Build a Solar-Powered Bristlebot

https://www.sciencebuddies.org/science-fair-projects/project-ideas/Robotics_p026/robotics/build-a-solar-powered-bristlebot (http://www.sciencebuddies.org/science-fair-projects/project-ideas/Robotics_p026/robotics/build-a-solar-powered-bristlebot)

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Experimental Procedure

Assembling Your Robot's Body

Follow the steps in this slideshow to build your robot's body. Make sure you read the captions below each image for important notes about each step.

Slideshow Images

1. Cut the heads off two toothbrushes with *slanted* bristles.

2. Do *not* use toothbrushes with straight bristles for this project, or your robot will not work.

3. Peel the paper backing off the bottom of the breadboard to expose the sticky tape.

4. Mount the battery holder to the sticky tape, as shown. Make sure it is centered on the breadboard.

5. Insert the AAA batteries into the battery holder. Press the flat ends of the batteries up against the metal springs.

6. Attach the two toothbrush heads on either side of the battery holder. Make sure to mount them symmetrically.
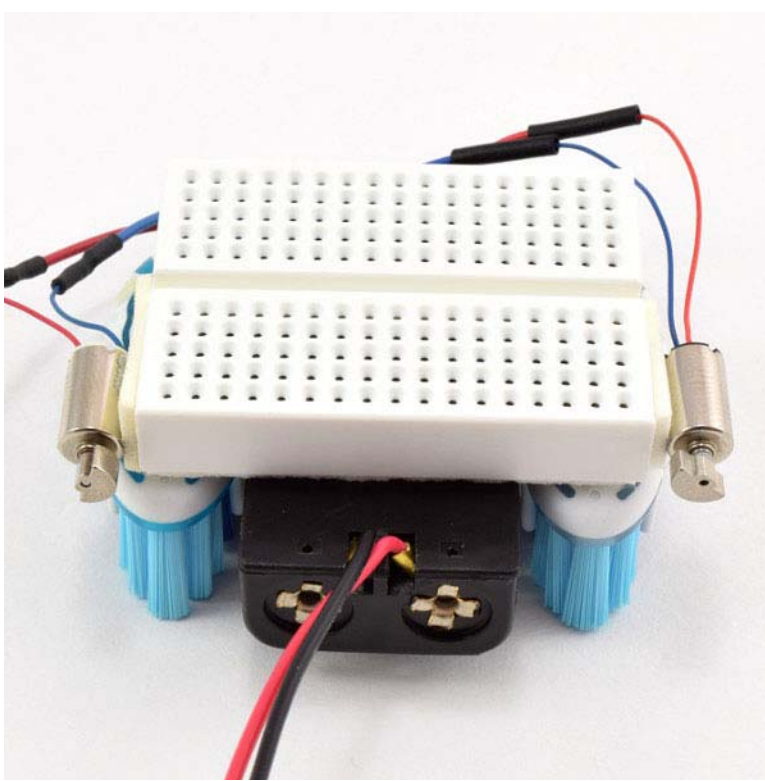

7. Attach the two vibration motors to the sides of the breadboard using double-sided foam tape. Make sure the small weights on the motors can spin freely and not get stuck.
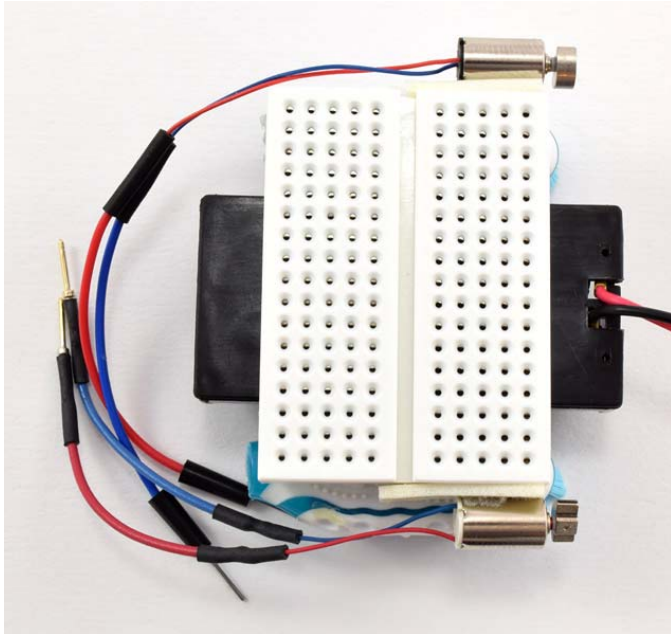
End of Slideshow Images

