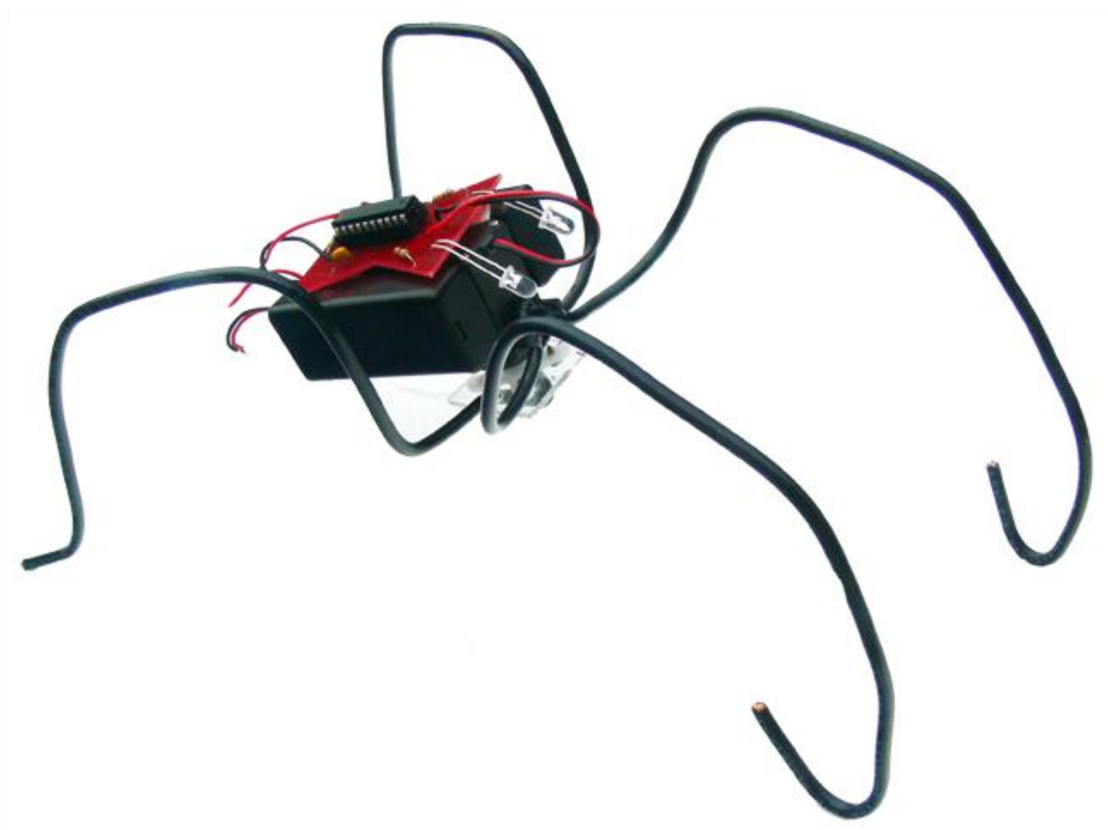
THE BLACK WIDOW WALKER KIT



This kit is for ages 12 and up. Four "AAA" batteries are needed but not included.

Welcome to the world of robotics! We hope that this kit sparks your interest and helps you further your knowledge of robots.

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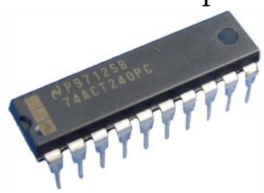
Disclaimer of Liability

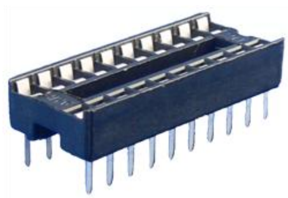
PARTS LIST

The first thing you should do is check to make sure you have all the required pieces and tools. You should have:

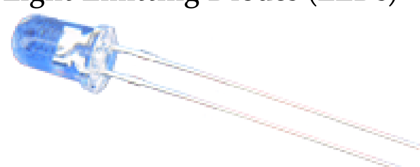
1 74ACT240 Chip



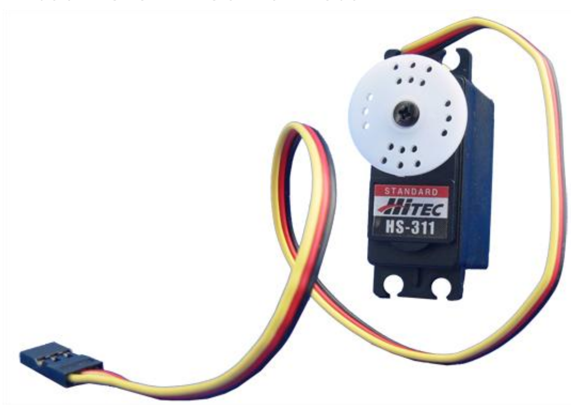
1 20 Pin DIP Socket



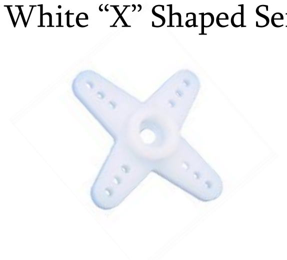
2 Light Emitting Diodes (LEDs)



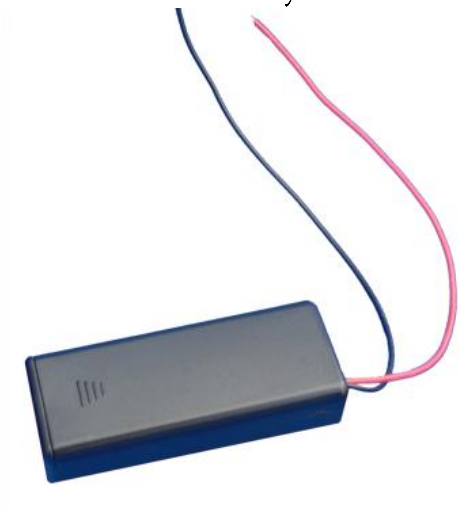
1 Hitec HS-3111 Servo Motor



1 White "X" Shaped Servo Horn (found in the servo accessory pack)

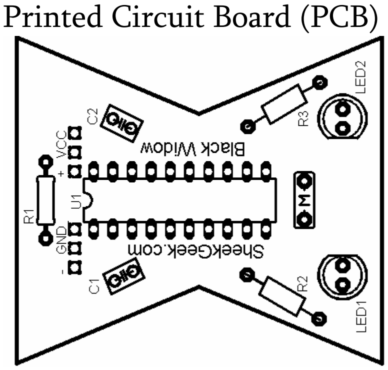


1 2 X “AAA” Battery Holder without Switch



1 2 X “AAA” Battery Holder with Switch

1 Printed Circuit Board (PCB)



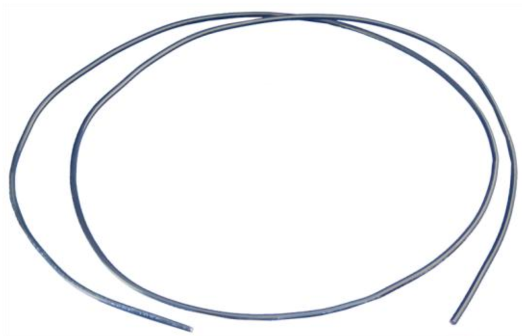
1 Acrylic Leg Mounting Bracket

6 Pieces of Two-sided Tape (4 pieces for the kit + 2 extra pieces)

2 150 Ohm (Ω) Resistors (as indicated by Brown-Green-Brown-Gold banding pattern)

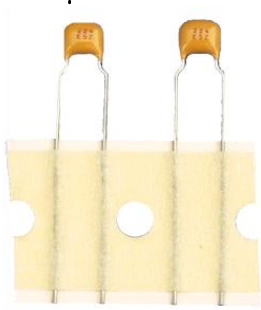
1 3.3 Meg Resistor (as indicated by Orange-Orange-Green-Gold banding pattern)

1 4 Foot Piece of 10 Gauge (AWG) Wire



4 Screws (found in separate packaging than the servo accessories)

2 0.22 μF Monolithic Ceramic Capacitors



NOTE: You may have some additional pieces not included on the parts list. The parts list contains only the items needed to build the Black Widow Walker. Any part not listed is not used in this kit.

