This single axis robotic arm lifts and lowers the target captured within its end effector. The arm’s end effector is a wire snare that a small servo extends and retracts. When the snare is extended, the arm can lower and lasso the target. Then the snare is retracted, capturing the target. A robot determines a successful capture (or release) by monitoring a switch mounted to the end of the arm. The end effector used on the robotic arm of the Space Shuttle and International Space Station inspired the snare used in this arm.

**Onwards and Upwards**

**Your Roboticist Guide**

![Figure 1. The complete single axis robotic arm with snare end-effector.](image)

**Parts in the Single Axis Robotic Arm with Snare End-Effector**

There are over 30 parts in this single axis robotic arm kit, as shown in figure 2.
The 1/8” inch thick plastic sheet of plastic in the kit is foamed PVC (poly-vinyl chloride) and called Syntra. Since it’s foamed (filled with air bubbles), it’s softer and easier to machine than regular PVC (which is a very hard plastic). The corrugated plastic sheet is called Correplast.

Inside the small zip bag are the small parts for the air including nylocks, or nylon lock nuts. The nylon insert inside nylocks prevents the nuts from working lose from the movement of the robotic arm. They require a pair of pliers to tighten, but once they’re on, they’re secure enough that you won’t have to worry about your robot’s arm falling apart during a competition.

A servo is an electro-mechanical device. It rotates to and holds a position based on the width of the electrical pulses sent to it by the robot controller. The robotic arm has two servos - the large one raises and lowers the arm (the Arm Servo) and the smaller one opens and closes the snare (the Snare Servo). A servo uses a servo horn to attach to objects it will rotate. Several horns are included with each servo and are made of white plastic.
The snare is thin diameter piano wire and it runs through two raceways inside the arm. A large momentary push button switch, called the Capture Switch, signals the robot controller when capture or release has been achieved.

**Parts in the Single Axis Robotic Arm Kit**
- 1” diameter pillar, 6” long
- 1/8” plastic tube, 14” long (cut into two pieces)
- 1” by 8.5” sheet of 1/8” thick Syntra
- 1” by 4.375” sheet of Correplast
- 6” of 3/16” square brass tube
- Servo package (GWS S03N STD)
- Servo package (GWS Pico STD)
- Momentary push button switch
- Piano wire, 20 mil diameter, 36” long
- Mini EZ Connector
- 4k7 ohm resistor (1/4W)
- Single row 3-pin male header
- Double row 3-pin male header
- ½” of ¼” diameter heat shrink
- 6” of 1/8” diameter heat shrink
- Pull-up resistor PCB
- Three 2-56 by 3/8” long machine screws
- Four 2-56 by ½” long machine screws
- Two 2-56 by ¾” long machine screws
- Nine 2-56 nylocks
- Two 4-40 by ¾” long machine screws
- Two 4-40 nylocks
- Aluminum servo bracket
Making the Arm Core
The Syntra and Correplast form the arm’s core. They mesh together at right angles and divide the interior of the arm into quadrants. The raceways and Capture Switch mount to the arm core which is then sheathed in a plastic tube. First cut the Syntra sheet using the pattern in figure 5.

![Figure 5. Dimensions of the robotic arm’s Syntra core.](image)

Pocket A is where the Snare Servo is located. Hole B is where the Arm Servo’s horn mounts to the arm. Slot C is the snare wire pass-through and slot D is where the Correplast core attaches to the Syntra core.

Use a sharp utility knife and drill to cut the Syntra core. Use a metal straight edge to guide the knife and do not attempt to cut through the Syntra in a single cut. Rather, make several shallow cuts. The two slots (C and D) are 1/8” wide. Drill hole B 1/16” in diameter.

After cutting out slot C, use a small hobby rat’s tail file to further shape the slot. The ends must bevel to allow the snare wire to pass cleanly through the slot without rubbing against the Syntra. Figure 6 illustrates how slot C is beveled.

