo skewer, two mini zip ties, a 9g servo and servo holder, two “L” brackets and some 4M x 8 nuts and bolts.



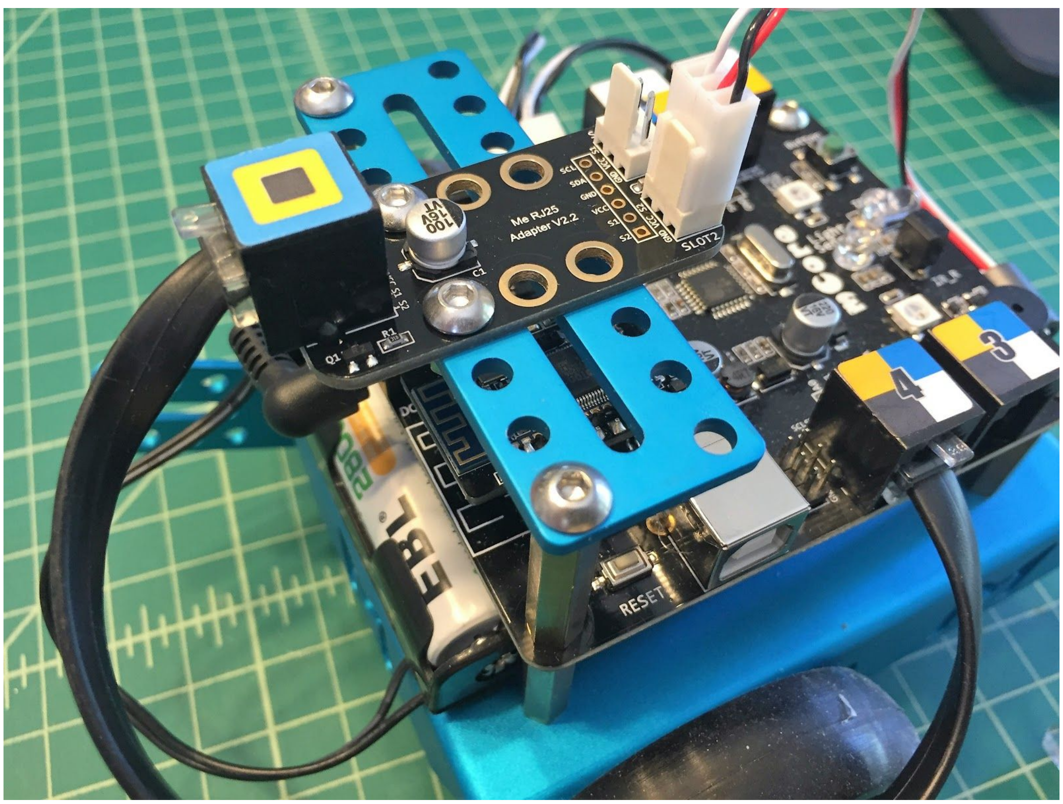
Begin by attaching the two “L” brackets to the front of the mBot as follows with four 4M x 8 nuts and bolts. The “L” brackets, servo and servo holder are included in the Servo Add-On Pack. [c05f007.jpg]



Next, attach the 9g servo to the laser cut acrylic bracket using the small bolts and nuts that comes with the servo add-on kit. If you’re using your own servo, download and laser cut the file here. [c05f008.jpg]

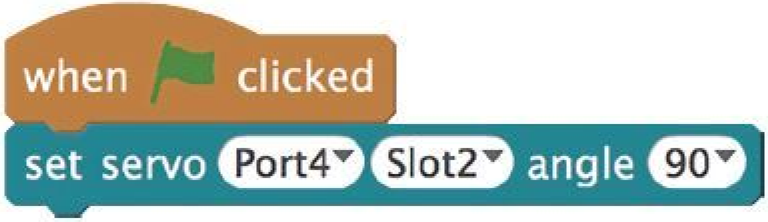


Remove the M4 screws from the back posts holding the mCore to your mBot and replace with the M4 x 25mm brass studs. [c05f009.jpg]

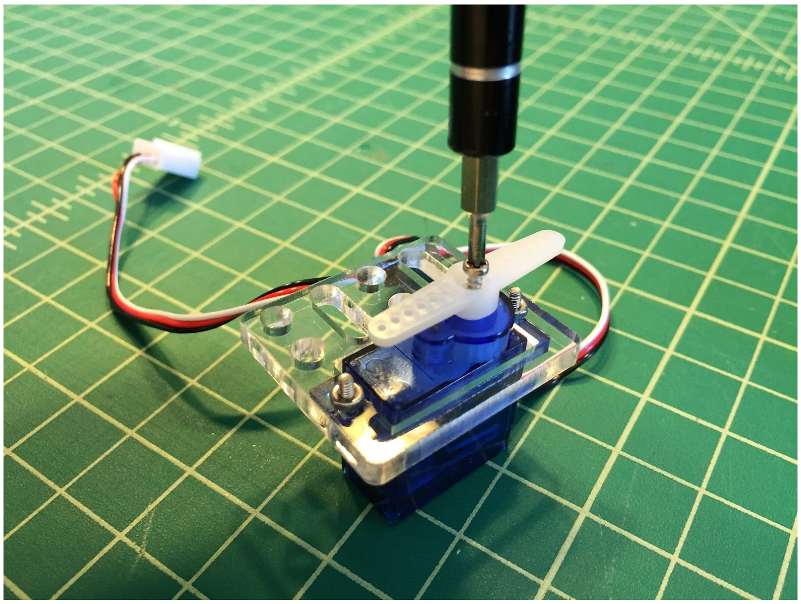


Now install the 9 hole blue plate to the brass studs with two M4 bolts and then the RJ25 Adapter to the blue plate with two M4 bolts and nuts. Plug the servo into Slot 2 of the RJ25 Adapter and then the RJ25 Adapter into Port 4 on the mCore. [c05f010.jpg]

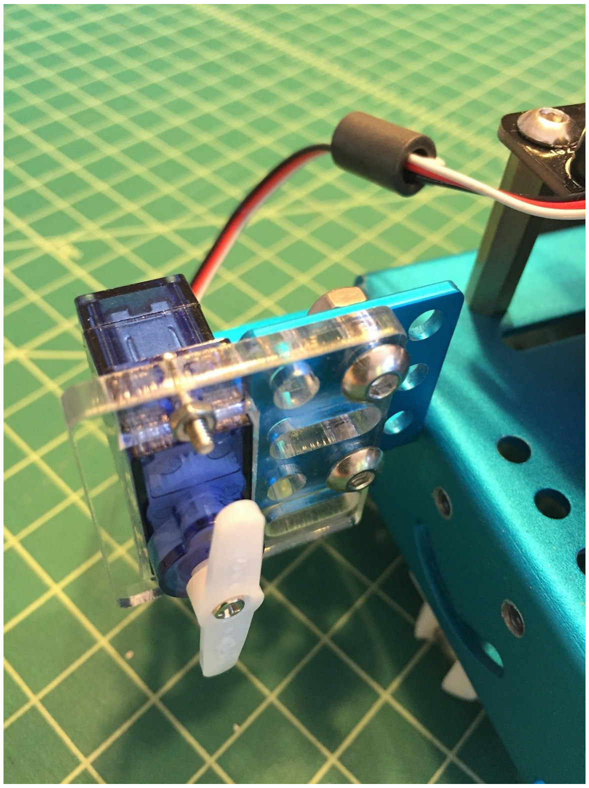
Before you install the servo to the front of your mBot, you need to center the servo. Connect the mBot to your computer using your preferred method (bBluetoothor 2.4G wireless serial). Then write the following code to center the servo and send it to your mBot.



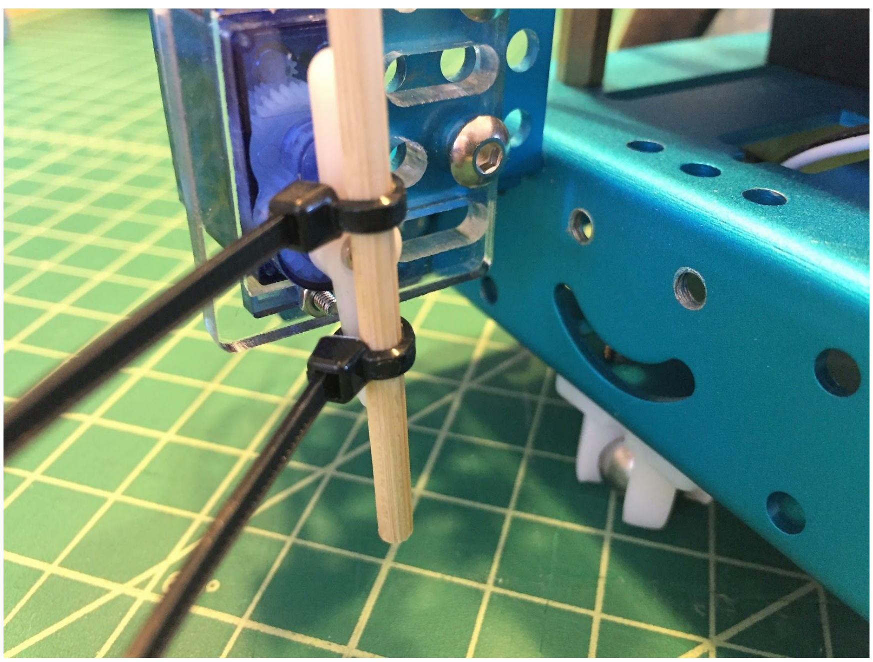
You can use this code with any program using a servo to get the servo centered. [c05f011.jpg]



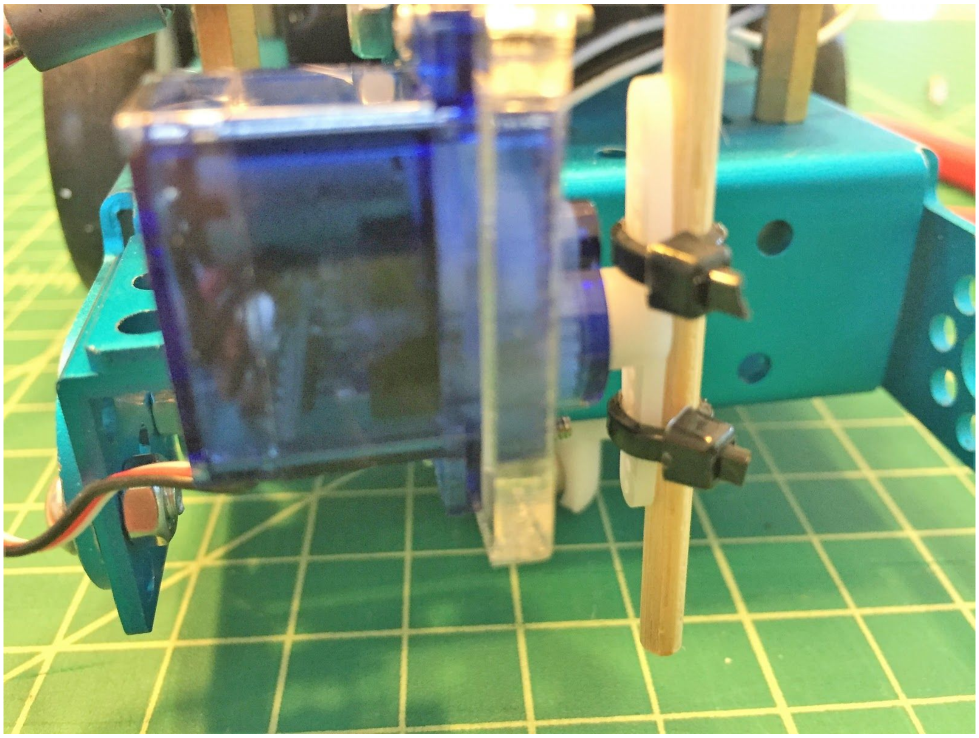
Now you’re ready to attach the servo arm to your servo using a very small Phillips head screwdriver and the tiny self-tapping screw that came with the servo. [c05f012.jpg]



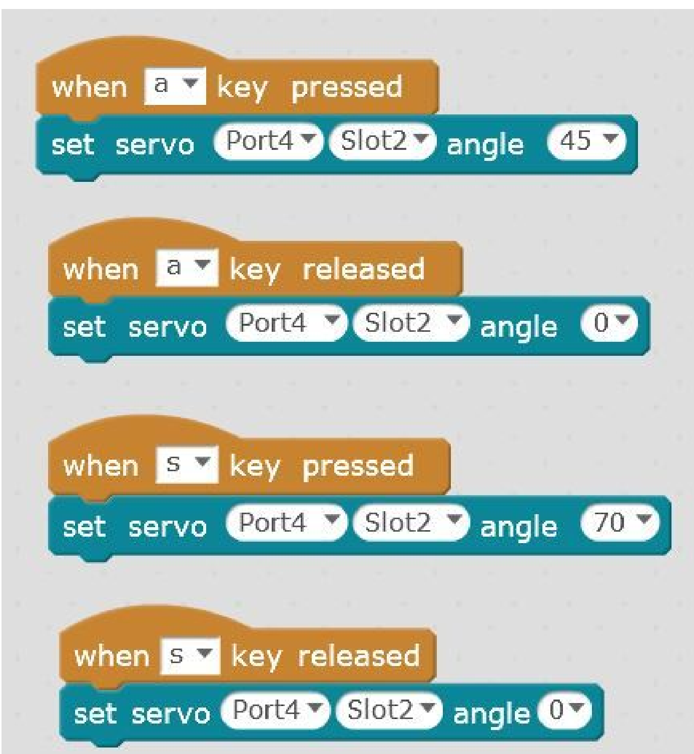
Attach the servo to the right angles mounted on the front of the mBot using two M4 x 8mm bolts and nuts. [c05f013.jpg]



Line a bamboo barbecue skewer up with the servo arm and attach with two mini zip ties. [c05f014.jpg]

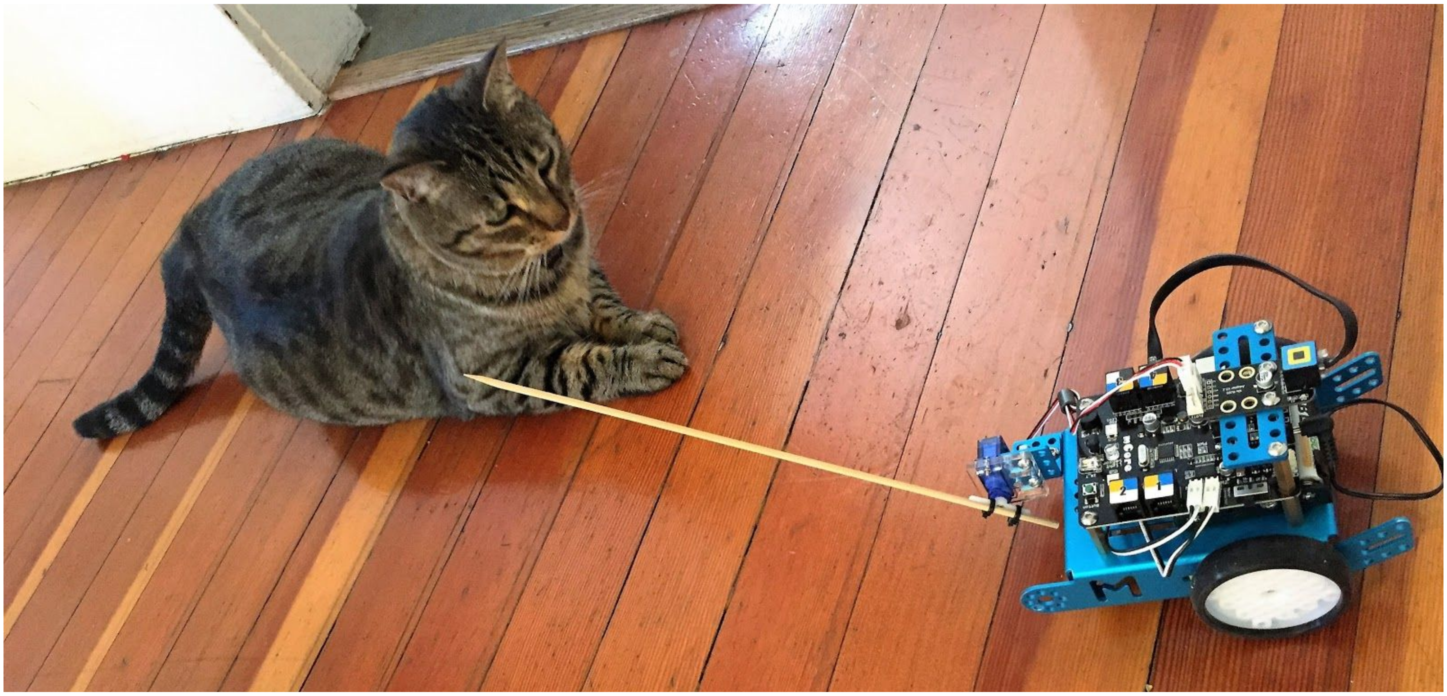


Pull the zip ties very tight, then clip the ends of the zip ties off with wire cutters. [c05f015.jpg]