Tools Needed

→ 20-30 Watt Soldering Iron
→ Solder
→ Wire Cutters
→ Wire Strippers
→ Small Phillips Head Screwdriver
→ Ruler
→ Protractor
→ Glue Gun + Glue (optional)

Soldering

Soldering is an important skill for anyone interested in or who may work in electronics. It may look and sound intimidating, but soldering is an easy skill for anyone to master. All it takes is a little practice and caution. WARNING! A soldering iron becomes very hot while in use. Be sure not to touch the iron. Also, do not breathe the fumes while soldering. Most solder contains lead, which is a hazardous material. Make sure you solder in a well-ventilated area. Always wash your hands after handling solder.

What is Soldering?

Soldering is a method of using a material with a low melting point to fuse materials together. This process requires the application of heat, which is provided by a soldering iron, and the use of solder. For constructing a robot, a soldering iron that is around 20-30 watts is sufficient to solder components onto the circuit board. A soldering iron over 35 watts can "fry" your components and may result in a broken robot. Most craft or electronics stores carry soldering irons for 5 dollars or less. You can even find soldering irons at dollar stores; however, you may want to find a soldering iron that comes with extra tips. It is much easier to solder with a *pointed* tip. Keep in mind that the solder you use should be electronics solder, <u>NOT</u> plumber's solder.

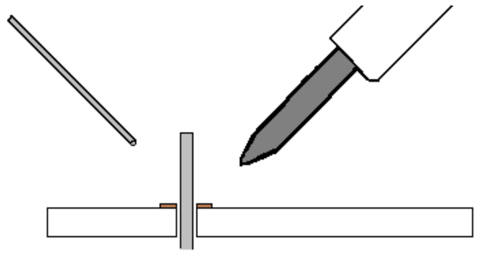
How to Solder (The fun stuff!)

If you have never soldered before, or need to brush up on your skills, it is best that you first practice soldering on spare parts. You should not begin on your kit until you have perfected your soldering skills. Now, the correct way to solder is:

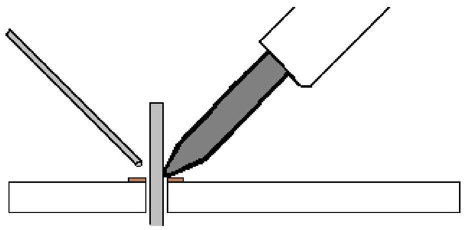
1. Allow your soldering iron to heat up. Generally, after you plug in the soldering iron, it will take about 5 minutes for it to warm up. If this is the first time you are using your soldering iron (or you have just put a new tip on) it is important that you "tin" the tip. Tinning is the process of heating up the iron and applying a thin coat of solder to the tip. This helps to achieve maximum heat transfer to the item you are trying to solder.

2. As mentioned earlier, if this is your first time soldering; practice, practice, practice! Once the iron is hot and tinned, you should practice soldering on a scrap board with scrap parts.

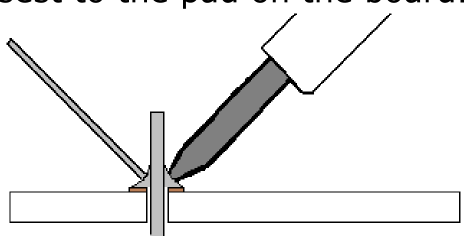
3. Place the leads of the piece you want to solder through the holes in the board where that piece will go.



4. Make sure you place the piece you want to solder so only the leads stick out on the side of the board with the solder traces and pads.



5. Apply the iron to the lead **and** pad you want to solder, and apply solder to that lead where it is closest to the pad on the board.

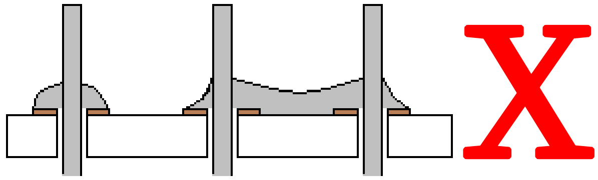


Try not to heat the lead **for more than 3 seconds**. This will ensure that you do not “fry” any of the pieces.

6. Make sure not to apply too much solder to the iron or connection. Too much solder can lead to unwanted connections.

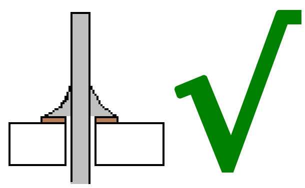
Here are some examples of what the finished connection should and should not look like:

SHOULD NOT



In the picture above the first soldered connection contains too much solder. This is indicated by the semi-circular, rounded appearance. The next two soldered connections are joined together or "bridged" by the solder. This is bad because the bridge is connecting parts of the circuit that should not be connected. This will result in a non-working robot.

SHOULD

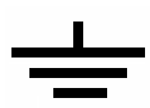


The above picture is how your soldering junctions should look. The junctions should also be shiny and smooth in appearance. With a little practice, your soldering junctions should look like this in no time.

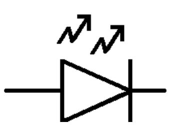
How the Black Widow Walker Works

BEAM was created and patented by Mark W. Tilden. The term "BEAM" is widely used as an acronym for **B**iology, **E**lectronics, **A**esthetics (Art), and **M**echanics. An aspect of BEAM is using cheap parts in simple circuits to create complex behaviors. The complex behaviors are often biologically inspired from insects and spiders.

Mark Tilden is the inventor of the Floating Bicore circuit, which is the "brain" of many simple walking robots. The Black Widow Walker uses a Floating Bicore circuit. The floating Bicore is an easy circuit to build and is easy to understand. First, let's look at how each of the parts work.



This is the schematic symbol for "ground". Ground in most cases is the negative side of the battery. This symbol is used to simplify the connections on the schematic. In conventional electronics, the black wire is usually connected to ground.



This is the schematic symbol for a light emitting diode (LED). LEDs are a special type of diode that emits light when the appropriate voltage is applied and current passes through it. Diodes are simple semiconductor devices that allow current to flow in only one direction. If you look at the schematic symbol, imagine electricity flowing from the big part of the triangle to the smaller part (left to right). That is the direction electricity is allowed to flow. LEDs are efficient at making light (lasting up to 100,000 hours!), and last MUCH longer than other methods of making light. To make sure LEDs last this long, they need a resistor in series with them in the circuit. This limits the current and prevents the LEDs from burning out.

This is the schematic symbol for a resistor. Resistors convert electricity into heat by resisting the flow of current in a circuit. The best way to understand how resistors work is to look at Ohm's Law. Ohm's Law deals with voltage, current, and resistance values. If you are given any two of those values, you can find the other. Here is a chart that shows their relationships:

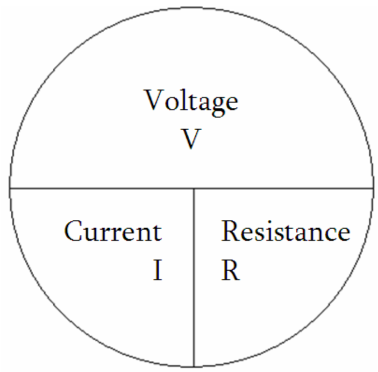


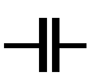
Chart showing Ohm's Law.

This chart helps creates formulas for calculating the value of an unknown. By covering the variable you are looking for (your unknown or variable), the positioning of the other two variables shows you how to create your formula. For example, resistances are needed for the LEDs in this kit. If you cover the resistance (R) on the chart, this leaves voltage (V) left over the current (I).

In math, this translates as V divided by I. Your resulting formula is $R = \frac{V}{I}$.