![Figure 6. Slot C was drilled out perpendicular to the Syntra core, now it must be beveled slightly because the snare wire passes though it as diagonally.](image)

The next step is to cut a slot into the Correplast core. See figure 7 for the location and dimension of its only slot. The slot is centered in the Correplast and 1/8” wide. This slot and slot D in the Syntra core mesh together at right angles.
Figure 7. Cut this slot in the center of the Correplast and 1/8 inches thick.

After cutting out the Syntra and Correplast, they will look like figure 8.

Figure 8. The Correplast (top) and Syntra, after being shaped. Notice Slot C in the Syntra is beveled, or sloped.

Syntra is not very stiff when its only 1/8 inches thick. Therefore, to prevent the Syntra from bending, a brass rail is bolted to it. The rail sits 1/8” above the bottom of the Syntra core and is held using four 2-56 bolts that are ½” long. The rail butts up against the end of the Syntra with the Snare Servo slot (Slot A) and ends at the beginning of the Correplast slot (Slot D). The rail is only 6” long.

Draw a line 1/8” above the bottom of the Syntra core (the line can be seen drawn on the Syntra in figure 8). Next, bolt the Arm Servo’s large circular servo horn to the Syntra at Hole B with a 2-56 bolt. The servo horn mounts to the other side (the bottom) of the Syntra as it appears in figure 8. In figure 9, the servo horn is visible because the Syntra has been flipped over. Note that the servo horn is turned so is can be mounted flush to the Syntra.
After bolting the servo horn to the Syntra core, flip it over again. The brass rail may have a sharp edge, so take a few minutes and carefully file the cut end smoother. Mark the brass rail ½” from one end and ¼” from the other end. The ½” end is mounted towards Slot D and the ¼” end of the rail is mounted towards Slot A. Remember, the rail butts up against the end of Syntra Core on the Slot A end. Now clamp (or tightly hold) the brass rail to the Syntra Core. Confirm the proper placement and orientation of the rail by looking at figure 10.

**Figure 10.** First, drill the ¼” and ½” holes in the rail. Later you will drill two holes in the rail, Syntra, and servo horn. The last hole is just through the servo horn and Syntra.

The first hole to drill is the left one, the one ¼” from the end of the rail. Use a 1/16” drill bit to make this hole. Then screw in a 2-56 machine screw, ½” long and nylock. Do not over tighten the nylock; it will pinch the Syntra if it is too tight. Now drill a 1/16” hole in the rail at the ½” end. Again, use a nylock to attach the rail to the Syntra.

In the next step, two holes are drilled through the Syntra, the servo horn, and the rail. Align the arm under a drill with the rail side of the arm facing up as shown in figure 10. Then drill one hole centered through the rail that will also pass through the right side of the servo horn. Before drilling the second hole, place a 2-56 bolt through this hole and servo horn. This bolt prevents the servo horn from rotating while drilling the second hole. The second hole also passes through the rail, Syntra Core, and servo horn. But this one is through the left side of the servo horn.
In the last step, drill a hole through the Syntra Core, centered above Hole B that will also pass through the servo horn. After drilling these three holes, bolt the rail and servo horn to the Syntra Core with 2-56 bolts that are ½” long. Use nylocks. At this point, the arm appears as it does in figure 11.

![Figure 11. The robotic arm should now appear similar to this.](image)

Now insert the Correplast Core into the end of the Syntra Core. Notice the Correplast is cut so there are five channels running down its length. However, the outer two channels are open - they are not completely closed on all four sides. The open slots on the edges of the Correplast Core are for the raceways. Slide the slot of the Correplast into the slot of the Syntra as far as it will go. The end of the arm now looks like figure 12.

![Figure 12. Once the Correplast is added to the Syntra, the end of the robotic will look like this. Notice the outermost channels of the Correplast are opened. The cross of Syntra and Correplast will create the quadrants inside the arm sheath.](image)

The snare wire runs through a small diameter plastic tube called a raceway. The raceway prevents the wire from jamming inside the arm. There are raceways on both sides of the arm and they are made from 1/8” diameter styrene plastic. There are two pieces in the kit. Cut the first one 6” long and the second one 5” long. Next, mark both raceways 5/8” from one end but do not mark the other end.