Write the above program in SCRATCH and send to your mBot. [c05f016.jpg]

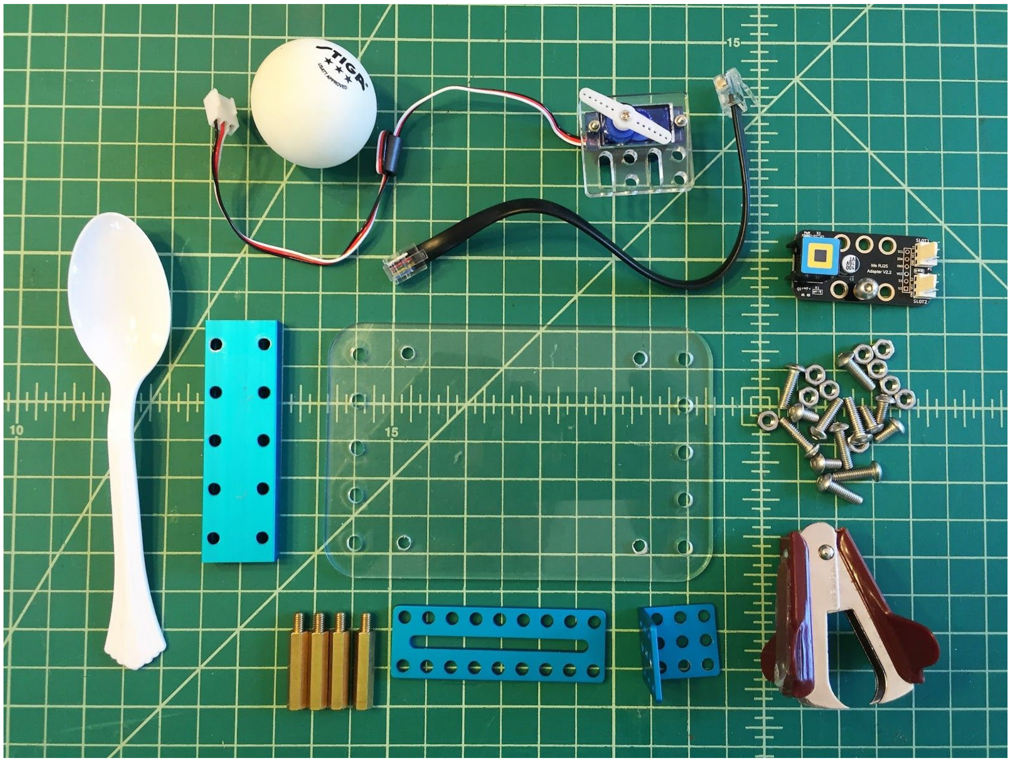
I had to edit the angles a little bit to get it them to go at a 45 degree and then at about a 90 degree angle. The spear will lower to a 45 degree angle when the “a” key is pressed on your keyboard and then will return up when released. The spear will lower to a 90 degree angle when the “s” key is pressed and then return when it is released.



Now you’re ready to joust with a cool skewer than can be raised and lowered using your computer. Safety is always important, so safety glasses are always recommended when working with sharp things. [c05f017.jpg]

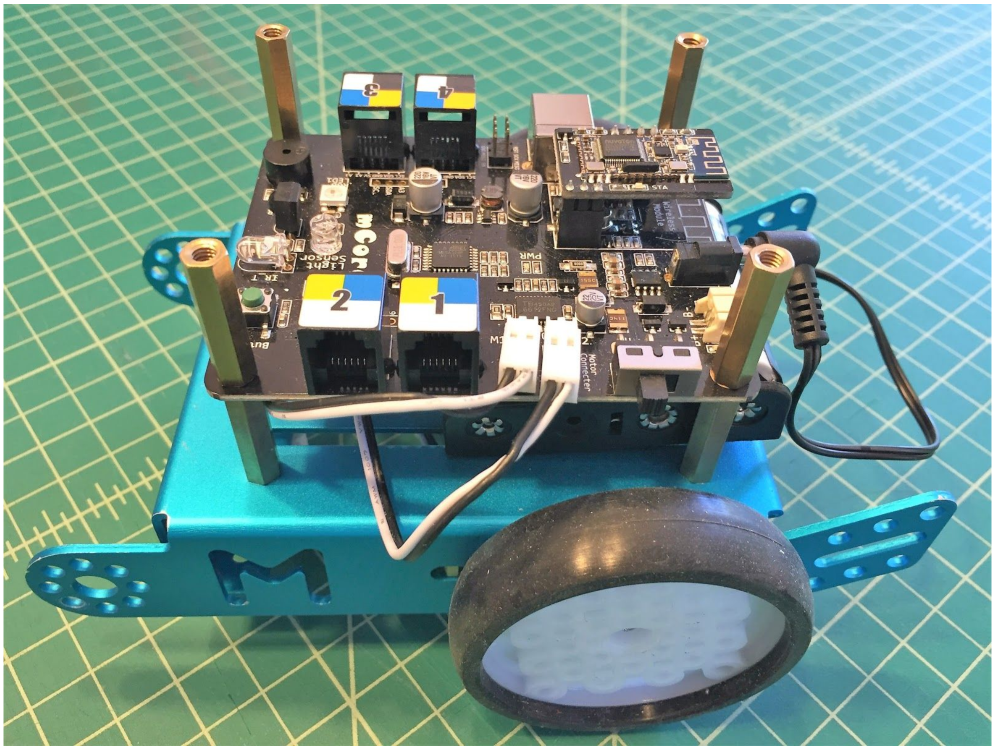
Catapult Ball Launcher

A whole different type of challenge is created using a ping-pong ball Catapult Ball Launcher – using a plastic spoon and servo to hold the spoon back. This ball launcher could be used to knock down obstacles, shoot at targets or aim for baskets.



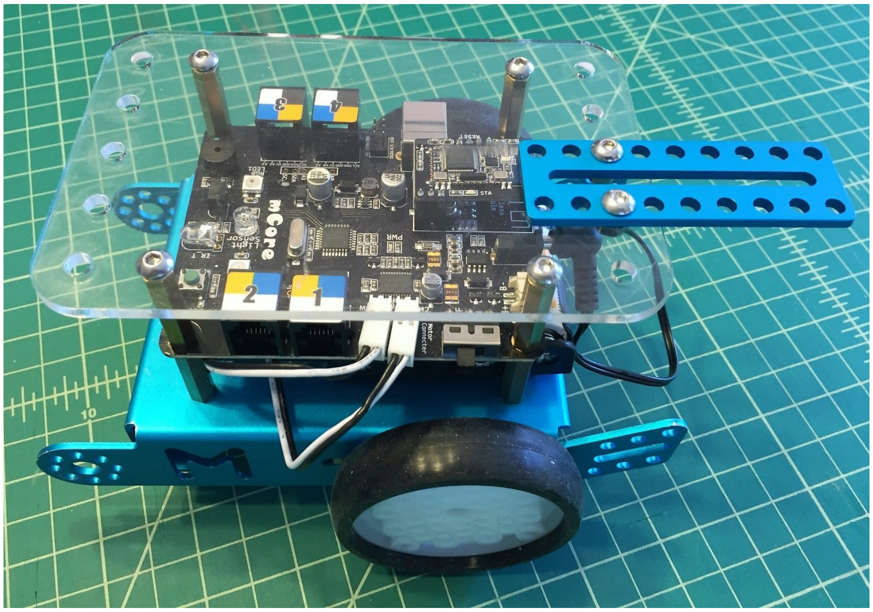
Here are all the supplies you'll need for a ping-pong ball launch rig. [c05f018.jpg]

For this project you would need the above items. The clear acrylic piece was talked about in chapter 1, page __________ as a case for the mCore. In this situation, we'll be mounting this platform to the top of your mCore to support the catapult mechanism and hold all the electronics. Laser cut files for the acrylic can be downloaded here ______________ or printed out as a full-scale PDF to be used as a template for hand-cutting on a material of your choice. Other key parts include a stiff plastic spoon and a standard staple remover.

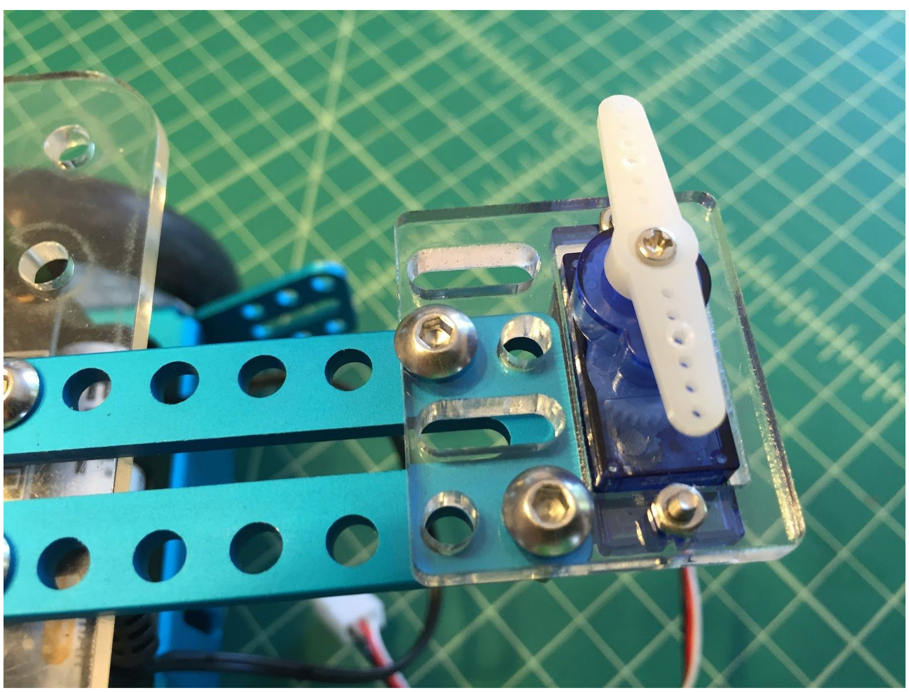


Remove the four M4 bolts holding on the mCore and replace with the four brass studs. Tighten securely. [c05f019.jpg]

Next, mount the acrylic platform onto the top of the brass studs using the four M4 bolts. [c05f020.jpg]

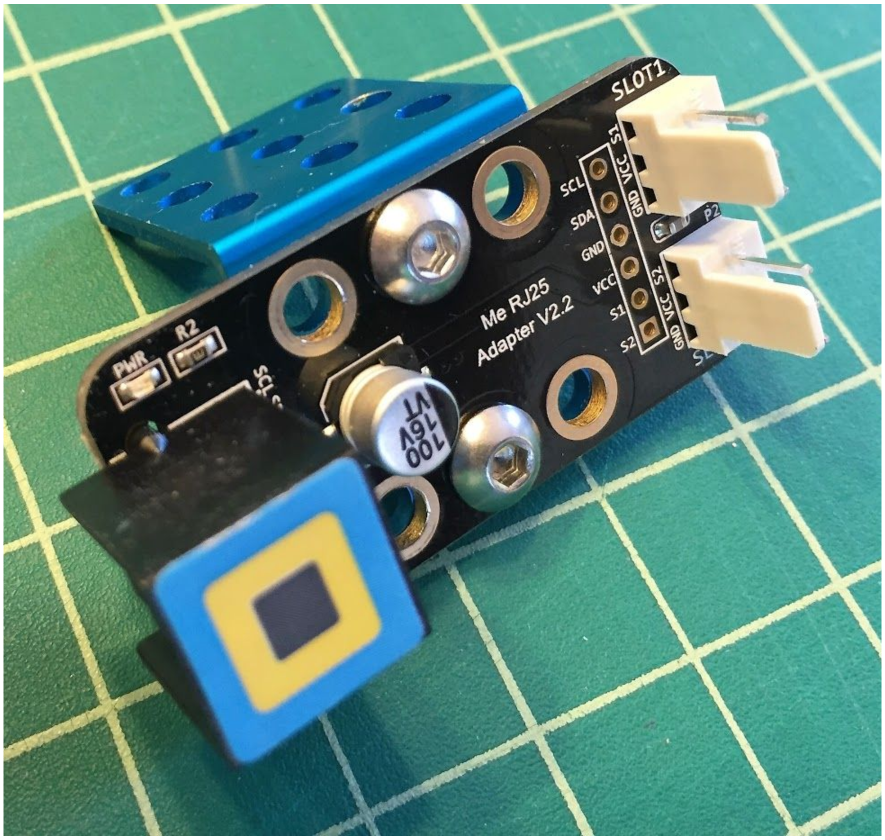


Install the 9 hole x 9 hole plate to the back of the plastic platform in the third hole and just off to the left side of the platform. [c05f021.jpg]

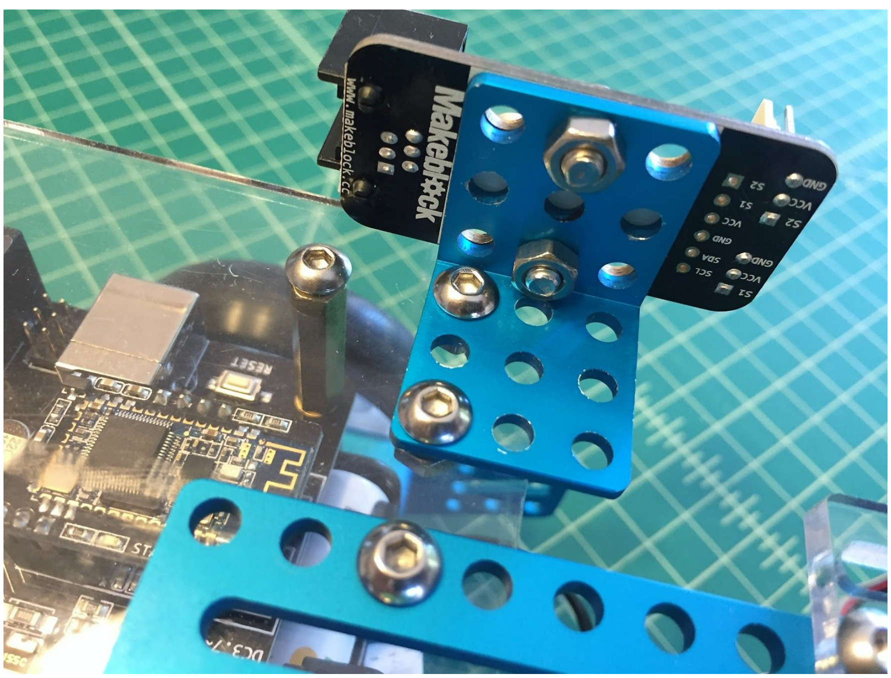


Mount the servo into the acrylic servo holder that came with the Servo Add-on pack following the instructions on page _________________. This picture needs a caption. [c05f022.jpg]

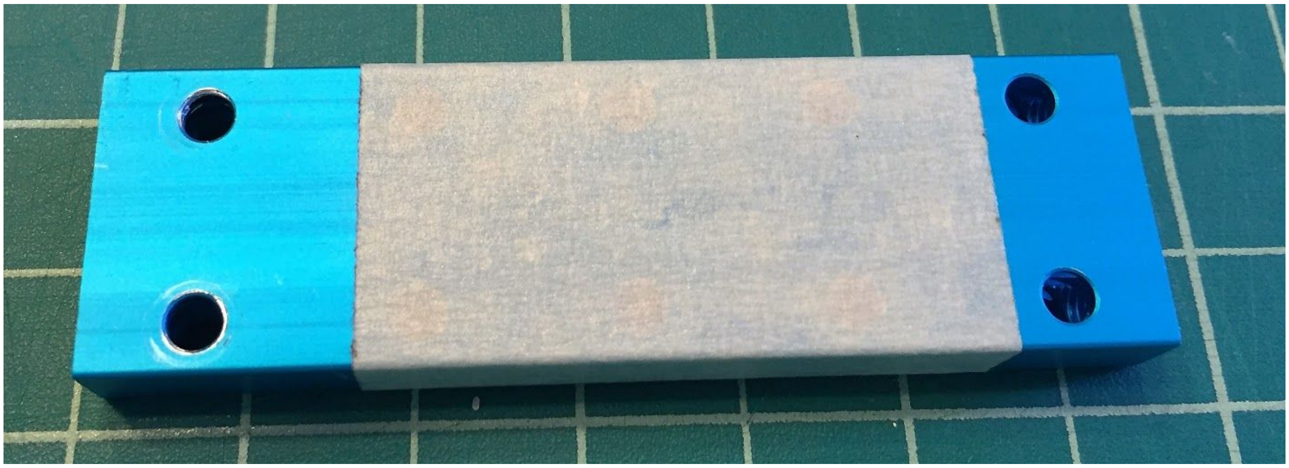
Then use M4 x 14 bolts to bolt it down to the back of the 9 hole x 9 hole bracket.