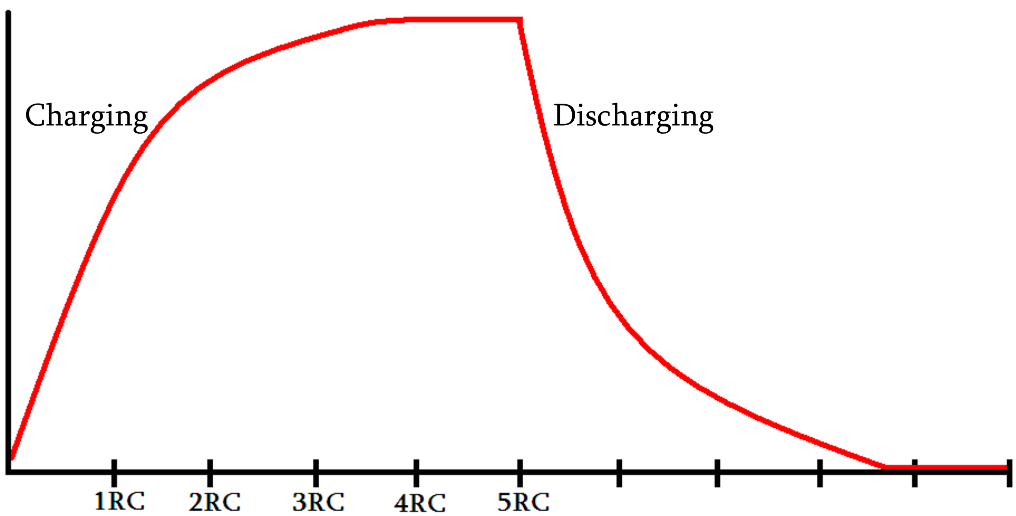
If you are looking for the voltage, cover the V and you are left with I next to R. Your resulting formula is I X R=V. If you are looking for the current, cover the I and you are left with V over R.

Once again, this translates as division, so the resulting formula is $I = \frac{V}{R}$.

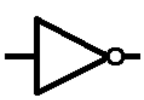


This is the schematic symbol for a capacitor. A capacitor is made of two pieces of conductive material, like metal, that are close to one another but do not touch. This allows a charge to build across the gap between the metal pieces. Capacitors can be thought of as rechargeable batteries with very short life spans. If you connect a battery to a capacitor, it will charge the capacitor. The ideal capacitor will retain that charge until you connect a resistance across its leads.

Once you connect a resistance across the leads of the capacitor, it will discharge. The rate at which it discharges is dependent on two things: the value of the capacitor (in microfarads) and the value of the resistance (in ohms). The time it will take the capacitor to charge or drain about 63% of its total charge (the RC time constant) is related to the formula: T = R x C. After about five time constants (5 x R x C), the capacitor can be considered either fully charged or fully discharged. The graph below shows the typical behavior of a capacitor charging and discharging.



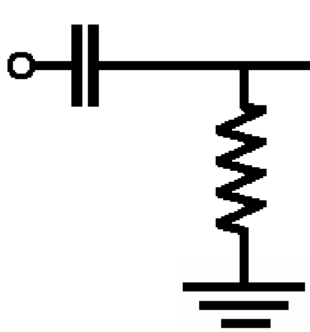
The voltage in a capacitor while charging and discharging.



This is the schematic symbol for an inverter. These are located inside the 74ACT240 chip used in the Black Widow Walker. Inverters are the simplest component of digital logic. Logic inputs are "high" (which is terminology indicating the positive side of the battery and is shown as "1",) and "low" (which is terminology indicating the negative side of the battery and is shown as "0.") If the input to an inverter is a logic high (1) then the output is a logic low (0.) If the input is a logic low (0) then the output is a logic high (1.) These values are easier to see in a truth table.

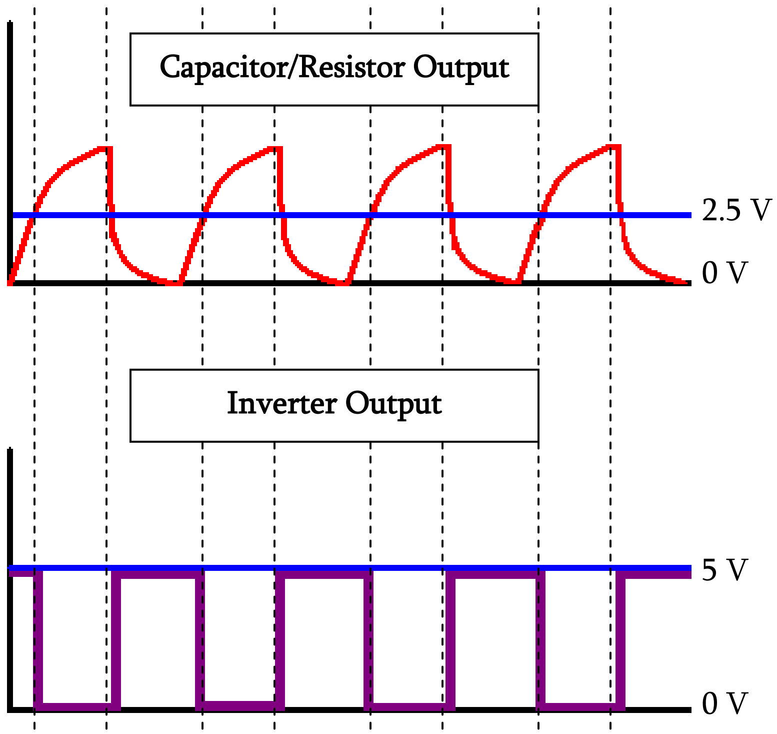
Input	**Output**
0	1
1	0

Arranging a simple circuit using a capacitor, a resistor and an inverter in the right way, we can get a single nervous (NV) neuron. This is the basis of BEAM walking robots.



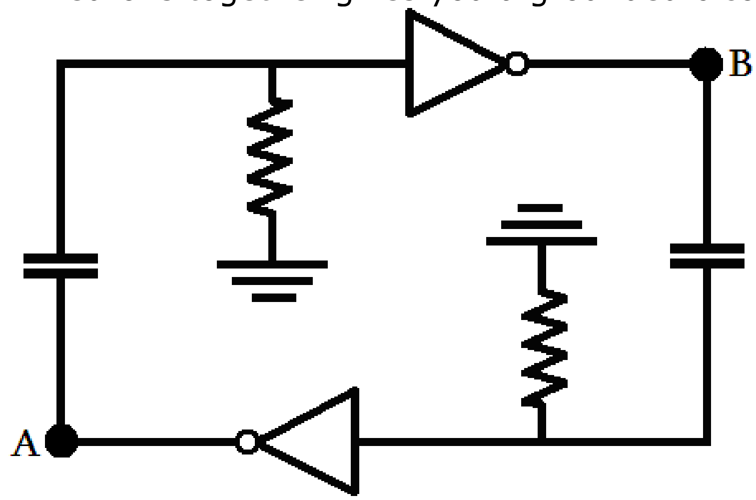
A single NV neuron; the basis of beam walking robots.

Applying a logic high (1) to the capacitor will cause an interesting reaction. The logic high of the input causes the inverter's output to be logic low (0). The resistor will drain the capacitor over a given time period based on resistance times capacitance (R x C). Once the voltage drops below a value that the inverter can see as a logic high, it will change from outputting a 0, to outputting a 1. This is easier to explain in a graph.



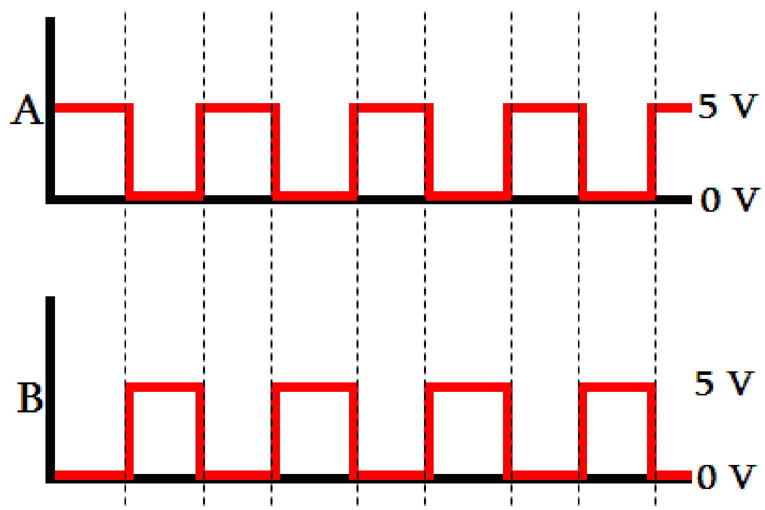
The voltage out of a capacitor or resistor as compared to an inverter.