The raceways sit inside the open channels of the Correplast and extend 5/8” beyond the end of the Arm Core. The 5” long raceway sits inside the Correplast channel on the servo horn side of the arm. The 6” raceway sits inside the opened channel on the rail side of the arm.
Put just a few drops of hot glue inside the Correplast Core’s opened channels and place the raceways inside. Be sure the raceways extend 5/8” beyond the end of the arm as shown in figure 13. You can also place a little hot glue between the Correplast and Syntra, but not within ½” from the end of the Arm Core (the right side in figure 13).

**Figure 13.** Notice the raceways extend beyond the end of the Syntra and Correplast. Visible in the closest raceway is a pencil mark 5/8” from the end. Do not apply hot glue to the Syntra and Correplast within ½” of the end of the arm (the hot glue visible at the end of the Arm Core in this picture had to be cut away).

At this time test fit the 1” diameter plastic arm sheath. Slide the pillar over the Arm Core, being careful not to bend the plastic raceways. Figure 14 shows what the end of the robotic arm will look. Carefully slide off the arm sheath and begin assembling the Capture Switch.

**Figure 14.** The opened end of the robotic arm. The Capture Switch will fit inside this openings. The raceways permit the snare wire to extend beyond the Capture Switch without snagging.

**Building the Capture Switch**
The next set of procedures constructs the switch that mounts to the end of the arm (in fact, between the ends of the raceways). The switch is a momentary push button switch. This means its red button must be pressed for the switch to close and the switch remains closed only as long as the red button is pressed. When the snare wire pulls a target into the end of the arm (as it does during capture), the target closes the Capture Switch, signaling a successful capture. When the target is released (by the snare wire extending), it opens the Capture Switch, signally a successful release.
Three wires connect to the Capture Switch. One side of the switch connects directly to ground while the other side of the switch connects to an input on the robot controller and a resistor. The other end of the resistor connects to +5 volts. Therefore, when the switch is opened, the resistor pulls the robot controller’s input to +5 volts because there is no way for current to flow from ground and across the opened switch to the microcontroller. The function of the resistor, to pull the voltage to 5 volts when the switch is opened, gives it its name, a pull up resistor. When the switch closes, current flows from ground, through the resistor, and to +5 volts. In other words, current bypasses the robot controller and it doesn’t detect +5 volts.

Figure 15. When there is no capture, the push button switch prevents current from ground reaching the robot controller’s input. The most negative connection is the input, so a current flows from it to +5 volts. As a result, the robot controller detects +5 volts. When there is a capture, current flows from ground to +5 volts through the resistor. No current enters the robot controller’s input, so it doesn’t detect +5 volts. The resistor connected to +5 volts ensures the input sees a direct connection to ground.

Start by assembling the pull up PCB. Bend the leads of the 4k7 ohm resistor (yellow, violet, red, gold or yellow, violet, black, brown, brown) and solder it to the small PCB labeled Pull Up. Cut two pieces of wire, one 4” long and the other 6” long. Strip ¼” of insulation from one end of each wire. One at a time, push the stripped end of one wire through a strain relief hole in the PCB, bend the wire, and then insert the stripped end into the strain relief’s corresponding solder pad. Note that the proper strain relief holes for the Capture Switch are the two that are on the opposite side from the three holes labeled, G, +, and S. Solder the remaining wire the same way in the other strain relief hole. In figure 16, these are the two blue wires on the right side of the PCB.

Figure 16. The pull up resistor PCB.

Next, strip ½” of insulation from the remaining ends of the two wires. Solder the 4” wire to one terminal of the switch by threading through the hole in a terminal and twisting it around itself. Solder the wire and terminal.
Cut three pieces of wire about one foot long and solder them to the G, +, and S pads on the other side of the pull up PCB. If you have three different colors of wires, then use black or green for the G wire (ground), red or other bright color for the + wire (five volts), and a third color for the S wire (signal). If however, all three wires are the same color, you will label them in just a moment. But first, strain relieve the wires by passing them through the large pads on the other side of the PCB. Now label each wire as G, +, and S with a piece of tape if they are not otherwise color coded.