Screw the RJ25 Adapter to the “L” bracket using two M4 bolts and nuts. [c05f023.jpg]



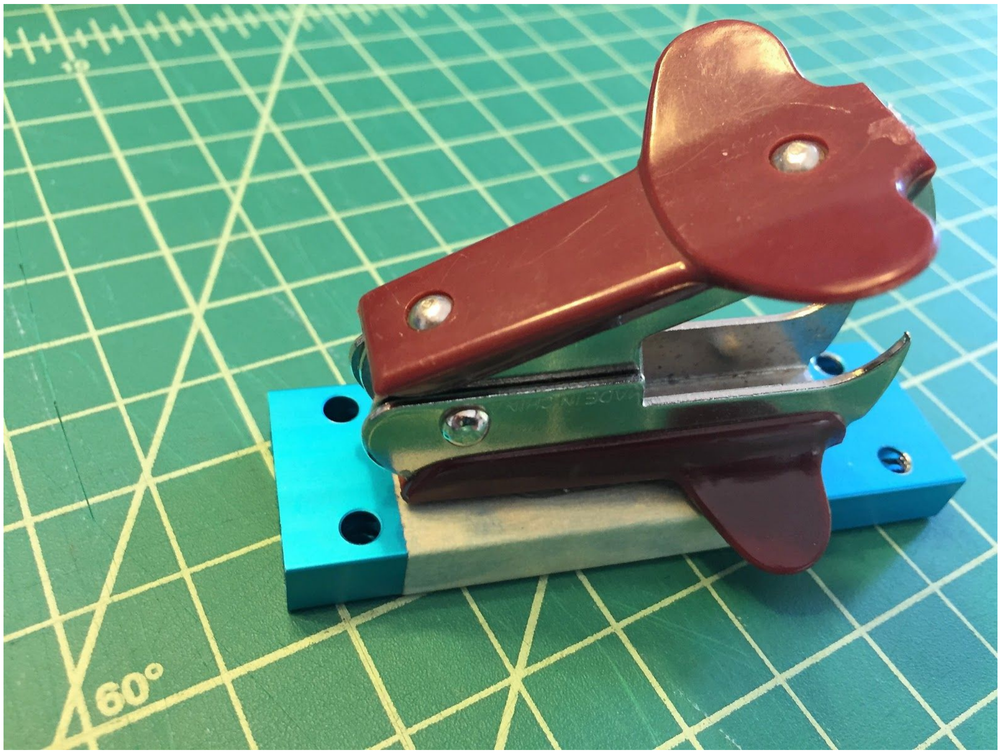
Attach the “L” bracket to the rear of the platform in the two remaining holes with M4 bolts and nuts. [c05f024.jpg]



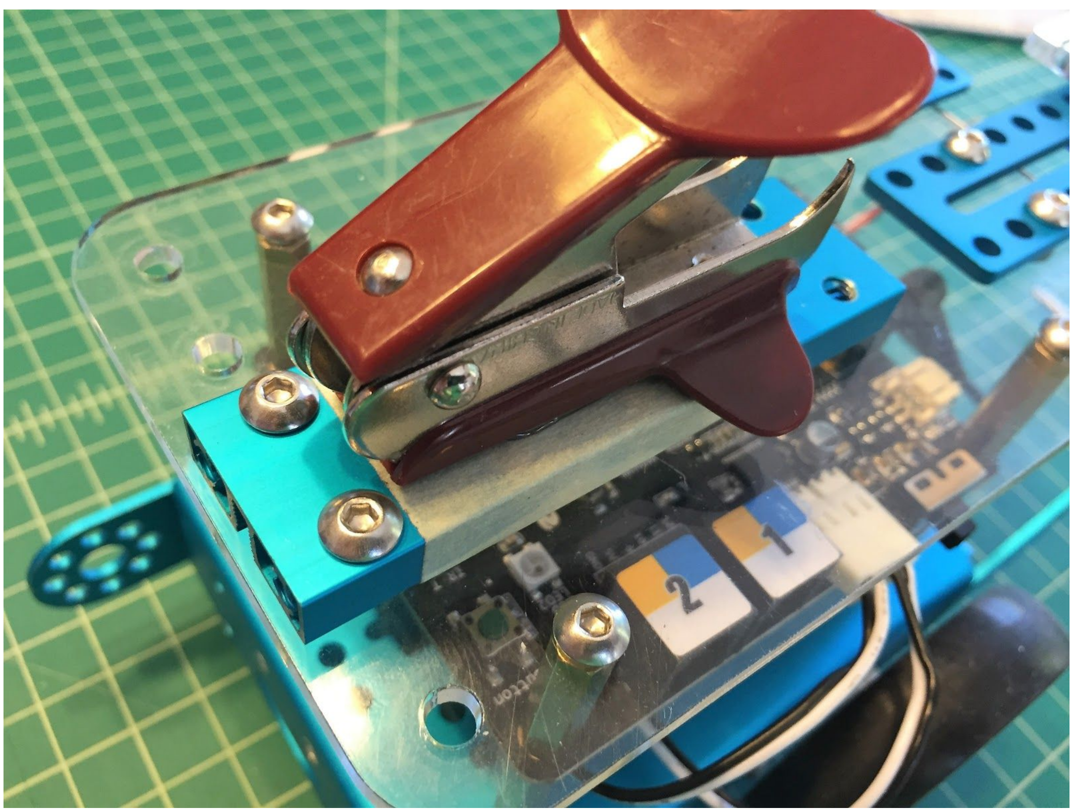
Take the double-wide 10 hole beam and cover it with masking tape. [c05f025.jpg]

We're going to be hot gluing the staple remover onto this part and want to protect the metal. Make sure you keep two parallel holes on the ends exposed as this is where you'll attach to the acrylic plate. It helps if you lay the masking tape on nice and smooth.

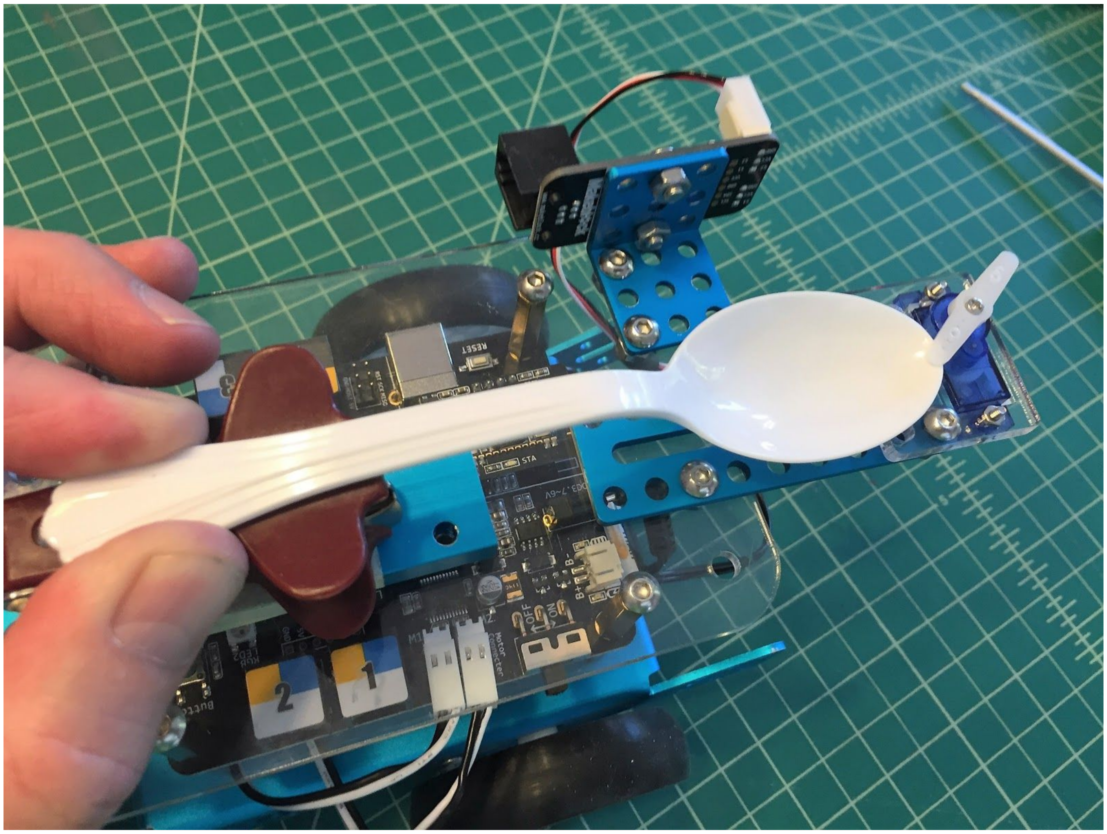
Now add a generous amount of hot glue to one side of the staple remover.[c05f026.jpg]



Now press it down evenly on top of the tape lined up with one end of the plate. Make sure the holes are exposed so that you can push an M4 bolt down through it. [c05f027.jpg]

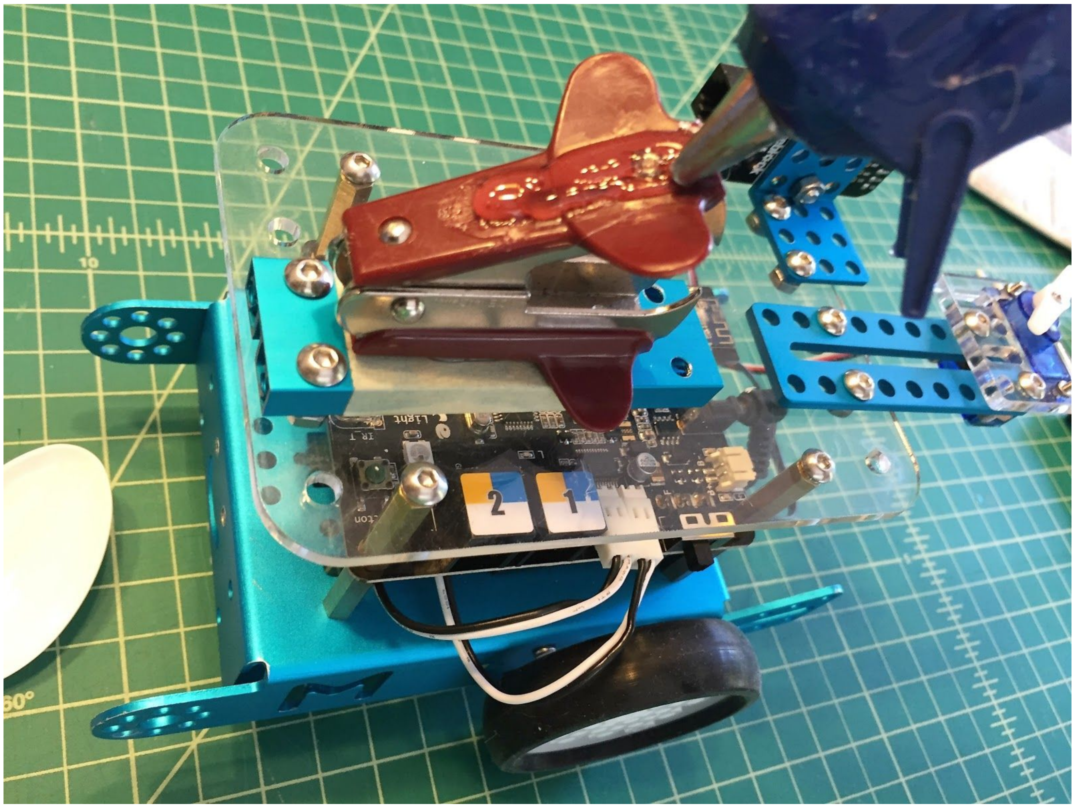


Attach the staple remover assembly to the back of the acrylic plate with two M4 x 14 bolts and nuts lines up as shown. [c05f028.jpg]

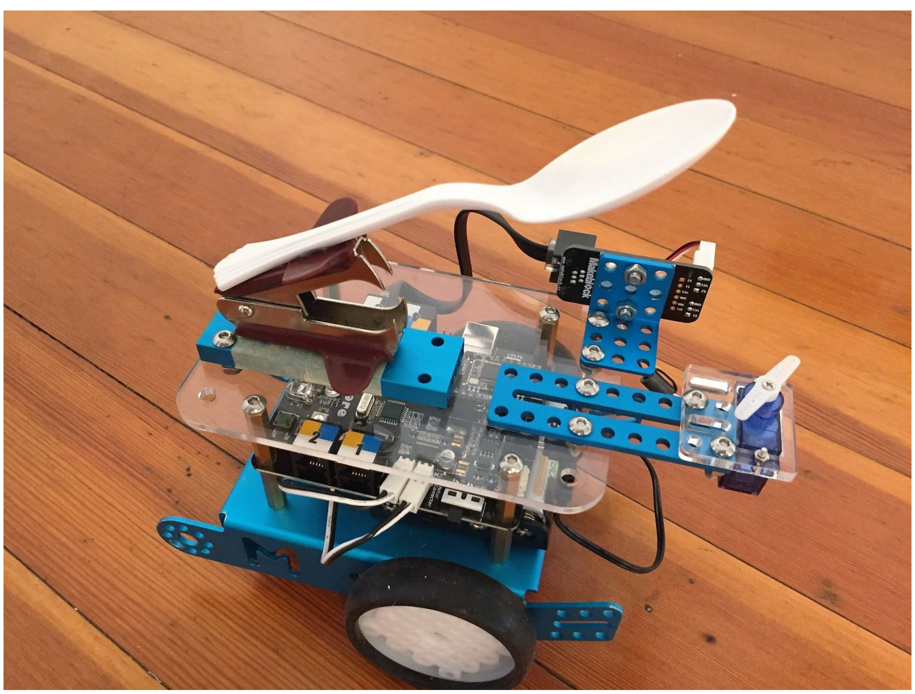


Test fit the plastic spoon on top of the staple remover. [c05f029.jpg]

The spoon should line up a little off center with the servo arm. The servo arm should be able to securely hold the spoon down in the trigger position. The servo arm will rotate out of the way to trigger the spoon catapult arm.