Attaching two NV neurons together gives you a grounded bicore.



A grounded bicore circuit with points A and B denoting the outputs of the inverters.

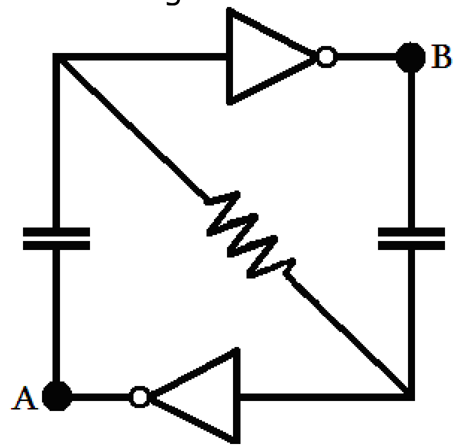
Measuring the voltages across points A and B in the figure below (the outputs of the inverters) results in outputs as shown in the following graph.



A graph showing the voltage output across points A and B.

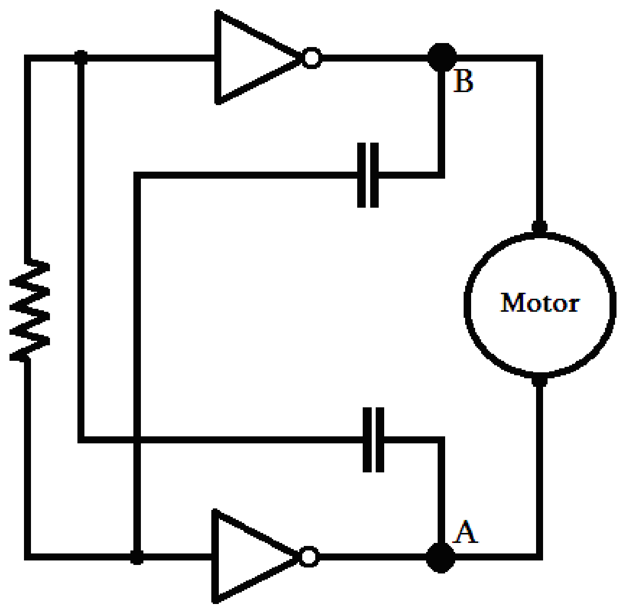
Notice how the outputs are the exact inverse of one another. This causes a voltage drop across the two points in which we will place a motor. The motor will spin left and right depending on which side is positive or negative. The motor itself can actually change the RC timing depending on how much current it draws. If the motor is stuck, or if it has a hard time moving, it will draw more current. This speeds up the RC time on one side of the bicore because it drains the capacitor on that side faster. This is how BEAM walking robots can learn to walk differently on different surface.

Replacing the two resistors with just one resistor, we get a more reactive yet more symmetric circuit; the floating bicore.



A floating bicore circuit.

Here is the floating bicore circuit redrawn to show the motor connections.



A floating bicore circuit with motor connections.

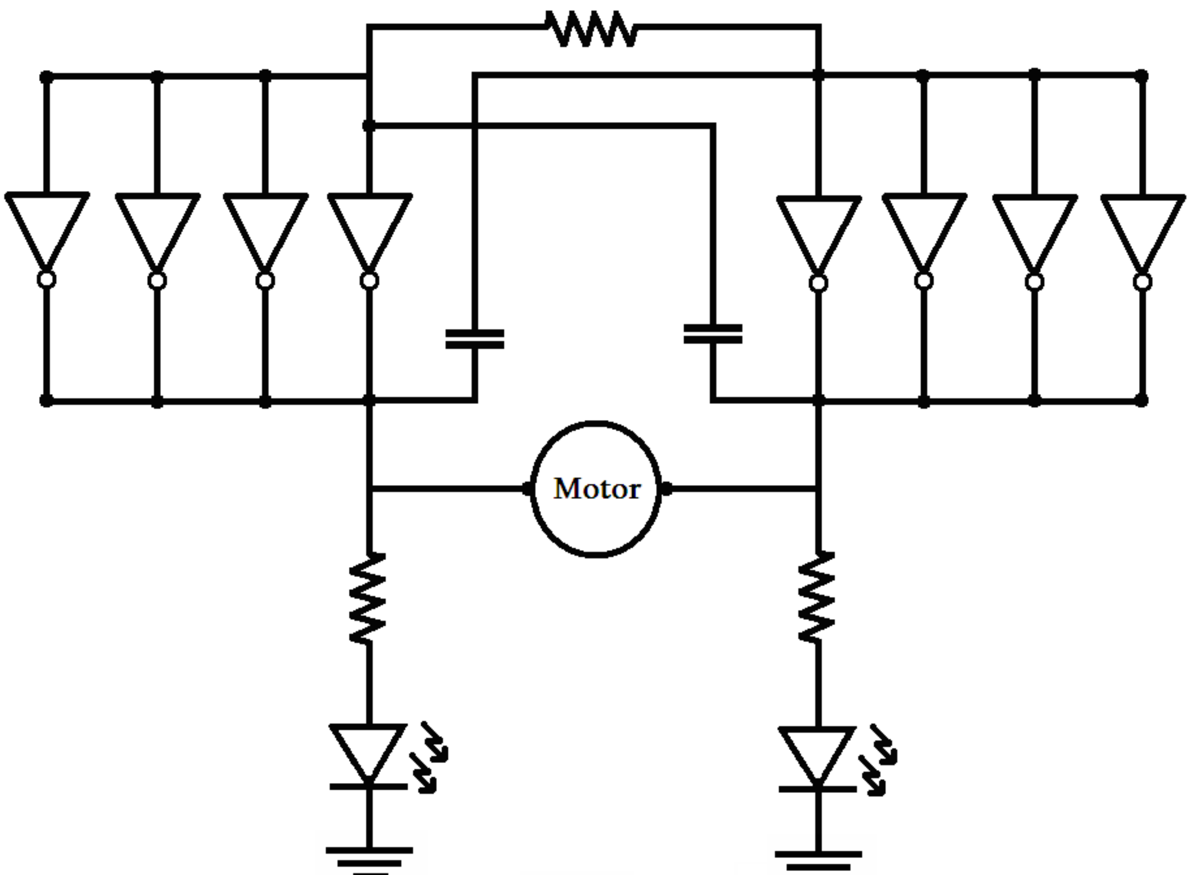
This circuit is the "brain" of many walking robots. The Black Widow Walker utilizes the same technology; however, it has a few additions to improve its functionality. For instance, there are four inverters in parallel on each side of the bicore. This is done to increase the amount of current flowing to the motor.

There are also LEDs attached to the outputs of the inverters so you can see which side is "on". The LEDs help you visualize what is actually happening in the circuit.