Now mount the Capture Switch to the end of the robotic arm. The red button is on the outside of the arm and the terminals (there are two of them on the side opposite the red push button) are wedges into diagonally opposite quadrants. The switch’s terminals only fit when they are on diagonal quadrants as illustrated below.

After fitting the Capture Switch on the end of the robotic arm, the pull up PCB fits within one quadrant as illustrated in figure 19.
Figure 19. The Capture Switch is fits tightly into the end of the arm because of its two terminals. The pull up PCB is a few inches away from the switch and lies within a quadrant. In this figure, the switch and PCB have been glued into place. Do not do glue the switch at this time.

After placing the switch in the end of the arm and the pull up PCB within the quadrant, you’ll see that two holes must be drilled into the arm, one through Correplast and the other through Syntra in order for the end of the free wire to reach the remaining terminal of the Capture Switch.

Figure 20. On the other side of the arm, the 6” long wire has passed through two holes in order to reach the last terminal of the switch. Do not hot glue anything at this time, even though it is shown in this figure.

Drill two small holes in the arm and pass the 6” long wire through the holes and to the last switch terminal. Remove the switch from the end of the arm and twist the bare end of the wire through the terminal. Solder. Now put the Capture Switch back on the end of the robotic arm and give it and the pull up PCB a small squirt of hot glue. Twist the wires slightly to tighten them up and put a drop of hot glue over the twists to hold the wires against the quadrants of the arm.

Slide the plastic arm sheath over the arm quadrant and make it flush with the black ring of the switch. The red button will protrude slightly beyond the end of the arm sheath. Squirt a little hot glue between the sheath and the Capture Switch, making sure no glue gets into the raceways.
Figure 21. The end of the robotic arm after the sheath and Capture Switch have been glued together. The snare wire in your robotic arm will not be in place yet.

Snare Servo

Never force the small Snare Servo to turn; let it turn under its own power. Put the rubber boots on the servo and slide the servo into Slot A of the Syntra Core. Mark the location of servo’s mounting holes in the Syntra and remove the servo. Drill 1/16” diameter holes through the Syntra. Put the servo back into the slot, turning the servo horn end of the servo away from the Capture Switch end of the arm (see in figure 22, the servo is oriented so its horn is on the left side). Use two 2-56 bolts, 3/8” long and nylocks to attach the servo.

Figure 22. The Snare Servo mounted into Slot A of the Syntra with 2-56 bolts and nylocks.

Next, locate the long, two-armed servo horn in the small servo pack. Also, locate the Mini EZ Connector. The Mini EZ is small and consists of two parts, a black plastic cap and a metal cylinder with a set screw. The metal cylinder has a pin opposite the set screw that fits through the holes in the servo horn. The metal pin slips through a pre-drilled hole in the servo horn and the black plastic cap is squeezed onto the pin on the other side of the servo horn. The cylinder and set screw mounts to the bottom of the servo horn as shown in figure 23. Do not squeeze the black cap too tightly; you want the Mini EZ Connector to freely spin on the end of the servo horn.
Figure 23. The Mini EZ Connector and servo horn. Use small pliers to squeeze the plastic cap onto the small metal cylinder’s pin.

Notice there is a small hole drilled on the side of the tiny cylinder of the Mini EZ Connector. This is where the wire snare enters the Mini EZ Connector. The set screw locks the snare wire into place. Unwrap the piano wire (careful, the ends of the wire are sharp). Wear safety glasses to protect your eyes if the wire snaps loose. Cut the wire to a length of at least 21 inches. Bend the wire in half without putting a fold or crease into the wire. Push the ends of the wire into the raceways at the end of the arm (at the capture Switch end) and down through the arm. The wires will protrude from the other end of the raceways, near the Snare Servo.

The wire in the 6” long raceway goes straight to the Mini EZ Connector. The other wire, in the 5” long raceway must be routed through Slot C before it can reach the Mini EZ Connector. Use tweezers or small needle nosed pliers to divert the wire through the slot and to the Pico servo. Do not bend the wire.