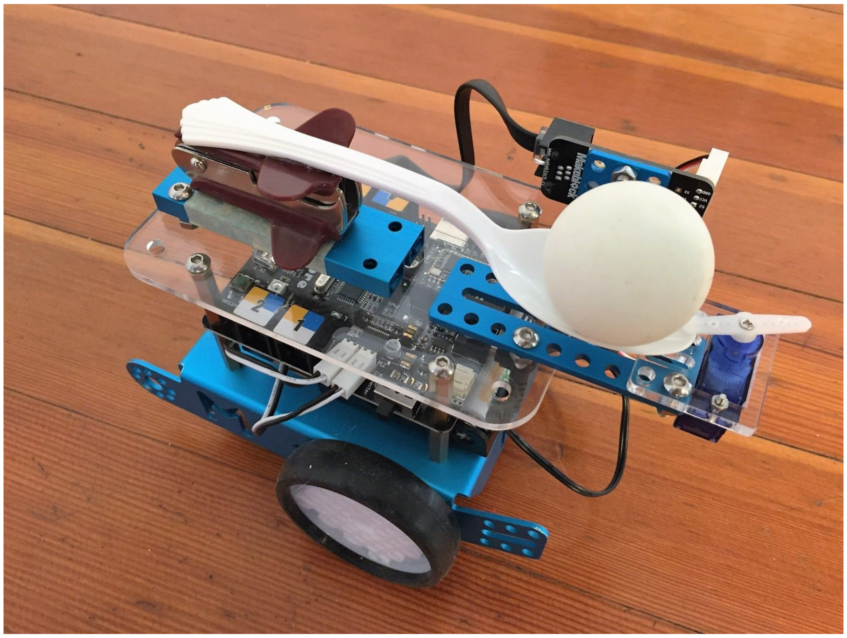


Once you know where the spoon should be placed (mark the end of the spoon with a sharpie if needed), add a generous amount of hot glue to the top side of the staple remover and press and hold the spoon in place. [c05f030.jpg]

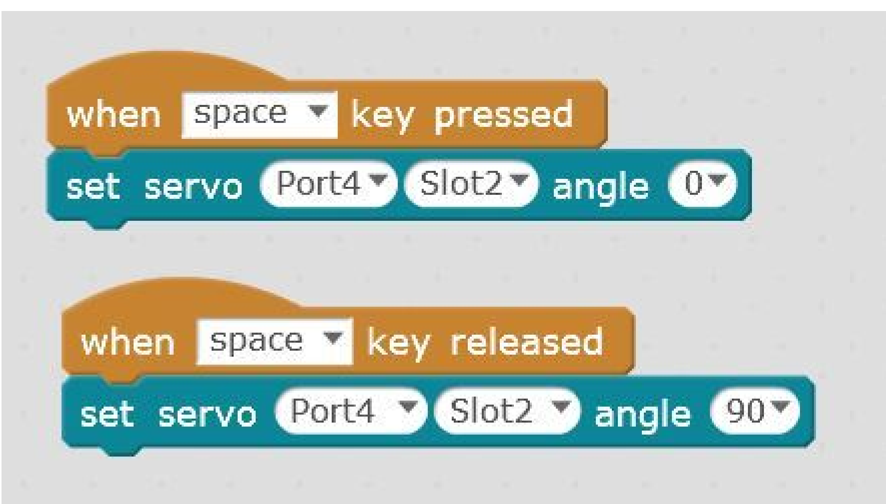


Connect an RJ25 cable from the RJ25 Adaptor to Port 3 on your mCore. [c05f031.jpg]

Connect the servo to slot 2 on the RJ25 Adaptor. The nice things about the servos that come with the Servo Add-on Pack is that they only install in one direction so you always get it plugged in correctly. If using a generic servo, follow the directions in chapter 3. This is what your finished assembly should look like with the spoon catapult in the “up” position.



Cock the spoon back and rotate the servo arm in place to hold it. Place your ping-pong ball in the spoon and now you’re ready to launch! [c05f032.jpg]



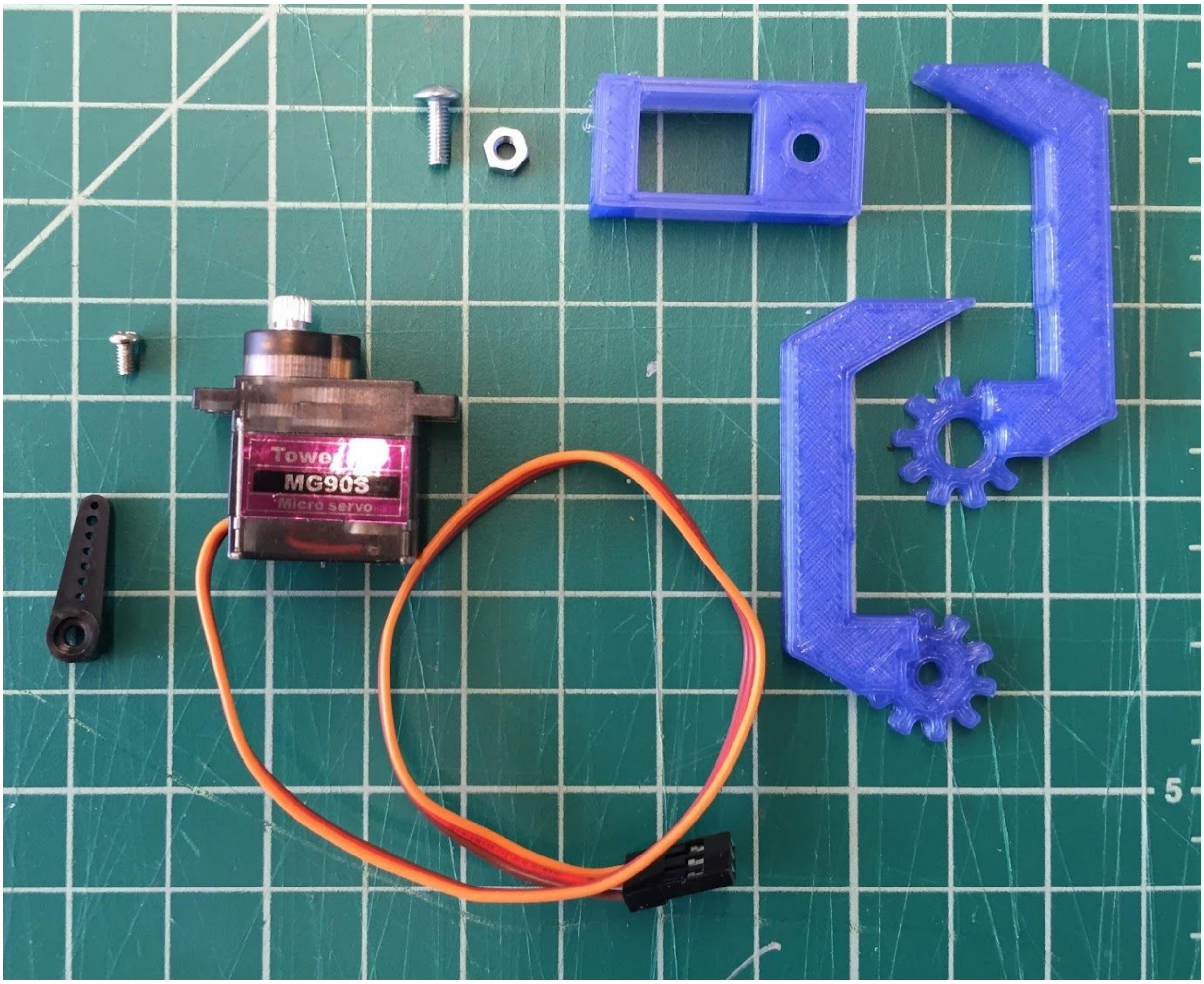
This code is really simple, with your space bar being the catapult trigger. [c05f033.jpg]

You may need to modify your code or center the servo (see page __________ for centering directions) to get your trigger to work properly. Now go set up some targets or create some challenges and fire away!

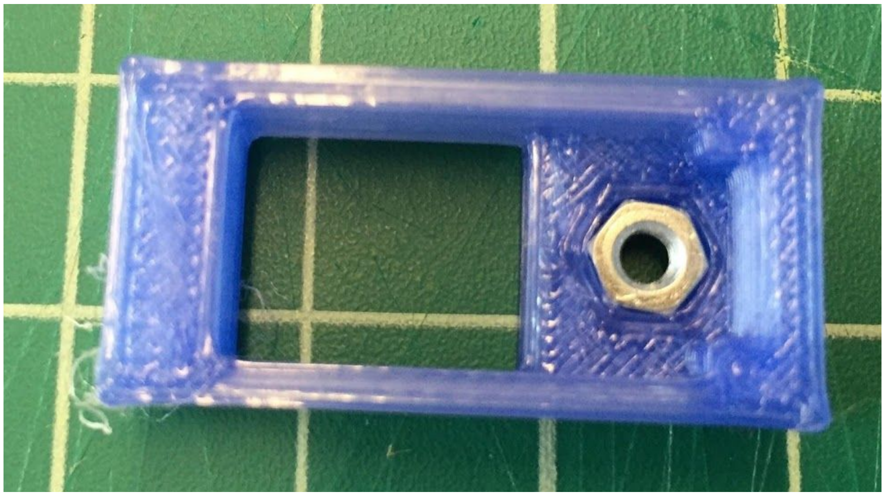
Robot with 9g servo grabber on front

Printing and assembling the servo grabber

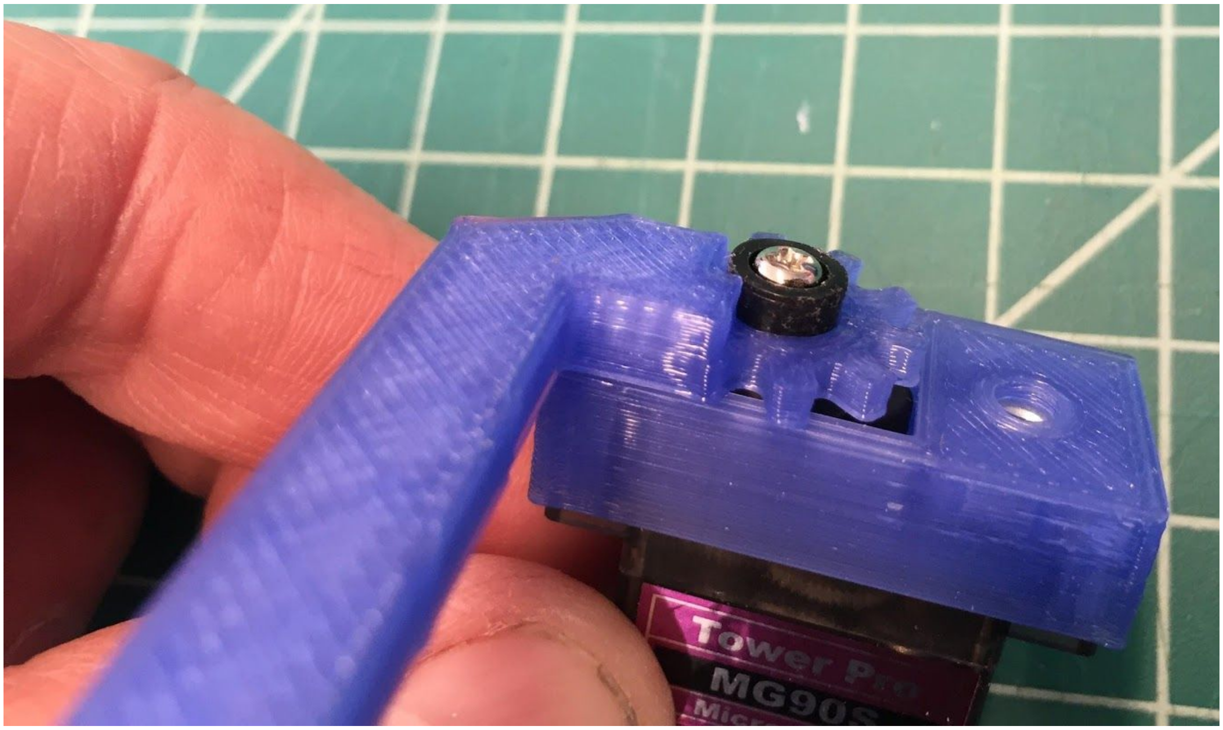
Hats off to Jon Kepler for coming up with this brilliantly simple robotic claw and posting it on Thingiverse. Download and print it at: https://www.thingiverse.com/thing:18339 It takes about 35 minutes or so to print. Along with these 3D printed parts, you'll need a micro servo (9g). The one shown here uses metals gears but still only costs a couple of bucks. You'll need the servo horns that go with them and a 3mm x 8mm machine bolt and 3mm nut.



Gather and print the above parts and then you'll be ready to go! [c05f034.jpg]

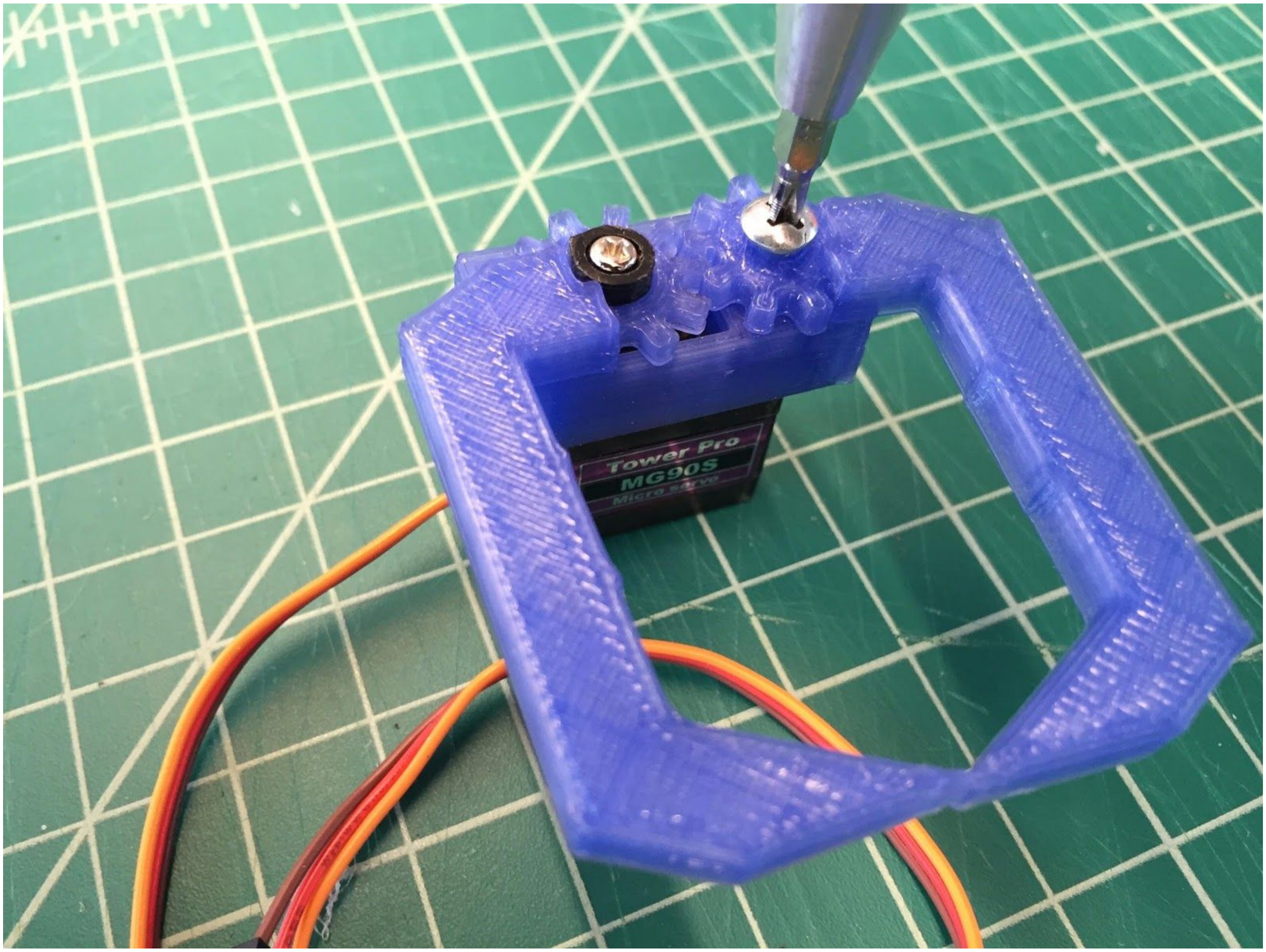

Turn the 3D printed servo box over and push the 3mm nut into the hex shaped indentation.
[c05f035.jpg]