As mentioned earlier, LEDs need resistors to limit the current and prevent the LEDs from burning out. Do you remember the Ohm's Law stuff in the resistor section? Well, that is needed to calculate the resistance for the current limiting resistors for the LEDs. One of the formulas we had found was $R = \frac{V}{I}$. The LEDs used in this kit have a forward voltage of 3.1 volts and a forward current rating of 20mA, where "forward" indicates values required to make the LED emit light. The source is 6 volts (four 1.5-volt batteries). First, we must find the voltage drop across the LEDs. To do this, subtract the forward voltage rating of the LED from the source voltage. 6 volts – 3.1 volts = 2.9 volts. We can now plug our values into the formula to find the resistance needed.

$$\frac{2.9 \text{ volts}}{20 \text{ mA}} = 145 \text{ ohms}$$

The closest standard value that is at least 145 ohms is 150 ohms. So, that is what we will use. With the addition of the inverters and the LEDs, the Black Widow Walker circuit looks like this:

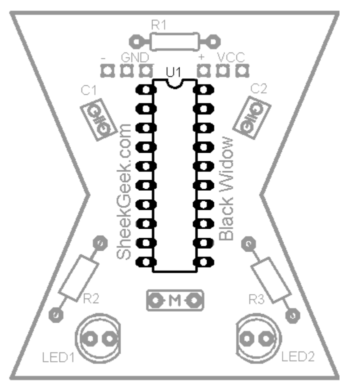


The Black Widow Walker Bicore circuit.

The Build

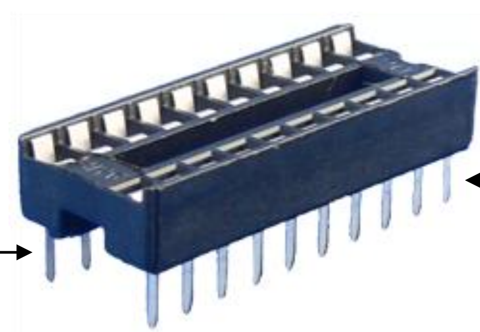
Gather all of the materials listed on the parts list and the needed tools. Please read all of the steps before building your Black Widow Walker. It is also important to reread each step before completing the step yourself. Following the steps incorrectly can result in broken pieces necessary for building your Black Widow Walker. <u>Pay close attention to any underlined instructions.</u>

1. Solder DIP Socket to the Printed Circuit Board (PCB)



Line up the 20 pins of the dip socket with each of the 20 holes in the PCB (as shown in the darkened part of the picture above). <u>Make sure that the U shaped notch on the DIP socket is lined up with the U shaped notch on the PCB as pictured.</u>

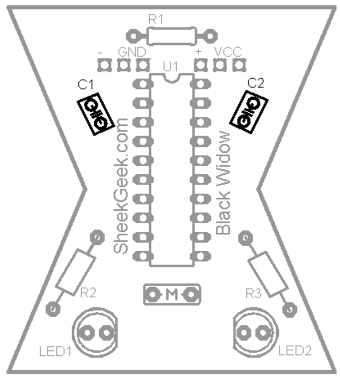
Bend Point after Insertion into the Board



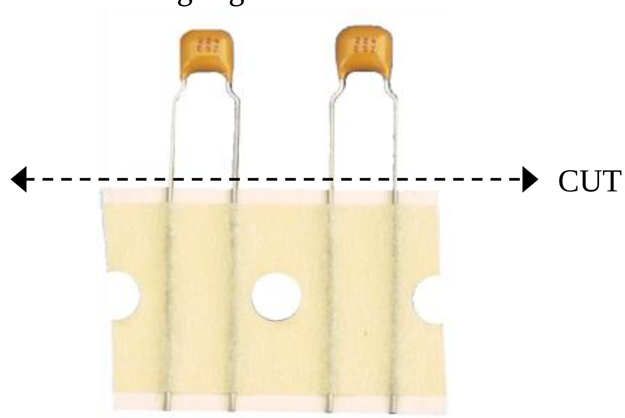
Bend Point after Insertion into the Board

Before soldering, bend two of the opposite corner pins sticking underneath the PCB. Be sure to bend the pins slightly, so they do not break. This will help keep the DIP socket firmly attached to the PCB while soldering. Which two opposite corner pins you choose to bend does not matter.

2. Solder Capacitors to the PCB



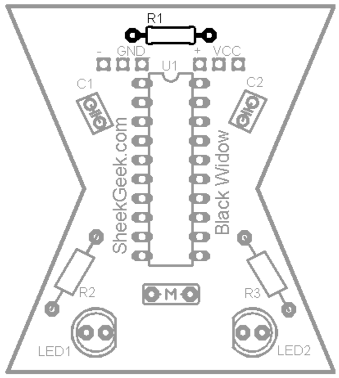
Remove the capacitors from the tape packaging. The capacitors will be soldered to the area highlighted above.



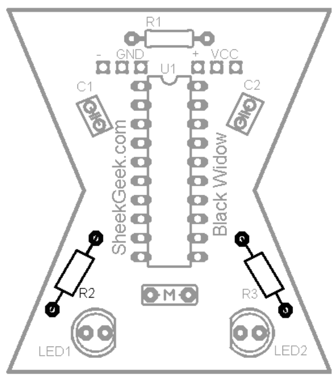
The leads (legs) on the capacitors are long enough that you can cut the entire taped area off if needed.

Before soldering the capacitors to the PCB, bend the leads to help hold the components in place. It does not matter which direction you put the capacitors into the circuit board. Now, solder the capacitors in place.

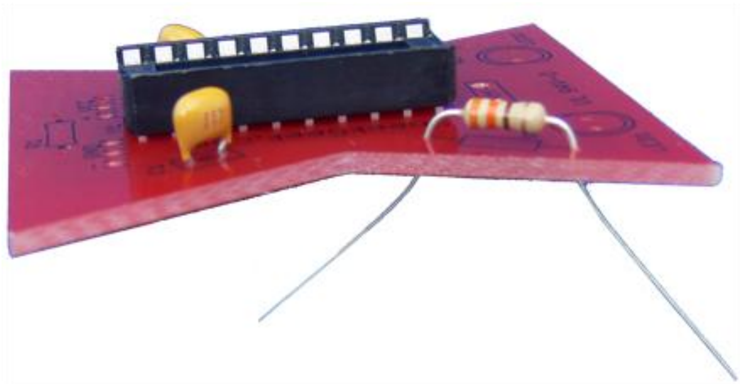
3. Solder Resistors



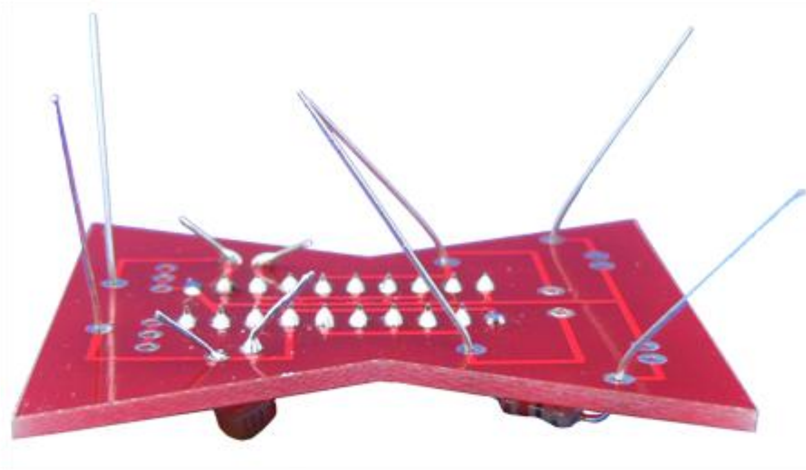
The R1 position is for the 3.3 Megohm resistor. Be sure to check that you have the correct resistor. It will have the Orange-Orange-Green-Gold banding pattern.



The R2 and R3 positions are for the 150-ohm resistors. Be sure to check that you have the correct resistors. They will have the Brown-Green-Brown-Gold banding pattern.

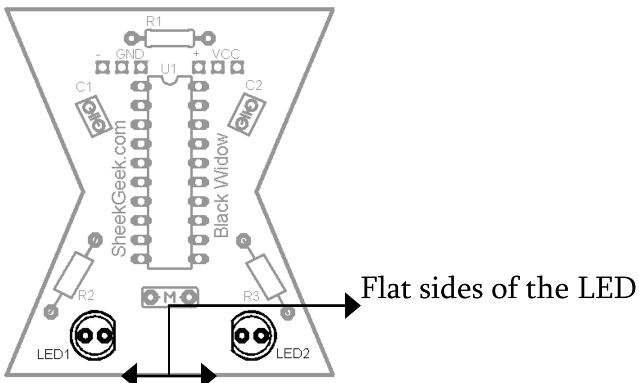


Bend the leads of each resistor to secure it in place before soldering as shown above. It does not matter which direction the resistors are placed into the circuit board.