Now push both ends of the wire through the hole in the Mini EZ Connector. For right now, tighten the set screw and put the servo horn on the Snare Servo. Attach the servo horn with the small servo screw, but do not over-tighten it. Later you will adjust the snare wire and servo.

Figure 24. The other arm of this servo horn was cut off. This is not necessary. Notice the snare wire from the 5” raceway diverts through the slot to reach the other side of the arm and the Mini EZ Connector.
Extending and Terminating the Servo and Switch Wires

The Arm Servo, the one raising and lowering the arm, has a sufficiently long cable. However, the Snare Servo’s cable is too short and must be extended with a splice. Start extending this cable by cutting off the black plastic connector at the end of the servo’s cable. Then strip ½” of insulation from the ends of the three wires. Twist the stranded wire tightly, but do not tin it at this time.

Cut three pieces of wire at least 6” long. Strip ½” of insulation from one end of each wire and twist the strands tightly. Take one of the new wires and twist its bare end around the bare end of a Snare Servo wire. If you have wires that match colors, then use the same color wire for each servo wire. Otherwise, it doesn’t matter. After twisting the wire, tin both with a soldering iron. Then slide a short length of heat shrink over the soldered connection and shrink. Repeat this for the remaining pairs of wires. After the Snare Servo wires have been extended, slide a fourth piece of heat shrink over the soldered connections and shrink that down. The additional wrap of heat shrink around all three spliced wires will further strengthen the splice.

Like the Snare Servo, the Arm Servo and Capture Switch cannot connect to ports of the robot controller with Futaba F connectors or bare wires. So cut off the F connector of the Arm Servo like you did for the Snare Servo. Before cutting it off, however, place both servo cables side by side and make sure they will be roughly the same length when you cut off the F connector.

The servos and Capture Switch cables will terminate with three pin male headers. The Capture Switch must have it cable terminate in the same way. The procedure explained below works for both servos and the Capture Switch.

Figure 25. The three pin header on the right replaces the Futaba F-connector currently at the end of the servos. However, since the robotic arm uses two servos, the servos terminate with a 2 by 3 pin header while the 1 by 3 pin header will terminate the Capture Switch cable.

Strip ¼” of insulation from the ends of the wires in both servo cables and Capture Switch. Twist the stranded wires tightly and tin. You will find a Helping Hands is useful for tinning the wires.
Figure 26. Helping Hands make tinning stripped wires a whole lot easier.

Before soldering the tinned wires to the three pin headers, the headers must be placed inside a receptacle. That’s because the plastic bar across the three pin header softens and distorts when it gets too hot. If you don’t have a spare receptacle lying around, you can use an I/O receptacle on your robot controller for this purpose. Just be careful not to get solder on your robot controller.

Since there are two servos in this arm, the servo cables solder to a 2 by 3 pin header (it is two 1 by 3 headers side by side). Plug the long ends of the 1 by 3 and the 2 by 3 headers into a receptacle and tin the short ends of both headers.

Figure 27. Tin the smaller pins only after the longer pins are inside a receptacle.
Figure 28. The 1 by 3 pin header’s long pins are inside this receptacle while the short pins are quickly tinned. Be careful not to get solder on your robot controller while you tin the short pins.

Slide a piece of heat shrink tubing over each wire in the servo and switch cables before going any further. In the next step, you will solder the Capture Switch cable to a single 1 by 3 header and the servo cables to a 2 by 3 header. Remember, the 2 by 3 header is just two 1 by 3 headers side by side. So one servo cable solders to the three pins on one side of the header and the other servo solders to the three pins in the other row.

Place the ground wire (usually the black wire in a servo cable) firmly against either one of the end pins in the header. The ground wire from the Capture Switch was either color coded when the wires were soldered to the pull up PCB or is labeled with tape. If all the wires are the same color, you’ll have to trace the spliced ground wire in the Snare Servo. **DO NOT** solder the ground wire to the header’s center pin. Use a hot, well-tinned soldering iron and quickly tap the wire and header pin. The solder in both will melt and fuse the wire to the header. Do not let the soldering iron touch the header pin very long and let the header pin cool before moving to the next pin.