Using a pair of wire cutters, cut the arm off the servo horn and then smooth it out with sandpaper.
[c05f036.jpg]



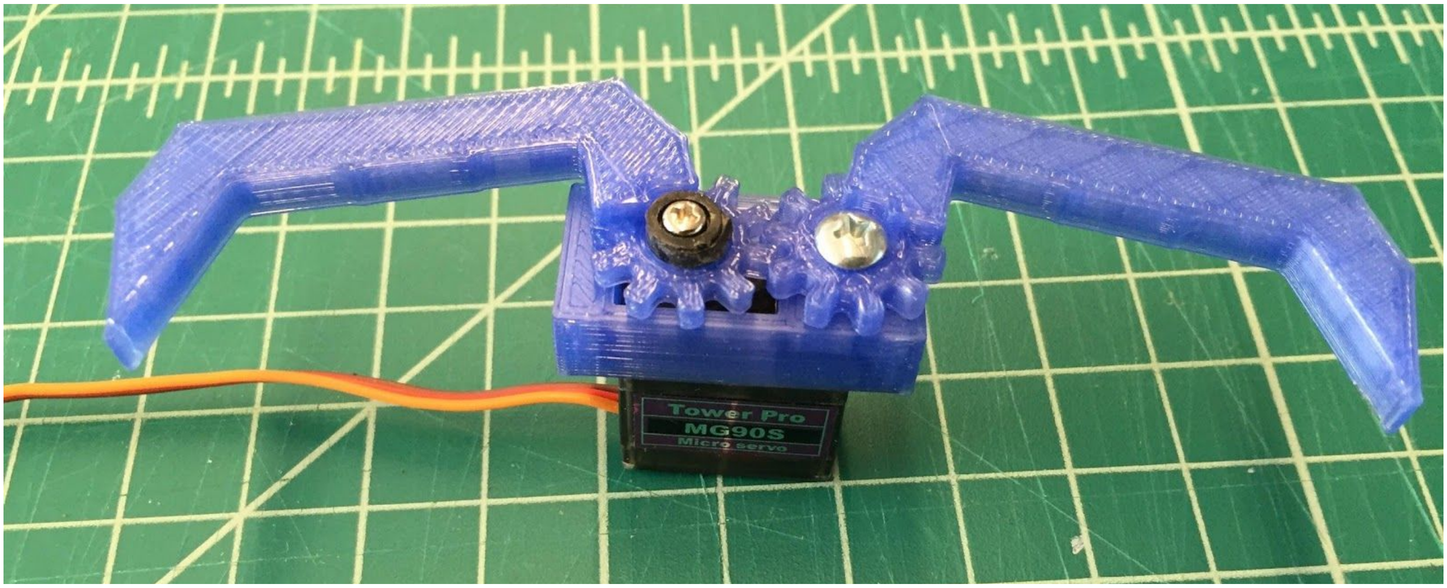
Place the servo box on top of the 9g servo with the servo shaft positioned over the opening in the servo box. [c05f037.jpg]

Position the right pincer over the shaft of the servo and attach with the screw that came with the servo. Use the piece of the servo horn (that you made in the above step) as a spacer.



Then position the left pincer next to the right with the gears interlaced. [c05f038.jpg]

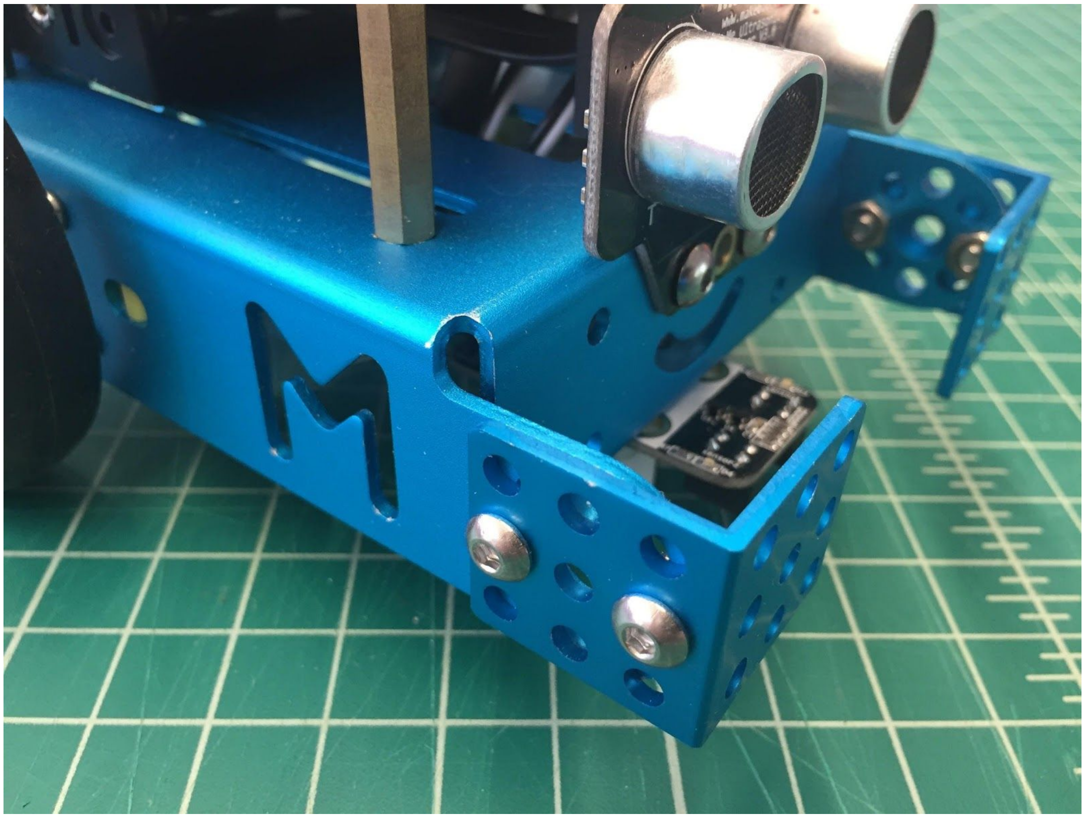
Attach with the 3mm bolt through the nut and tighten loosely so the pincers can move.



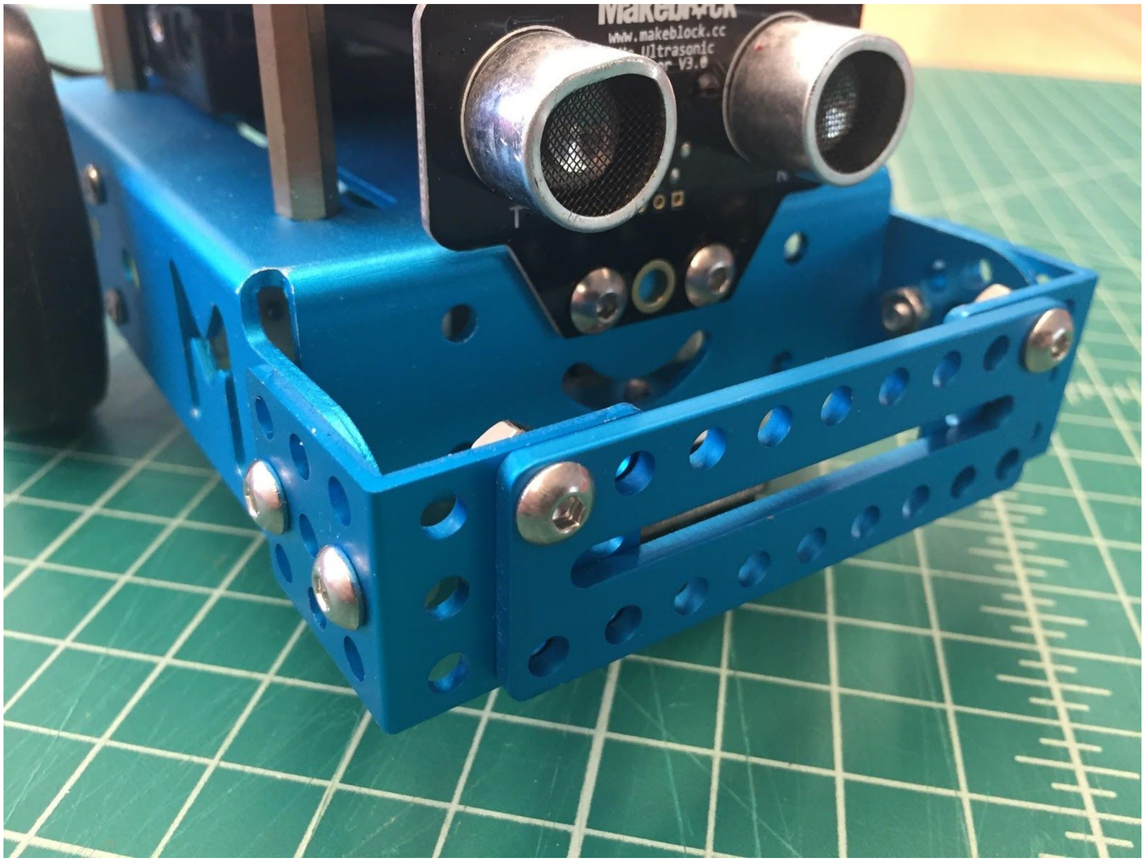
The pincer arms should move in a grasping motion. [c05f039.jpg]

The principle behind the servo arms is very simple. One arm is directly connected to the shaft of the servo. The other arm is linked by gears to the first arm. When the servo shaft turns, the first arm rotates and, thanks to the gears, forces the second arm to move in the opposite direction, thus bringing the two arms together. Once attached to the mBot, the arms may need to be adjusted after you get the servo calibrated.

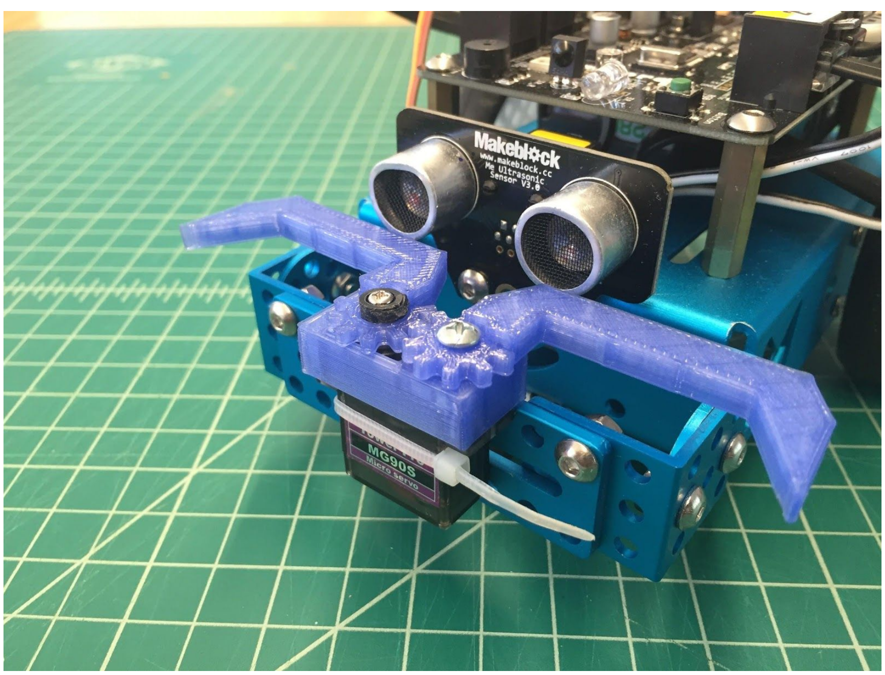
Next, you're going to build a bracket for your mBot to attach the grabber mechanism.



Screw the aluminum “L” brackets included with the mBot Servo Pack onto the front brackets of the mBot chassis using the M4 screws and nuts.   [c05f040.jpg]

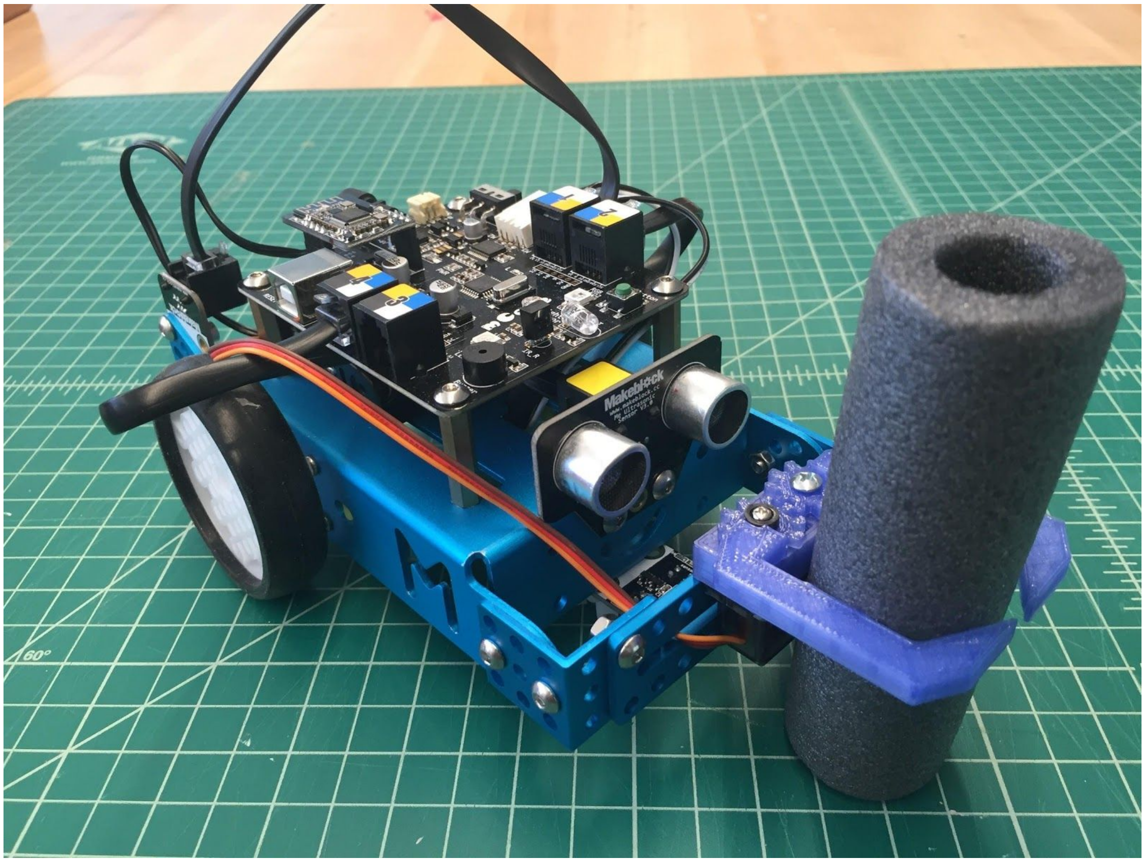


Next screw the aluminum plate to the “L” brackets as shown. [c05f041.jpg]