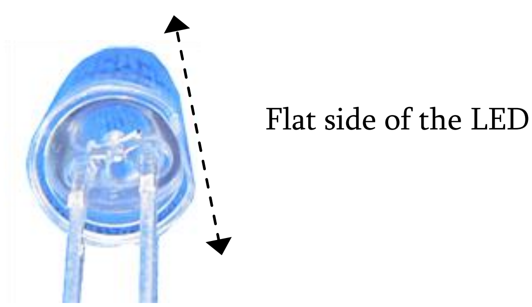


After all the resistors are secured in place, solder each of the leads.

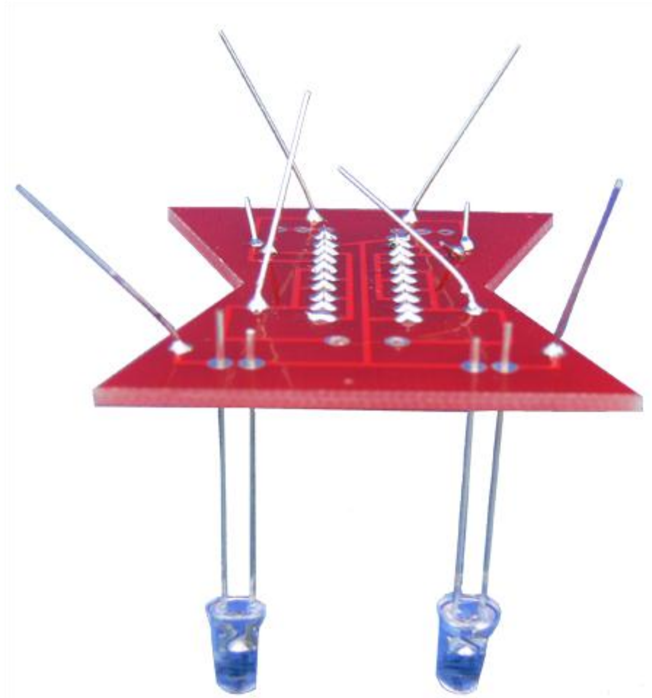
4. Solder LEDs



The LEDs will go in the positions highlighted above. Notice that each circle for the LED has a flat side.



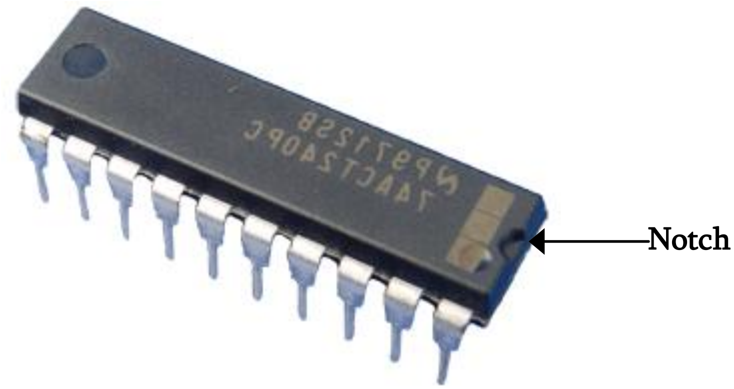
If you look at the underside of your LED, you will notice that is also has a flat side. <u>LINE UP THE FLAT SIDE on the LED with the FLAT SIDE of the LED graphic drawn on the PCB.</u>



Place the leads of the LEDs about ¼ inch through the board and solder in place.

All of the major components are now soldered to the PCB. Cut away all excess leads using wire cutters. The underneath of your PCB should look like above.

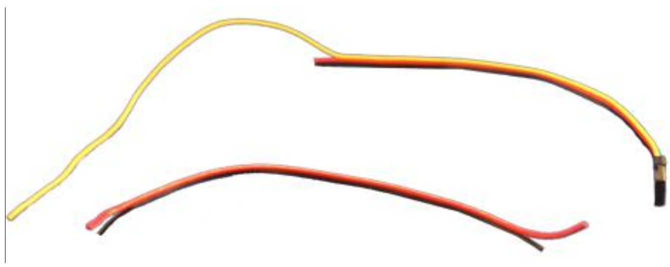
5. Put 74ACT240 Chip into the dip socket.



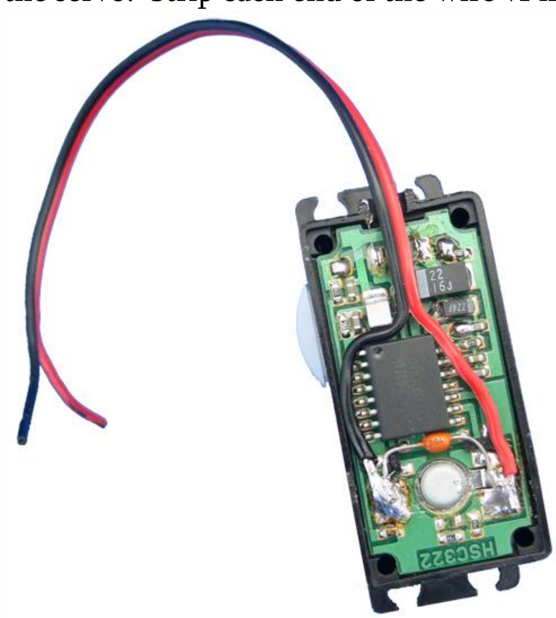
Line up the notch in the chip with the notch in the dip socket. Insert the chip, carefully ensuring all pins are in the corresponding socket.

6. Modify Servo

Unscrew the bottom four screws on the servo and remove the bottom plastic piece to expose the inside workings of the servo. Place the tip of the soldering iron to the connection of the three wires to the servo circuit board. Pull on the wires gently until they are released from the circuit board.



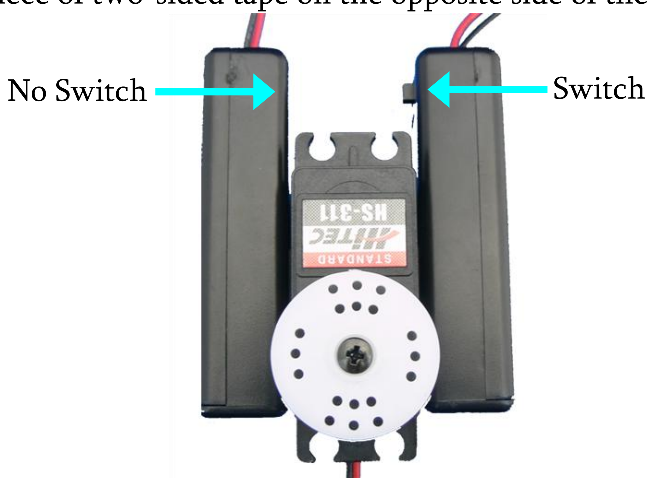
Separate a 6-inch section of red and black wire from the wire assembly that was removed from the servo. Strip each end of the wire ½ inches.



Route the wire around the chip as shown and solder each wire to the new location as shown. Make sure the wire is laying as close as possible to the circuit board so the plastic piece will fit back on. After the new connections are soldered, screw the bottom plastic piece back on to the servo assembly.

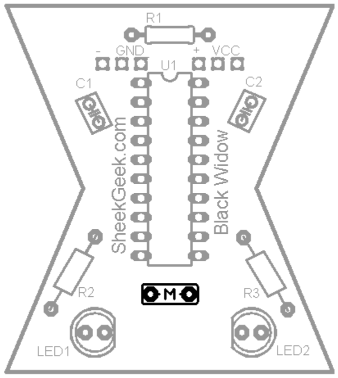
7. Assemble Body (Servo + Battery Packs)

Using a piece of two-sided tape, secure the battery case without a switch to the left hand side of the servo as shown above. Make sure the end of the battery case is in line with the end of the servo motor with the wires sticking out. <u>Make sure the removable cover of the battery case is facing outward so you will be able to put in the AAA batteries later</u>. Place the second piece of two-sided tape on the opposite side of the servo.