Figure 29. Two of the servo wires have been soldered to this header. Note that the red wire is soldered to the center header pin.
Solder the red wire to the center pin and let the header cool again. It doesn’t matter which end the white or black wire is soldered to for the switch, but the red wire must be soldered to the center pin. The same is true for the servo cables, except, the white wires from both servos must be on the same side of the 2 by 3 header (as must be the black wires). Next slide the heat shrink over the soldered connections and heat them with the hot air gun. It won’t take long for the heat shrink to shrink. Leave the header plugged into the I/O receptacle while shrinking the tubing.

![Soldered header and heat shrink tubing](image)

**Figure 30.** The Capture Switch cable will look like this when you’re finished soldering it to the header.

After soldering both servo wires to the 2 by 3 header, squirt a little hot glue between the pins and wires. No not let hot glue ooze out or it may interfere with plugging other headers into neighboring receptacles.

![Soldered header with hot glue](image)

**Figure 31.** A little messy, but the hot glue around this 2 by 3 header will help keep all the wires in place.
Attaching the Arm to a Robot Base
The aluminum rail serves as the servo pedestal. There are six holes drilled through it, two small holes for 2-56 machine screws and four for 4-40 machine screws. The 2-56 machine screws and nylocks attach the robotic arm to the robot base. The 4-40 machine screws attach the servo to the aluminum rail and shown in figure 32.

![Figure 32. Two 4-40 machine screws attach the servo to its aluminum base. The servo is sitting on the rail as screws hold its mounting wings to the aluminum.](image)

Use two washers on the 4-40 machine screws, as the mounting holes in the servo wing are a bit large. Now stand the servo up on end and bolt the aluminum bracket to the robot base. Before making holes in the robot base, move the arm up and down be make sure its location leaves the arm free to swing up and down.

Now plug the servo and Contact Switch cables into the robot controller. The servo header goes to an output and the Contact Switch goes to an input.

![Figure 33. The servo header plugged into a robot controller output.](image)
Adjusting the Snare
The last step is to adjust the length of the snare wire and tightening the Mini EZ Connector. Remove the servo arm from the snare servo and loosen the set screw.

Send a command to center the Snare Servo. The command will look like the following for a BASIC Stamp or PICAXE.

**BASIC Stamp**

```plaintext
X VAR BYTE
FOR X = 1 TO 30
   PULSOUT 1,750
   PAUSE 20
NEXT
END
```

**PICAXE**

```plaintext
SERVO 1, 150
PAUSE 2000
END
```

Change the I/O pin in the code to the I/O the Snare Servo is plugged into. In the BASIC Stamp code, this is the number after PULSOUT (1 in the example above) and in the PICAXE example, this is the number after SERVO (also 1 in the example).

Switch off the robot controller after the Snare Servo is centered and push the servo horn back onto the servo. The servo horn is oriented so it hangs down form the Snare Servo and over the rail below. The gives the servo horn the greatest among of swing left and right.

Pull both ends of the piano wire through the Mini EZ Connector until the snare is large enough to just slide your little finger through. Hold the wire and Mini EZ and lift the servo horn off the Snare Servo. Try to keep the wire from slipping as you tighten the set screw. Put the servo horn back on and screw the servo horn onto the Snare Servo.

That completes the robotic arm. You may find that the snare needs a little more adjustment or the robot needs to be counter balanced for the weight of the arm.

Using the Simple Robotic Arm
A CheapBot robotic controller uses the SERVO command to raise and lower the arm and to open and close the snare. The SERVO command has the following syntax.

**SERVO I/O Pin, Pulse-width**
I/O Pin is the name of the output port the servo cable is plugged into. Note, be sure the cable is plugged into an output and not an input.

Pulse-Width is the length of the pulses being sent to the arm’s servo. It’s a number between 75 and 220. Number 75 is one extreme of the servo’s rotation and 220 is the other extreme. You’ll have to experiment with your arm to find which extreme each number represents.