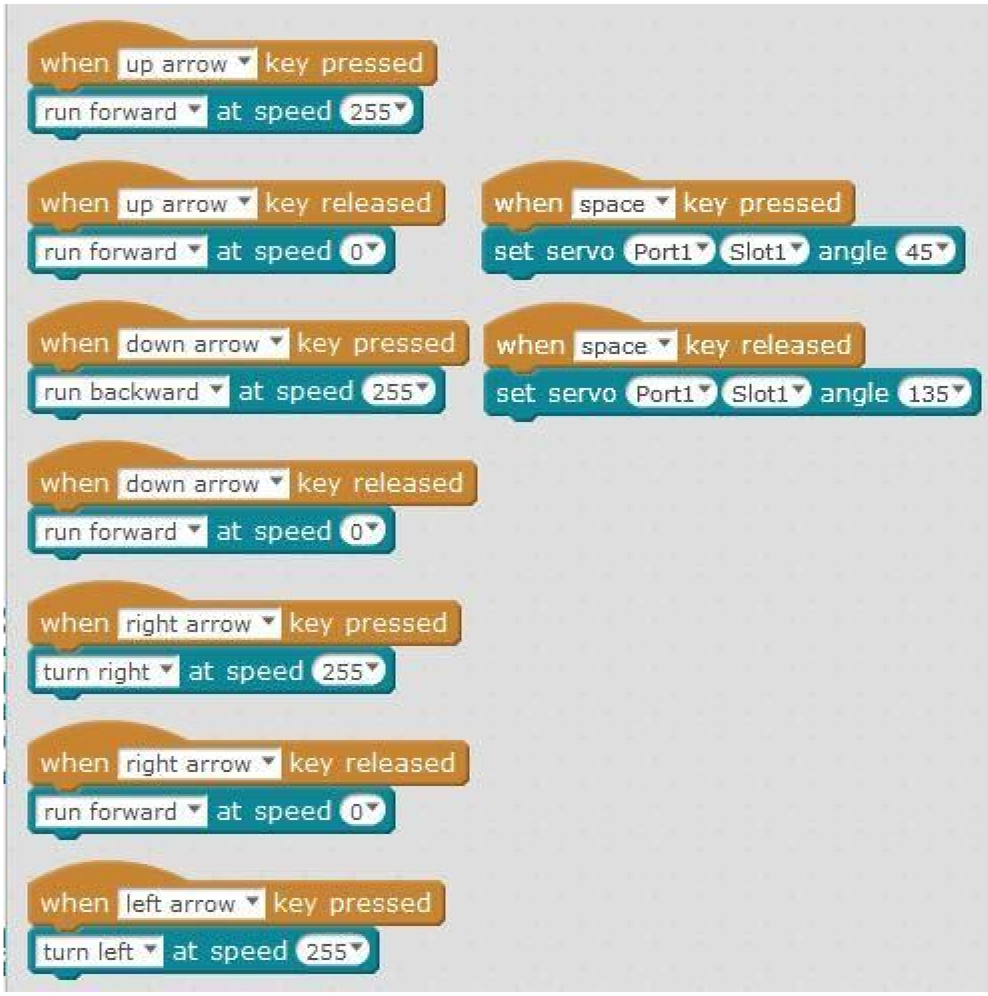


Using a mini zip tie attach the servo grabber to the front bracket and cinch tight. [c05f042.jpg]

Connect the servo to the mCore, Port 1 using the RJ25 adapter. The grabber works well grabbing things like foam pipe insulation. I attached the RJ25 adapter to the back of the mBot using some M4 screws and nuts. The wires can be neatened up using more mini zip ties or twist ties.



Here is the servo grabber in the closed position holding a piece of foam pipe insulation. [c05f043.jpg]

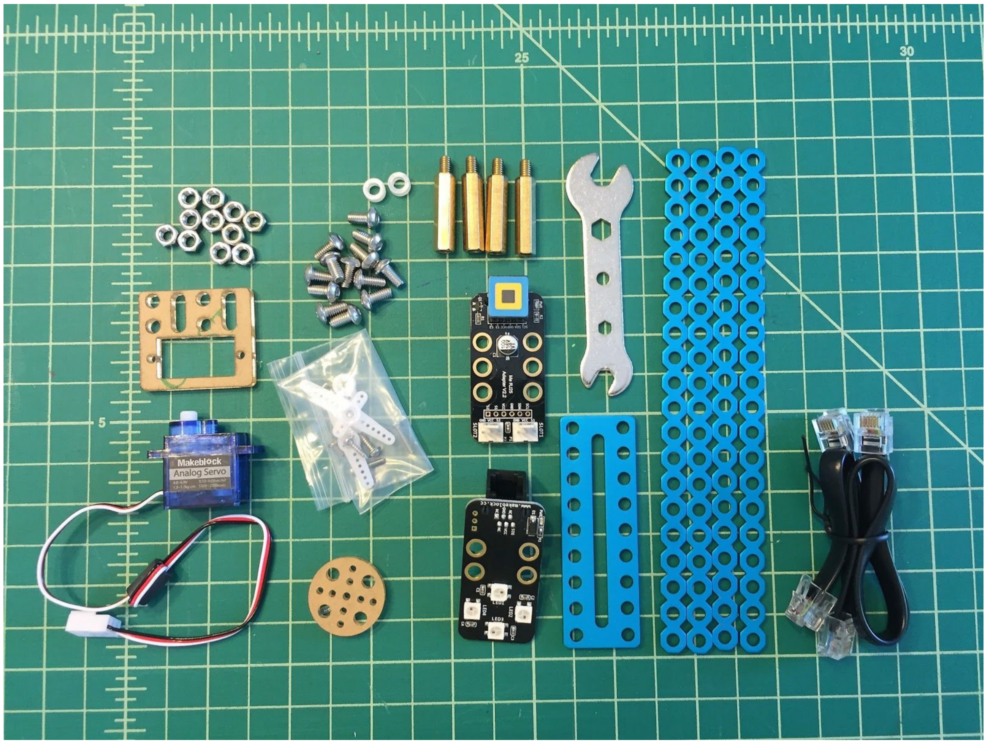


In the above SCRATCH code, the code on the left controls the mBot using the up, down, left and right arrows. The code on the right, opens and closes the grabber claw using the space bar. [c05f044.jpg]

<u>Servo add-on pack (LIght-Emitting and Head Shaking Creature)</u>

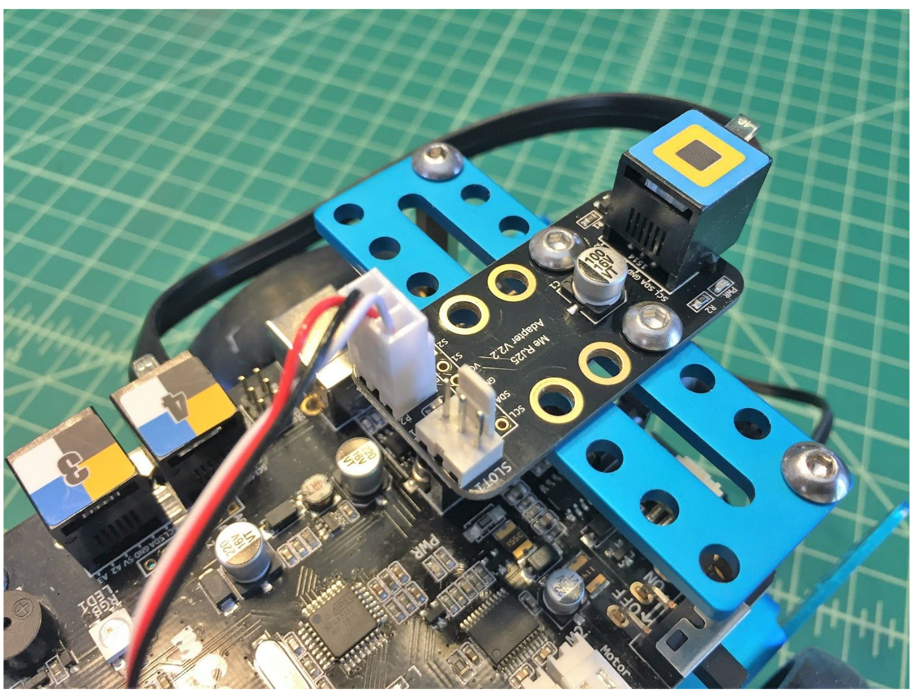
The Servo Add-on Pack includes:

- M4 Brass Studs (4)
- M4 Bolts x 8mm
- M4 Nuts
- RJ25 cable (2)
- Plastic Spacers
- 9g Servo with Holder
- RGB LED Sensor
- RJ25 Adaptor
- 3 hole x 3 hole “L” bracket (2)
- Cuttable Linkage (4)
- M5 x M7 Wrench
- 9 hole x 9 hole plate (2)



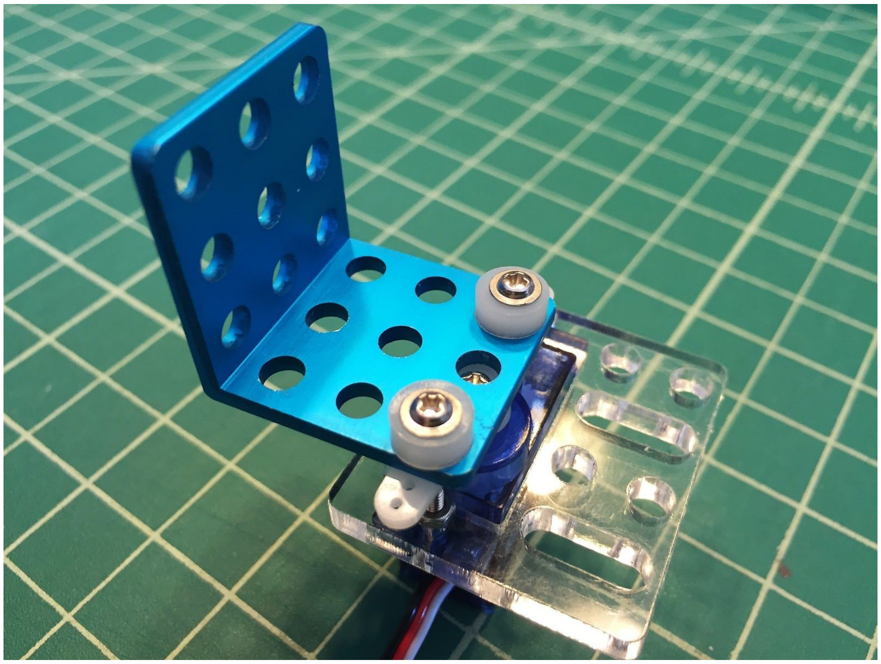
The Servo Add-on Pack [c05f045.jpg]

With the Servo Add-on Pack you can build a Dancing Cat, Head-Shaking Cat or Light-Emitting Cat. For this project, we'll be combining the Light-Emitting and Head-Shaking features. This will create a robot with a lighted LED “head” that can move back and forth using a servo.

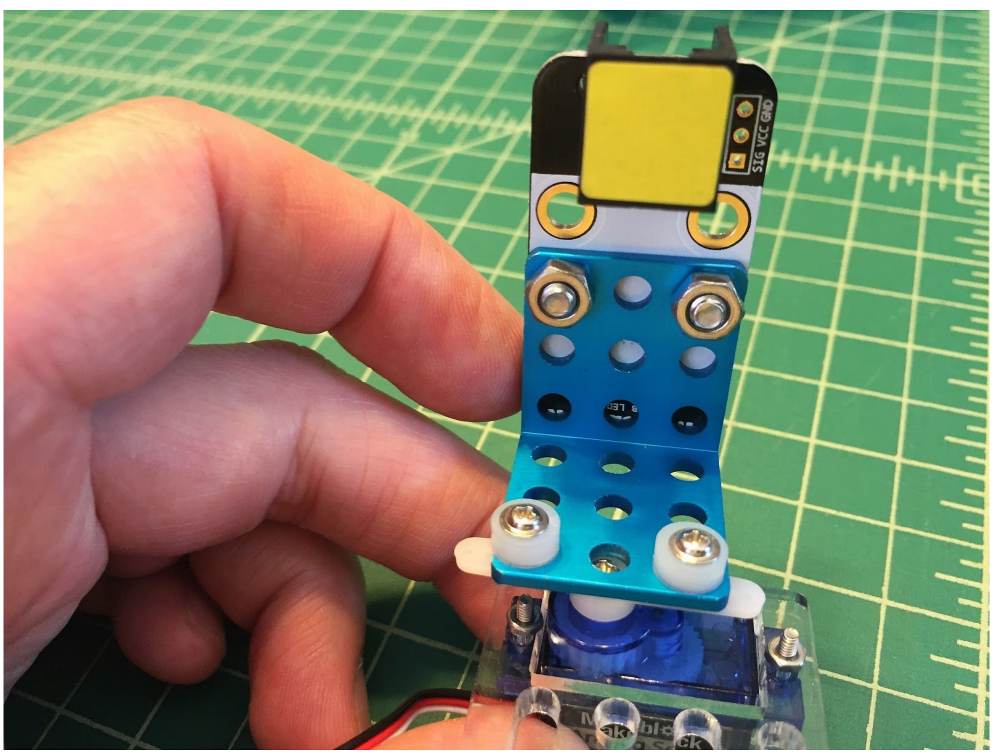


Attach the rear plate to the top back of your mCore [c05f046.jpg]

Attach the rear plate to the top back of your mCore following the steps listed earlier in the chapter for the spear-lowering project. Then attach the RJ25 Adapter and center the servo as described in the spear-lowering project section as well.

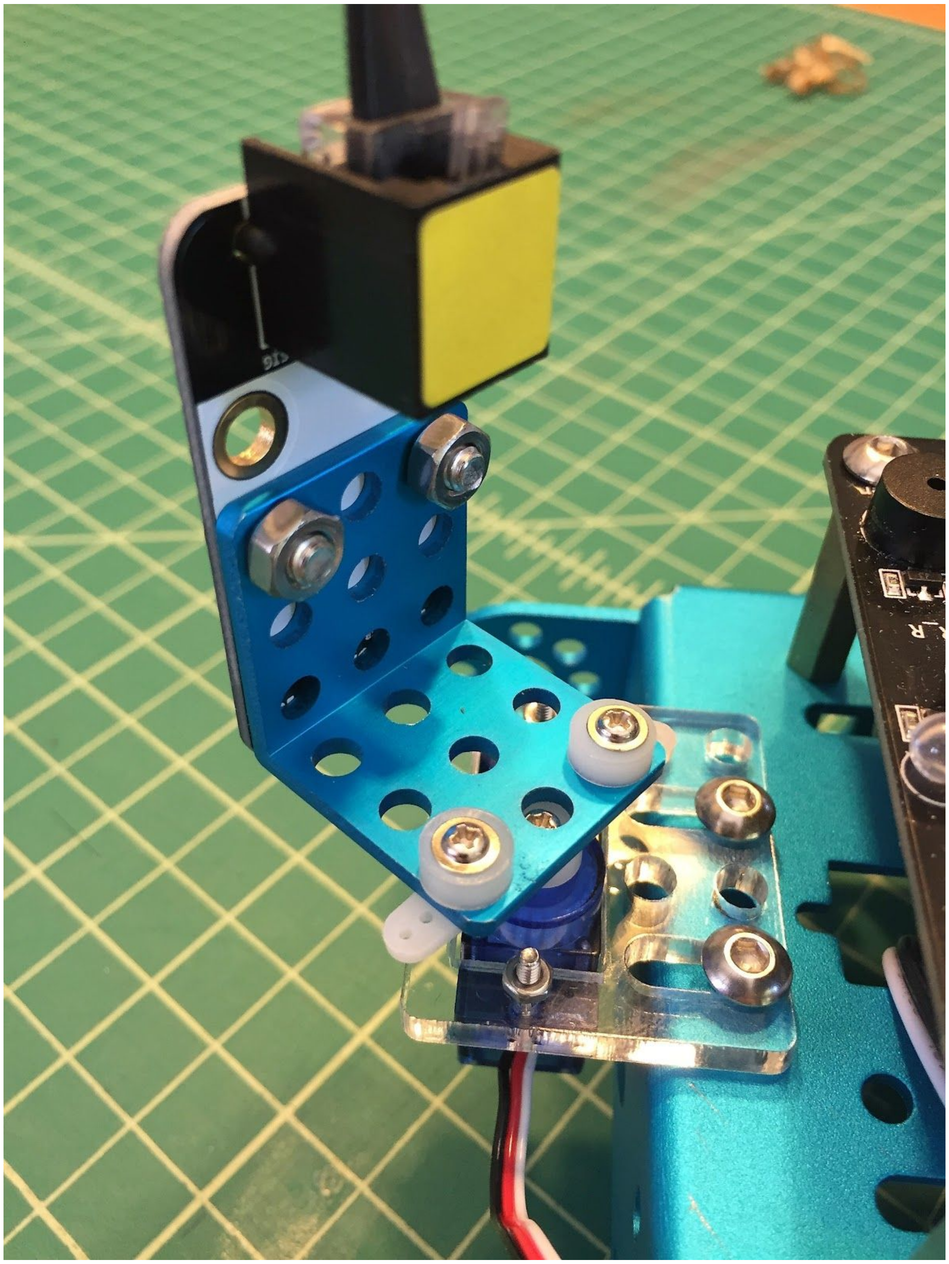


Once the servo is connected and centered, attach the “L” bracket to the servo arm using the two self tapping screws that came with the servo. [c05f047.jpg]