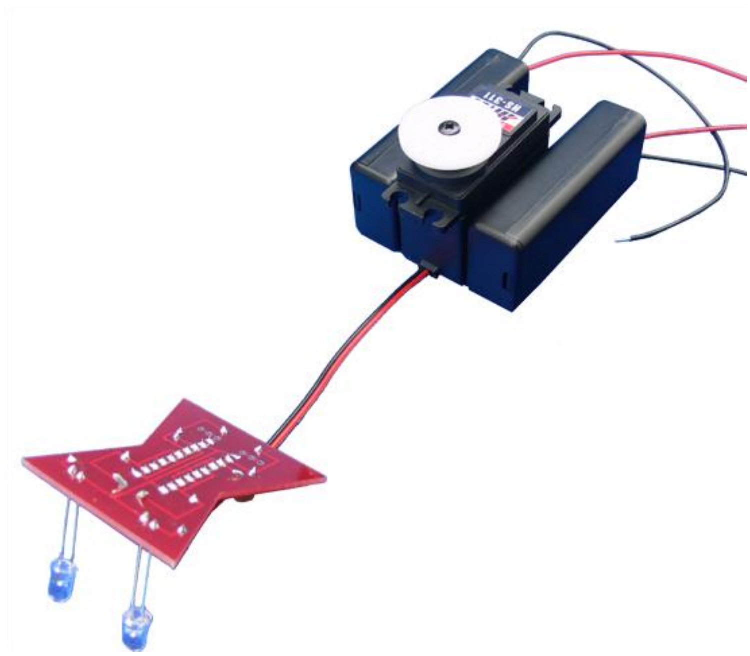


Position the battery case with a switch on the right hand side of the servo as shown above. Once again, make sure the end of the battery case is in line with the end of the servo motor with the wires sticking out. <u>Make sure the switch is facing inward and the removable battery cover is facing outward.</u>

8. Solder Servo Motor Wires



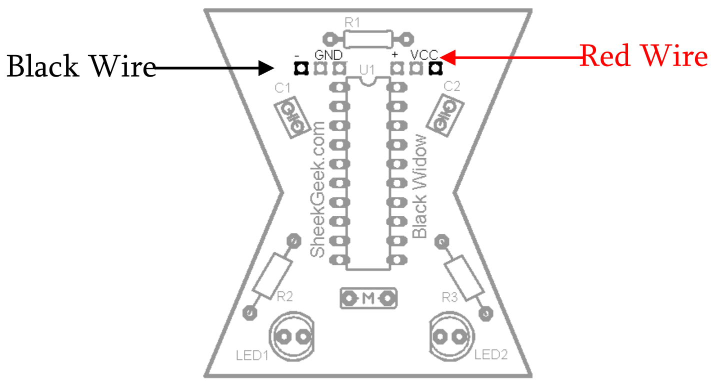
The servo motor wires will be soldered onto the highlighted position.



Solder the motor wires to the board.

9. Solder Battery Packs

Solder the black wire of the battery pack without a switch to the red wire of the battery pack with a switch.

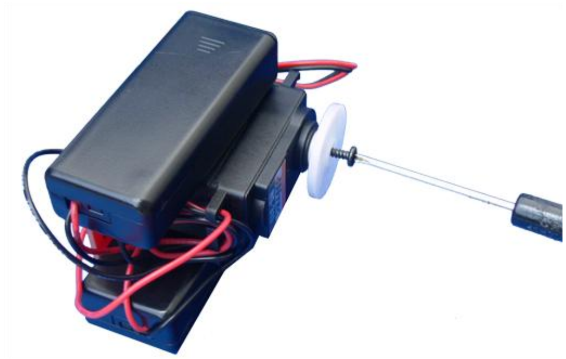


Next, solder the red wire of the battery pack without a switch to the outermost hole on the PCB next to the writing "+ VCC". Then, solder the black wire of the battery pack with a switch to the outermost hole on the PCB next to the writing "- GND".

10. Tape the PCB to Body

Now that you have assembled the body of the robot and finished soldering all the necessary pieces to the PCB, you are ready to attach the PCB to the body. Use two pieces of double-sided tape stacked, one on the top of the other. This makes the tape thicker and makes the PCB stick better.

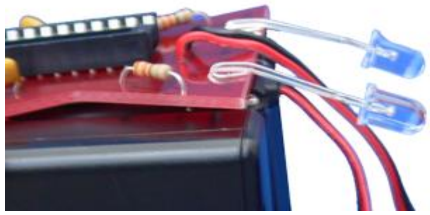
11. Remove existing servo horn and replace with "X" shaped one.



Carefully unscrew the servo horn already attached to the servo. Replace it with the white "X" shaped servo horn located in the bag in the servo box. Use the existing screw to screw the new servo horn in place.

Inside the gearbox of the servo, a gear has a stop on it. It will only allow the output shaft to spin about 180 degrees total. Spin the output shaft of the servo to the center. Do this by spinning the motor all the way left until it stops, then all the way right until it stops, and then put the output shaft half way between each stop of the gear). Then adjust the 'X' shaped servo horn until it is in an 'X' configuration as shown below. Do not turn it too much to ensure it is roughly in the center of the two motor stops.

12. Bend LEDs down.



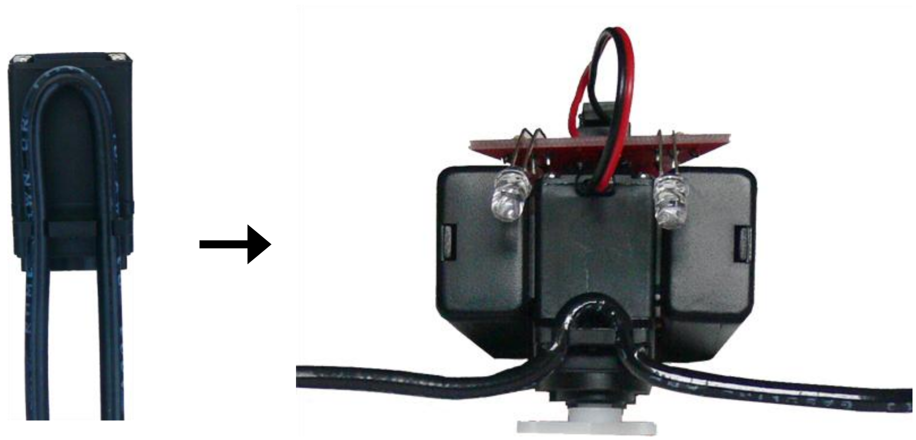
To complete the look of your Black Widow Walker, carefully bend the LEDs downward. This will direct the light emitted from the LED to the floor in front of the Black Widow Walker as it is walking.

13. Cut the 10-gauge wire in half. This will result in two pieces each two feet long. One piece will be used for the front legs and one piece will be used for the back legs.

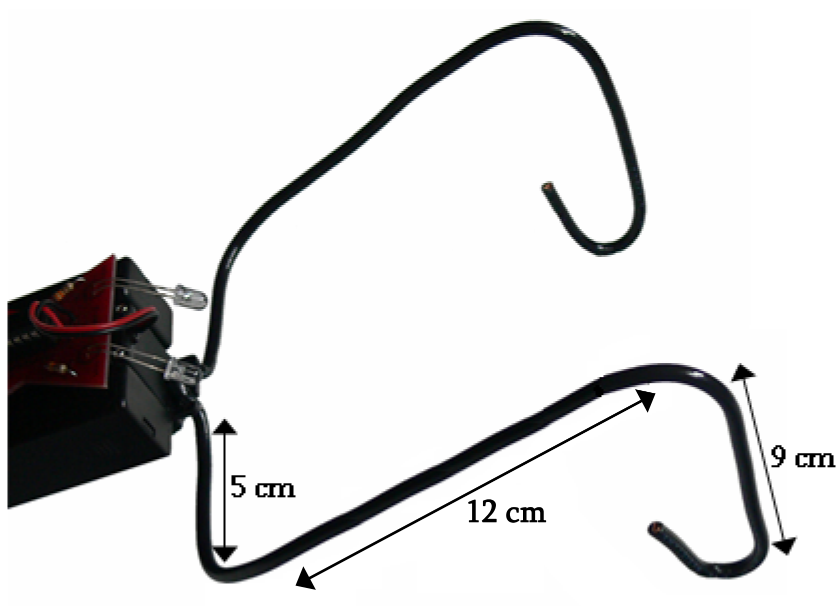
14. Attach front legs and shape.