Pulse-Width is actually a measurement of time. The units of time are $0.00001$ seconds (or $0.01$ milliseconds). So a Pulse-Width of 200 is $0.002$ seconds (or 2 milliseconds) long. Each pulse is five volts high. Between pulses is a rest (zero volts) of about 20 milliseconds. Therefore, the SERVO command produces an electrical signal of square waves like the one illustrated below.

![Square wave diagram]

**Figure 34. This pulse is at five volts for 2 milliseconds and zero volts for 18 milliseconds.**

A servo rotates to a position dictated by the length of time the pulse is five volts. If the pulse shortens to 1 millisecond, the servo will rotate to a position $180^\circ$ away from the 2 millisecond position. The position will be the same position anytime a servo receives a pulse width that is five volts for 1 millisecond. To give a servo time to reach its proper position, it needs to receive several pulses. Typical servos can rotate from one extreme to the other in as little as 20 pulses, or in about $\frac{1}{2}$ seconds.

The snippet of code to raise or lower the arm to the up and down positions could look like this.

```
Arm_Down:
    servo 1, 175
    pause 1000
    return

Arm_Up:
    servo 1, 140
    pause 1000
    return
```

To raise the arm, call the Arm Up subroutine with the GOSUB command like this.

```
GOSUB Arm_Up
```
The above commands will raise and lower the arm rather abruptly. The raising and lowering of the arm can occur more smoothly with the following subroutines.

```
Arm_Down_Slowly:
    for b0 = 140 to 175
        servo 1, b0
        pause 50
    next
    return

Arm_Up_Slowly:
    for b0 = 175 to 140 step -1
        servo 1,140
        pause 1000
    next
    return
```

The exact values for the arm up and down positions depends on the alignment of your robot’s arm. You’ll need to experiment with different values and see which works best. Be aware that your arm could rotate backwards in relation to the example given. If so, you’ll use a higher value for the pulse width to lower the arm and a smaller value to raise the arm.

Finally, there are more than just tow positions for the robotic arm. The arm can be raised only part way up or lowered only part way. Experiment with different arm settings and drive your robot around.

**Snare Servo**

The Snare Servo operates the same way as the Arm Servo. You’ll just have to use a different output port for the Snare Servo. Right now your Snare Servo is set to the mid point, or the command,

```
SERVO 1,150
```

You’ll need to find the proper code settings to open and close the snare. Opening and closing involve rotating the servo about 45° either way from the central position. Experiment gently with the Snare Servo. Make small changes to the SERVO command and observe the direction and amount the Snare Servo rotates. Once you find an open snare and close snare position, save the SERVO values. Create subroutines for open and close snare similar to the subroutines used to raise and lower the robot arm.

**Capture Switch**

To determine if a capture of the target has occurred, code needs to determine if there is zero volts (a logic low) on the input port the Capture Switch is plugged into. The code for determining this is shown below.
B0 = PIN0
IF B0 = 0 THEN Capture
IF B0 = 1 THEN No_Capture

In the redundant example above, the Capture Switch is plugged into Input #0 (PIN0). The byte variable B0 is being set to the current state of Input #0 in the first line of code. Then two comparisons are made of B0. If B0 equals 0, then the Capture Switch was closed and the program jumps to a label called Capture to execute additional code. If variable B0 equals 1, then the Capture Switch is not closed and the program jumps to a label called No_Capture to execute some other code. The example is redundant because if B0 does not equal 0, it must equal 1, so there is no need to check for a 1.

Complete Arm Code
An example of the code used to operate a robotic arm could look like this (this is only the calls to subroutines).

SYMBOL B0 = Capture

Pick_Up_Sticks
GOSUB Raise_Arm
GOSUB Drive_Robot_to_Destination_1
GOSUB Open_Snare

Attempt_Pickup:
GOSUB Lower_Arm
GOSUB Check_Capture
IF Capture = 0 THEN Okay
IF Capture = 1 THEN Missed

Okay:
GOSUB Raise_Arm
GOSUB Drive_Robot_to_Destination_2
GOSUB Open_Snare
GOTO Pick_Up_Sticks

Missed:
GOSUB Open_Snare
GOSUB Raise_Arm
GOSUB Tweak_Robot
GOTO Attempt_Pickup
END