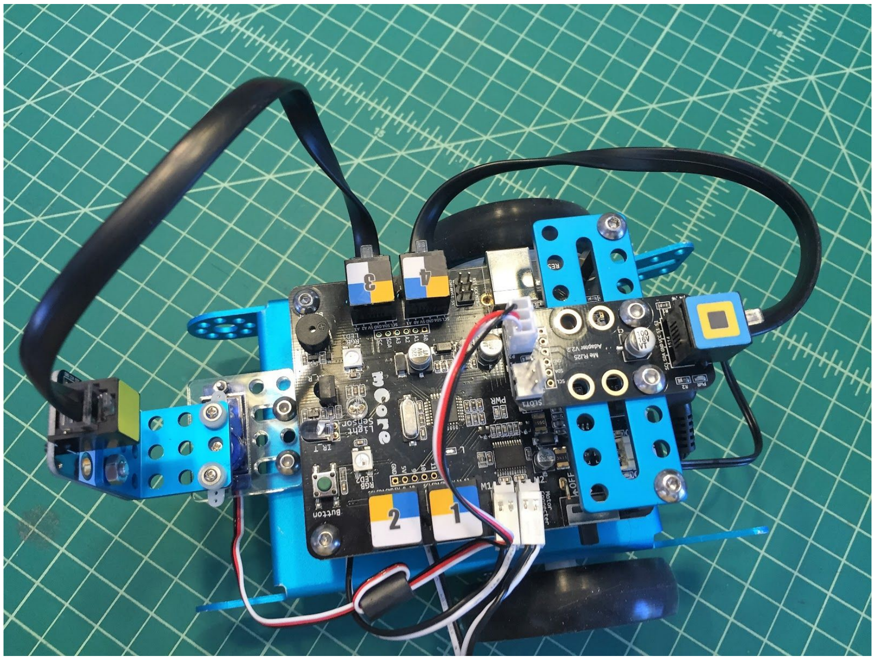


Position the LED sensor onto the “L” bracket as shown and secure with two 4M x 8 bolts and nuts. [c05f048.jpg]

Make sure the sensor is attached in the top holes of the “L” bracket and bottom holes of the LED sensor so that the sensor can rotate about freely on the servo.



Plug the RJ25 cable into the sensor so it is positioned out the top. [c05f049.jpg]

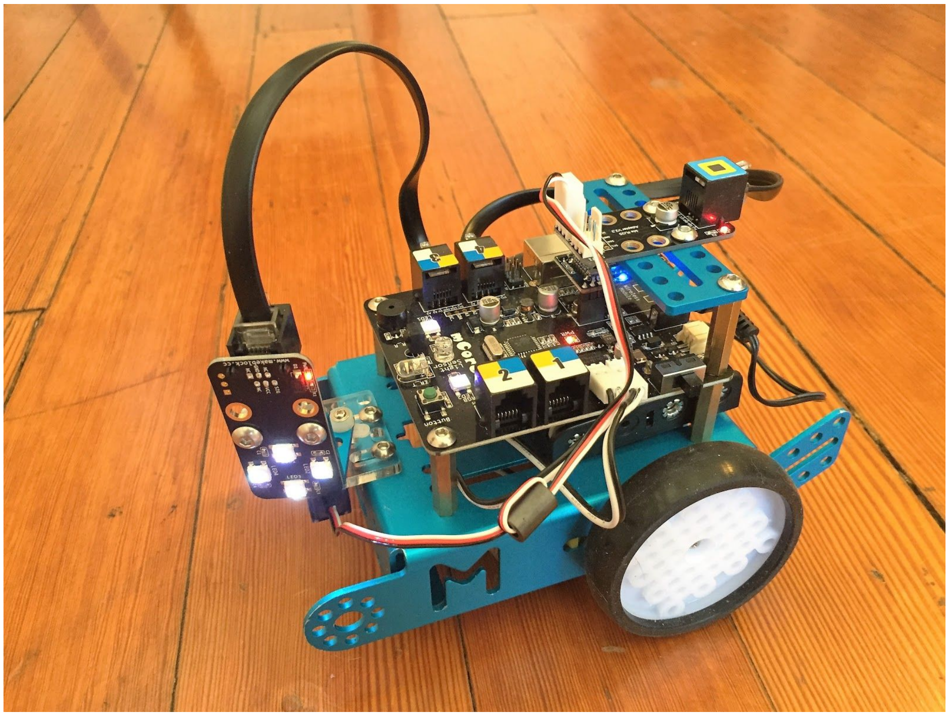


Then plug the other end of the RJ25 cable into Port 3 on the mCore. [c05f050.jpg]

Plug a second RJ25 cable into Port 4 and the other end into the RJ25 adapter mounted on the back of the mCore.

This image needs a caption. [c05f051.jpg]

Use SCRATCH to program the LED to turn on and off and to move the light side to side using the “L” and “R” keys on the keyboard as shown below:

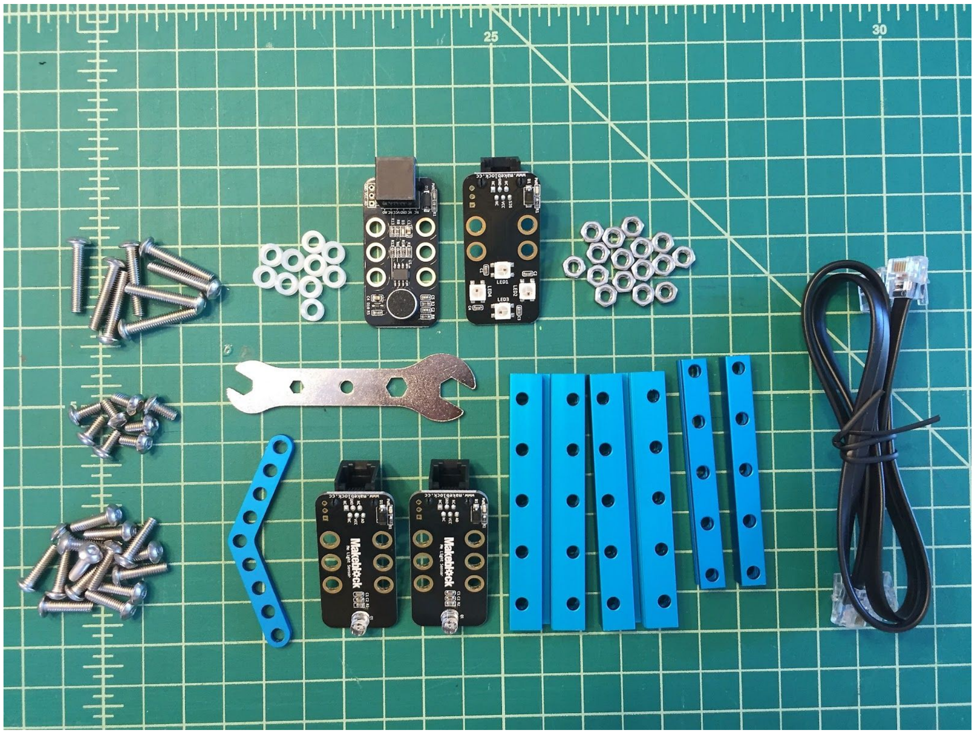


This image needs a caption. [c05f052.jpg]

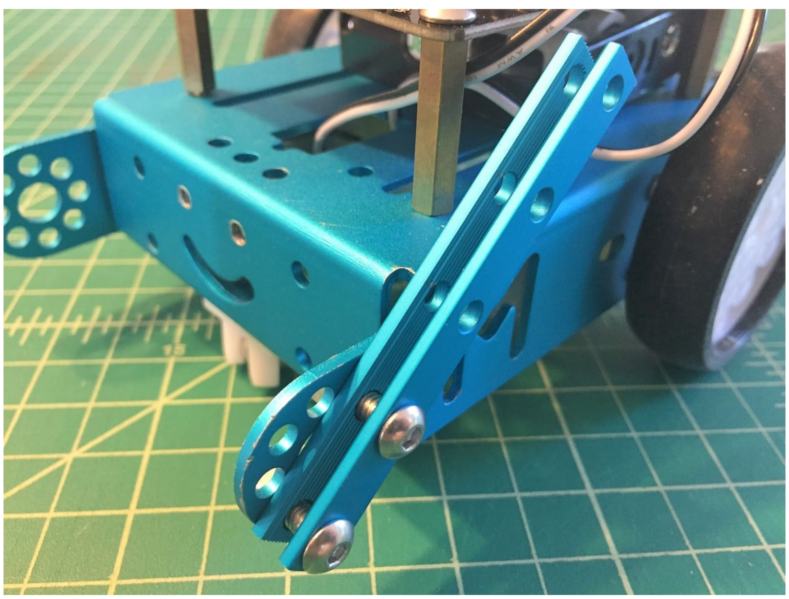
Light and Sound Add-on Pack (Light Chasing Robot)

For the following project, you'll use the Light and Sound Add-on Pack. You'll be creating a bot that follows a flashlight using two Light Sensors. The Interactive Light and Sound add-on pack includes:

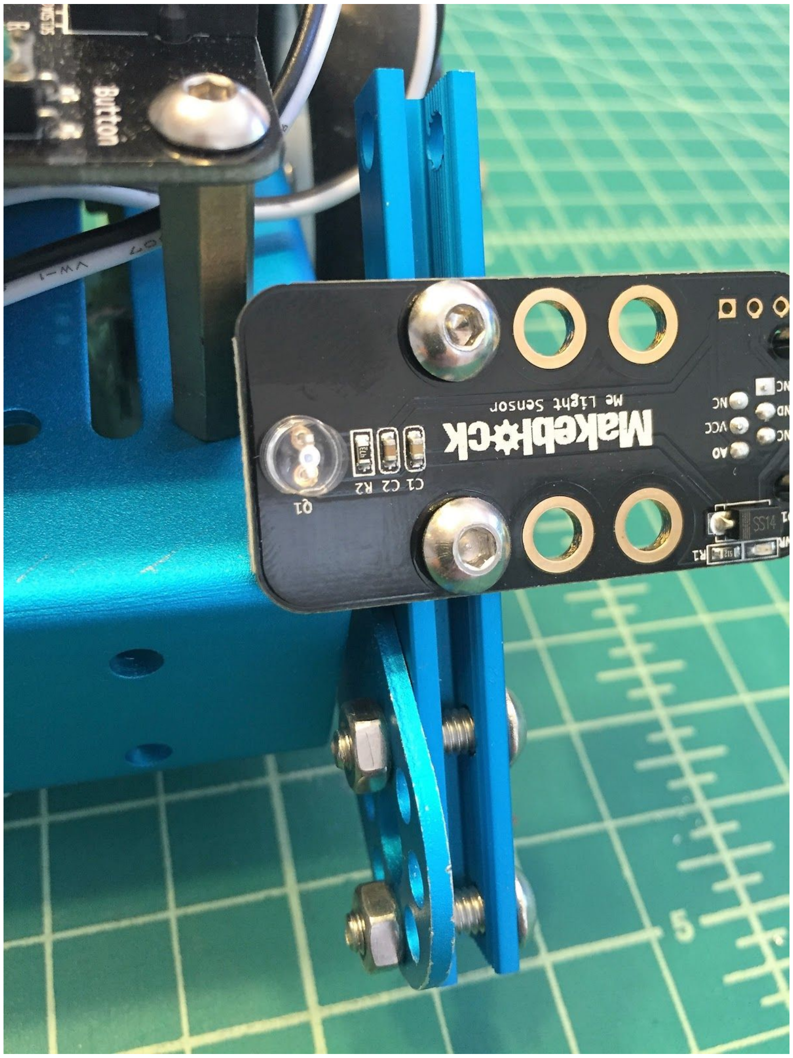
- M4 nuts and plastic spacers
- M4 bolts x 8mm, 14mm and 22mm
- Light Sensor (2)
- RGB LED Sensor (1)
- Sound Sensor (1)
- RJ25 cable (2)
- 45 degree metal plate
- Double-wide 10 hole beam (2)
- Single-wide 5 hole beam (2)
- M5 + M7 wrench



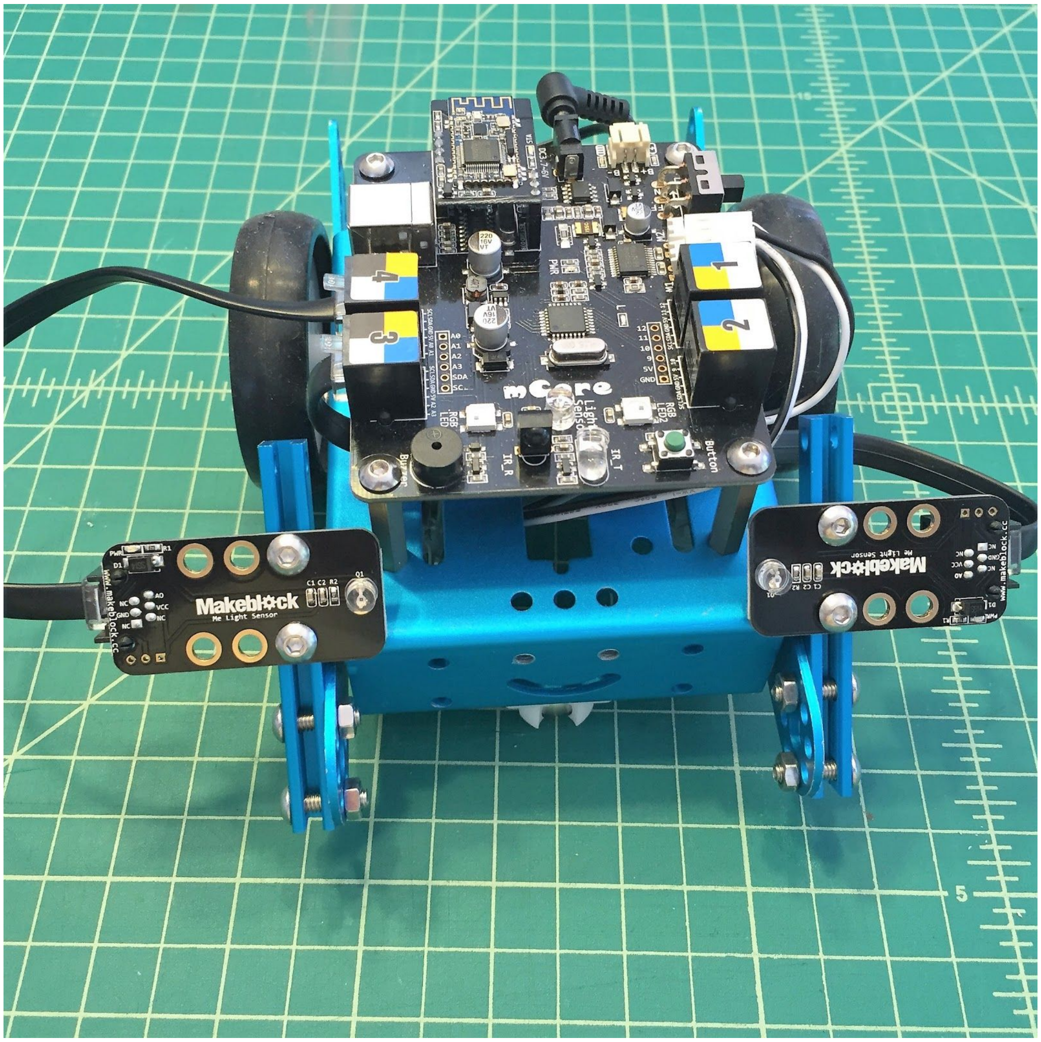
For this project, we're going to build the Light-Chasing Robot using some beams and the two Light Sensors. [c05f053.jpg]