NOTE: A template with spots indicating where the legs should touch the ground is included after the following steps.

Find the halfway mark (about one foot) and bend the front legs in half. To make a tighter bend, make a loop, pull tight, and then straighten the loop until the legs are parallel.

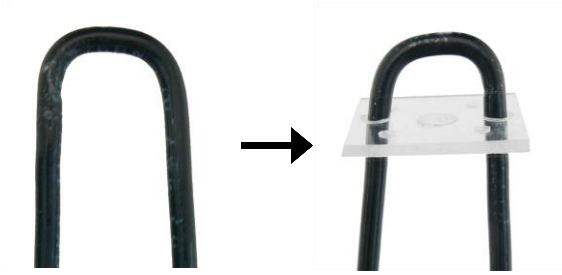


With the bend at the top, feed the legs through the two holes in front of the servo motor. Bend two legs outward to help secure the legs in place.



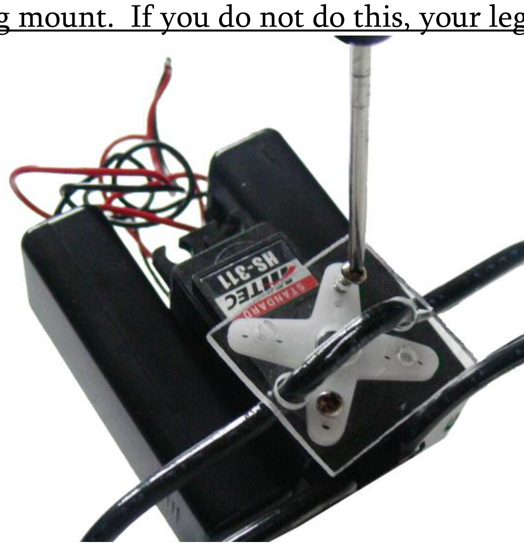
Bend the front legs to the given specifications. Make both front legs using the same measurements. A measurement is not given for the leg piece that is bent up because the length of this piece is not important and may vary.

15. Attach back legs and shape.

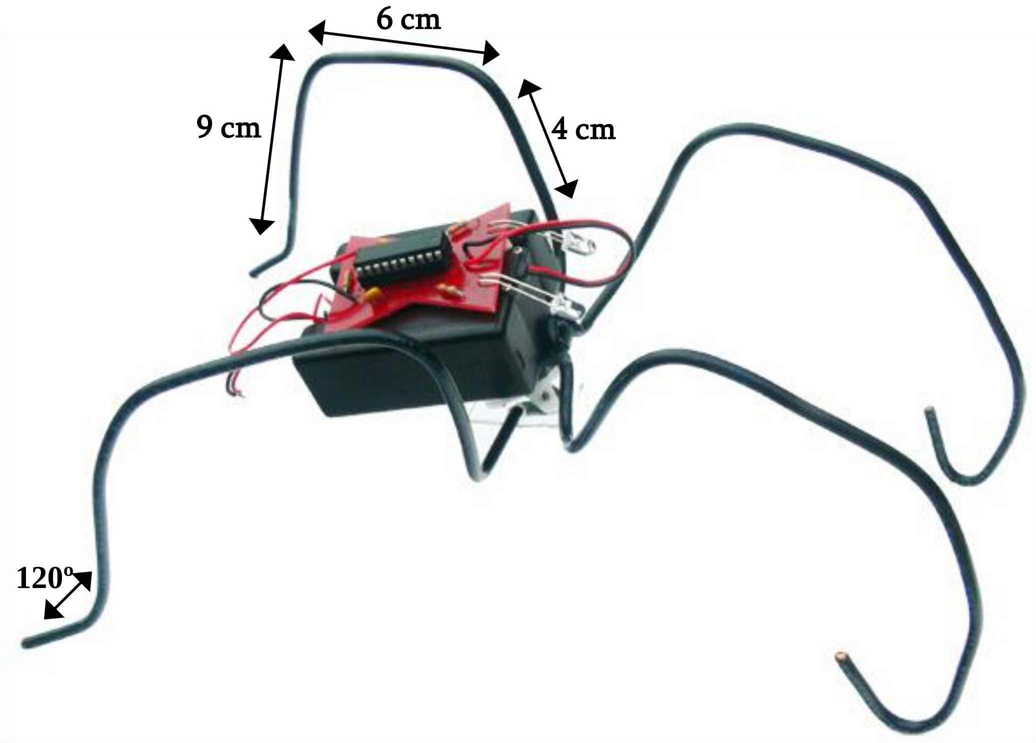


Find the halfway mark (about one foot) and bend a 7/8 inch section in the middle of wire. With the bend at the top, feed the legs through the two large, outer holes in the leg mount.

Bend two legs outward to help secure legs in place. <u>WARNING: Place thumbs on the side of the plastic leg mount while bending legs downward to distribute pressure evenly through the leg mount. If you do not do this, your leg mount will break!</u>



Line up the four corner holes of the leg mount with the middle screw holes in the servo horn. Screw your leg mount and legs to the servo horn using the four screws found in one of the pink antistatic bag.



Bend the back legs to the above specifications. Make both back legs using the same measurements. Make sure the final bend is 120 degrees! The length of the last piece of the leg is variable. It should be cut to the length needed to allow the leg touch points to match up on the leg template provided in the next section. Cutting the back legs helps create needed grip for the Black Widow Walker while walking.

16. Insert the batteries and turn the switch on.

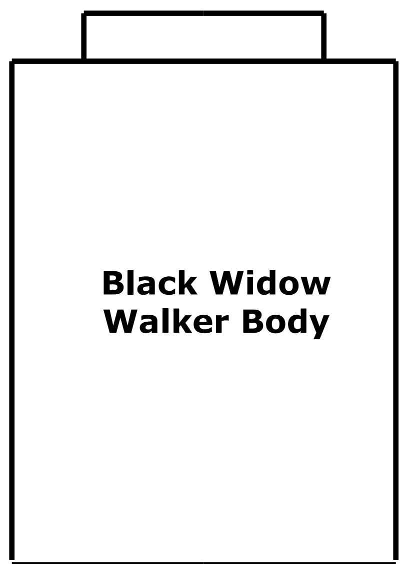
17. Test walking gait and modify legs if needed.

If your Black Widow Walker is walking well, congratulations you are finished! If your Black Widow Walker is not walking well, use the process of trail and error. Turn the Black Widow Walker off and adjust the legs. Turn the Black Widow Walker back on and see how it walks. Repeat the process until your robot is walking satisfactorily.

Front Legs

LEG LAYOUT

Line up the body of the Black Widow Walker with the center figure. Make sure each leg falls within the correct box when standing on this layout.



Back Legs

SheekGEEK PRESENTS

Certificate of Excellence

____

Insert Name Above

Has Successfully Built a

Black Widow Walker

Troubleshooting

Please read the manual carefully to make sure you have not missed any important information. Pay close attention to instructions that are underlined; however, be sure to real ALL instructions.

Problem: The legs are too wobbly/loose and the robot will not walk right.
Problem: I lost all of the screws.
Problem: I broke the motor mount piece.
Solution: Reinforce the connection of the legs with hot glue.

Problem: When I turn the robot on, nothing happens.
Solution: Be sure the batteries are inserted properly and are fully charged. Check all solder connections.

Contact Us

SheekGeek can be reached by the contact form at www.SheekGeek.com or through email at sheekgeek@sheekgeek.com

Notes