Mount the double-wide two hole beam to each side of the front of the chassis with two M4 x 14mm bolts and nuts. [c05f054.jpg]

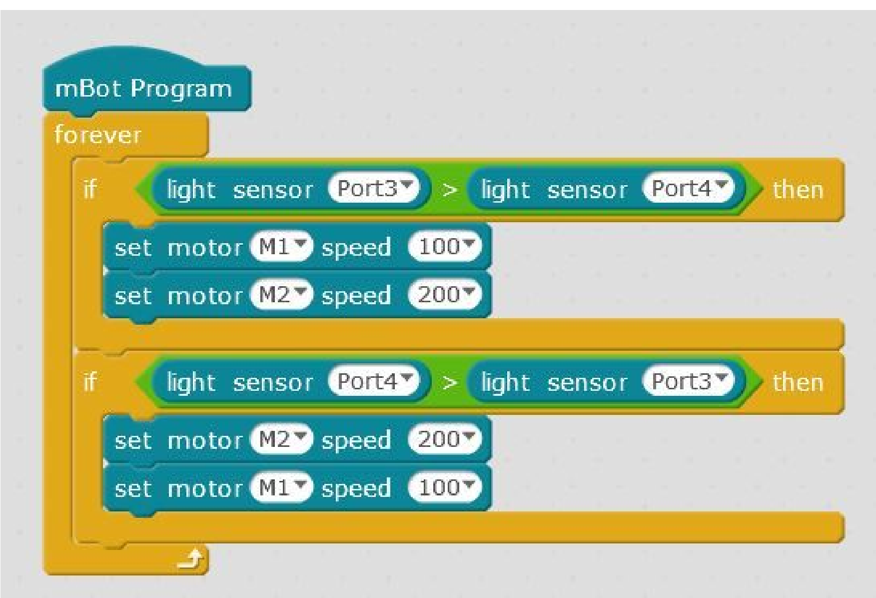


Each channel has a threaded inside, so you can screw the Light Sensor into the channel using two M4 x 8 bolts. [c05f055.jpg]



This is what it should look like with both Light Sensors mounted to the front. [c05f056.jpg]

The RJ25 jack should be facing out. Plug the RJ25 cable on the right side (when viewed from the back of the mBot) into Port 4 and another cable on the left side into Port 3.



Now program in SCRATCH the above code and send to your mBot. [c05f057.jpg]

You'll now have an mBot that follows after the light from a flashlight whether it be straight ahead or using light to get the mBot to turn right or left using the light.

3-Axis Accelerometer and Gyro Sensor (TBD)

Do you have something for this? Have you had success using them? I rewrote the Software section in part to clarify which program needs to be loaded in order to use these sensors with mBlock.

Maze-solving mBot using standard sensors

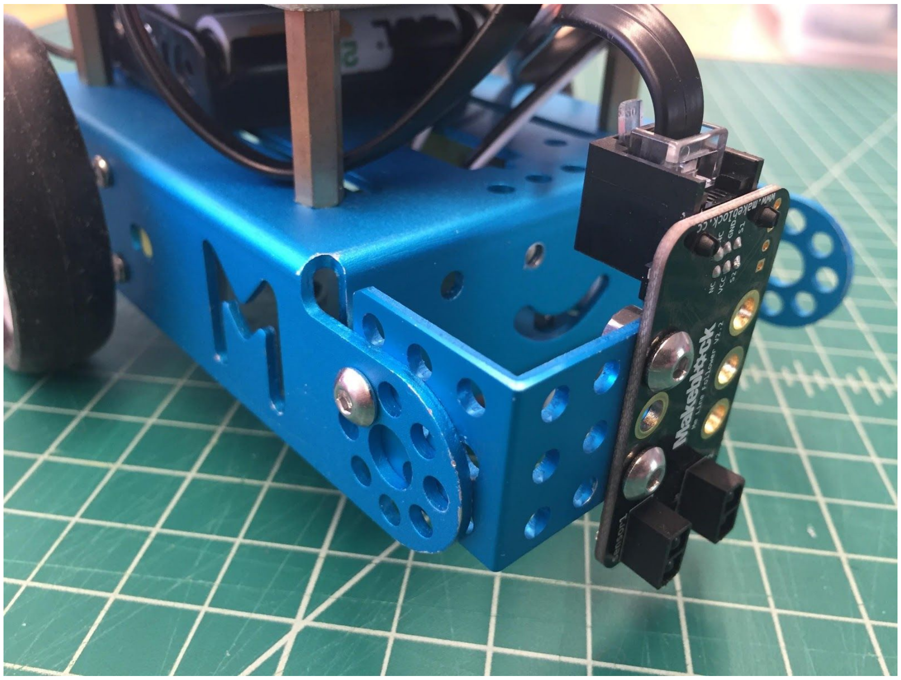
Josh Elijah in his article on makezine.com, "Beginner Robotics: Understanding how Simple Sensors Work" describes the characteristics of true robots well. He says, "For a robot to truly be considered a robot, it must be able to sense and affect its environment."   The article uses a robot operation called sense > think > act. In a nutshell, the sensor (e.g. distance sensor or line following sensor) senses the environment, then the microcontroller "thinks" or makes a decision about what to do. Finally, it acts or carries out the decision.

The next project, brilliantly conceived by Dani Sanz (juegosrobotica.es) from Spain, illustrates robotic operation excellently. His website is translatable using Google and I've translated his SCRATCH code here. Dani's project illustrates how global the mBot platform reaches.

The line-following sensor and distance sensor that come with the mBot kit are the only sensors needed for this maze-solving design. These sensors sense the environment which in this case is a maze. The mCore "thinks" about what to do and then carries out the decision. This feedback loop operates continuously from the time the mBot starts the maze until when it finishes.

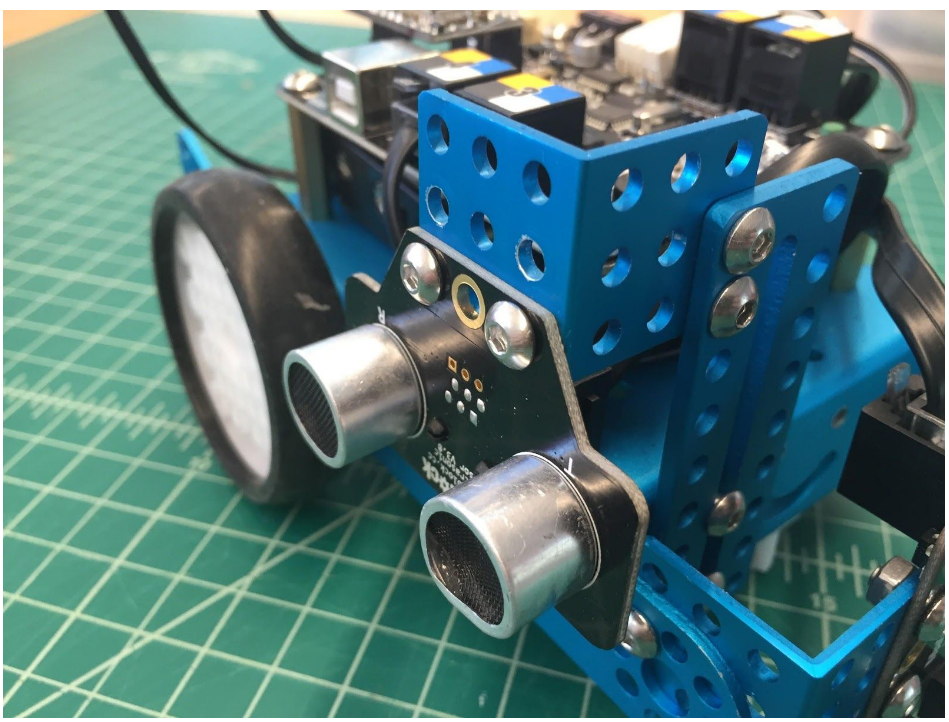
The brackets that come with the mBot Add-on Servo Kit work well for this. It comes with two "L" brackets and two Plates and plenty of M4 screws and nuts.

Using an "L" bracket, mount the line-following sensor vertically instead of horizontally (like when it's used for line following). Use one M4 screw and nut to hold the "L" bracket in place, then two M4 screws and nuts to secure the line sensor.

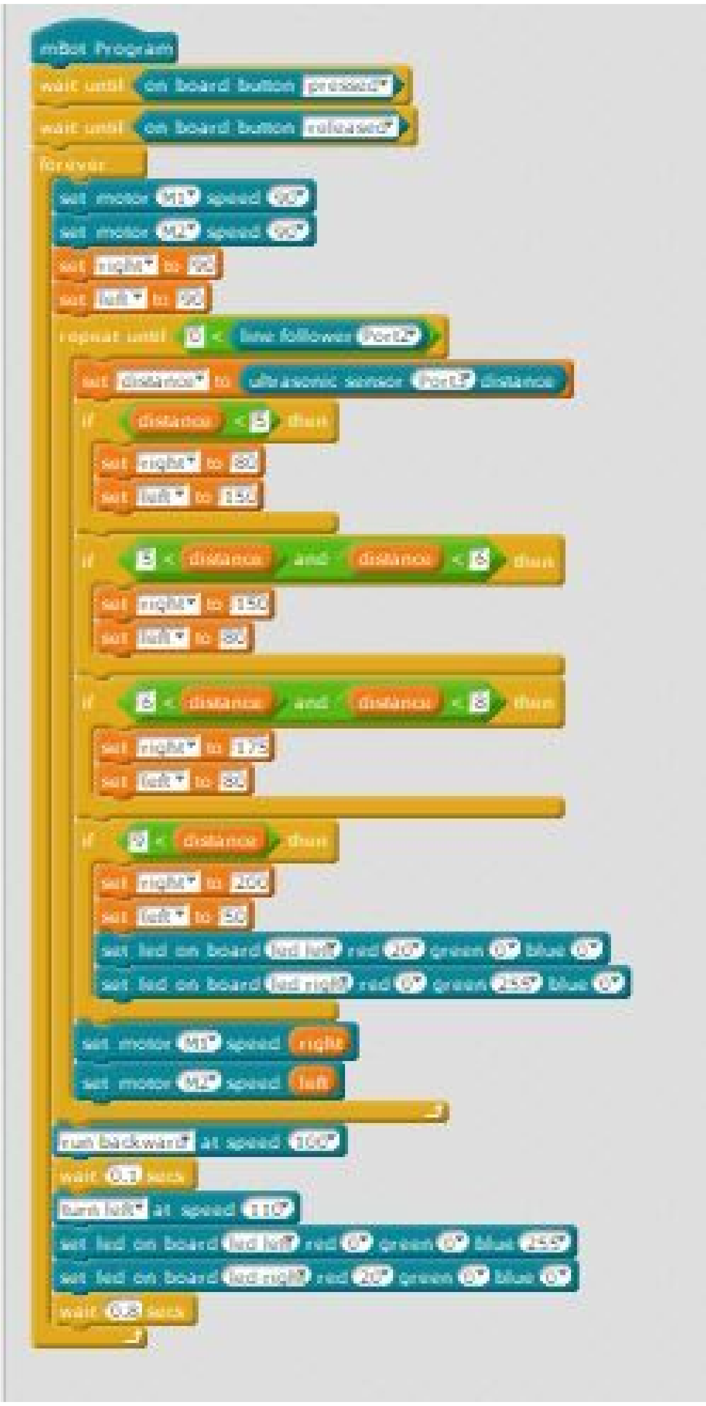


This picture needs a caption. [c05f058.jpg]

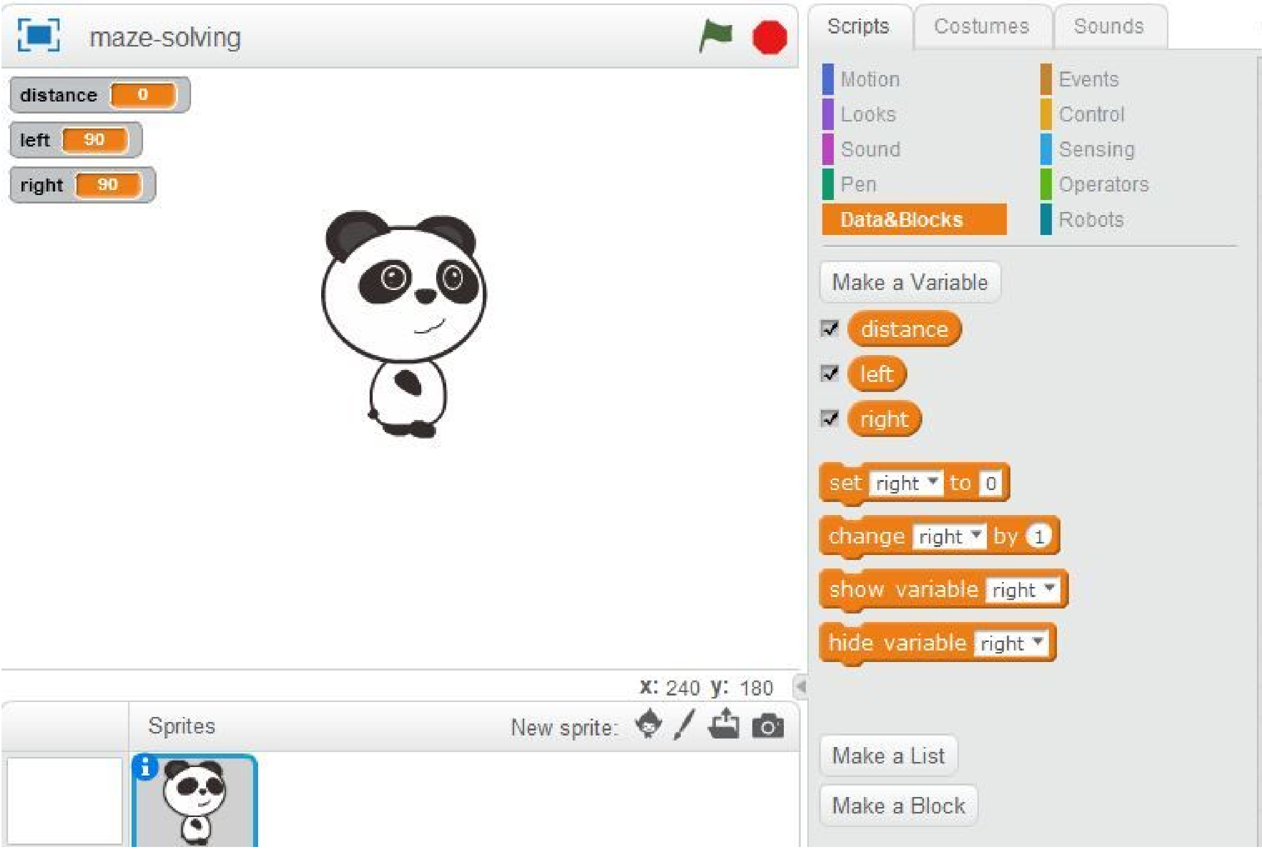
Use two M4 screws and nuts to attach a plate to the front of the mBot chassis and two M4 screws to attach a second “L” bracket to the plate facing out. Then attach the Distance Sensor upside down to the bottom of the “L” bracket facing out on the right-hand side of the mBot.



Plug the Line-Following Sensor into Port 2 and the Ultrasonic Sensor into Port 3. [c05f059.jpg]



SCRATCH programming for Maze-solving robot with Distance Sensor and Line-Following Sensor is indicated above. [c05f060.jpg]



Here are the variables needed for the program. [c05f061.jpg]

The maze is made out of foam pieces placed on the floor. Above is a screen grab from YouTube. [c05f062.jpg]

While this chapter has looked at many of the “stock” items offered by Makeblock like the Add-on packs, the next chapter will really delve into how to use the mCore with any off the shelf components like pumps, motors and LED’s. Chapter 6 will also dive deeper into the workings of DC motors and how to connect standard DC motors to the mCore board in a way that works with many projects and many kids.