Assembling Your Robot's Circuit

If you have never used a breadboard before, you should refer to the Science Buddies resource How to Use a Breadboard (http://www.sciencebuddies.org/science-fair-projects /references/how-to-use-a-breadboard) before you continue. Build the circuit on your robot's breadboard by following along with the slideshow. Make sure you read the captions below each image for important notes about each step.
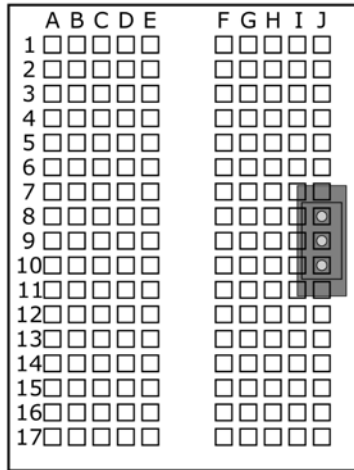
Slideshow Images
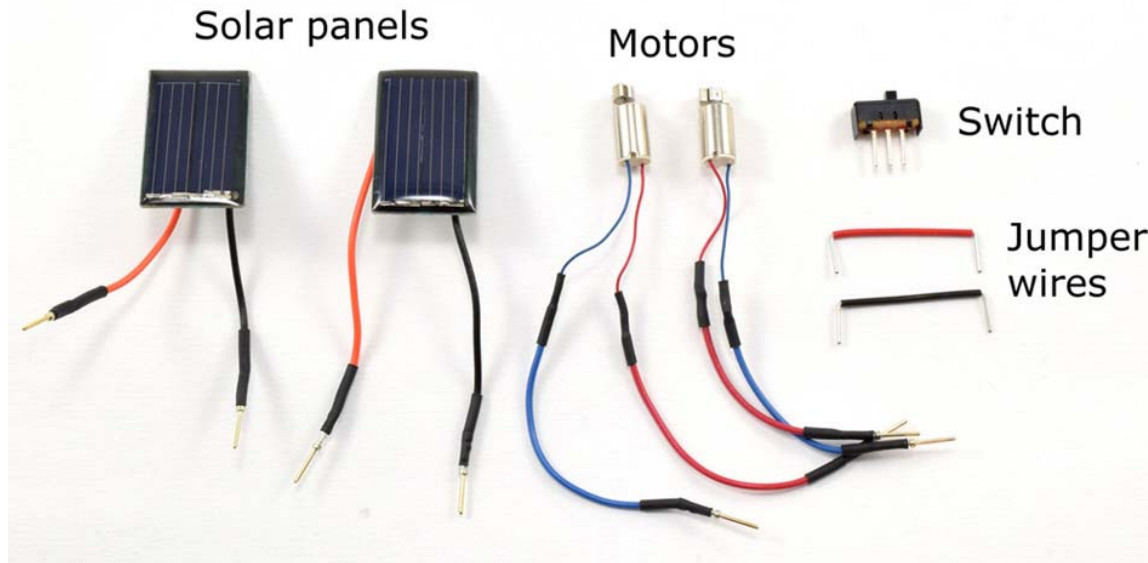
1. Identify these parts in your bristlebot kit.

2. Orient the robot's body so the battery pack wires are facing to your right.

3. Blank breadboard. The breadboard in your kit does not have row and column labels. Labels are shown in the diagram for reference, but you will need to count the holes on your breadboard.

4. Insert the power switch into holes J8, J9, and J10. The direction in which the switch is facing does not matter. Slide the switch 'up' toward row 1 of the breadboard.
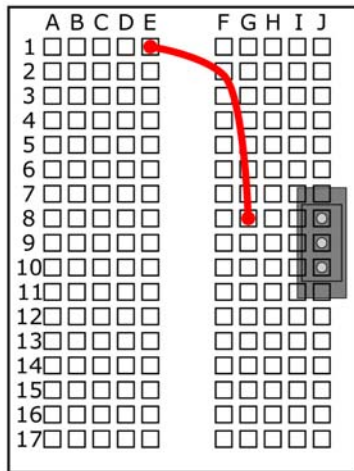
5. Connect the red jumper wire from E1 to G8.
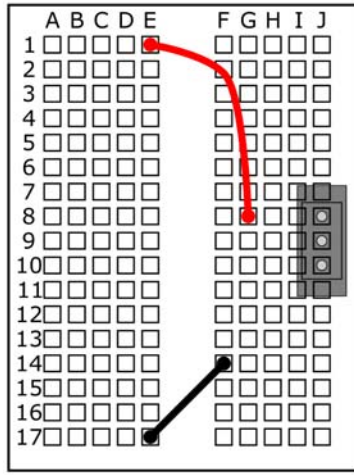
6. Connect the black jumper wire from F14 to E17.
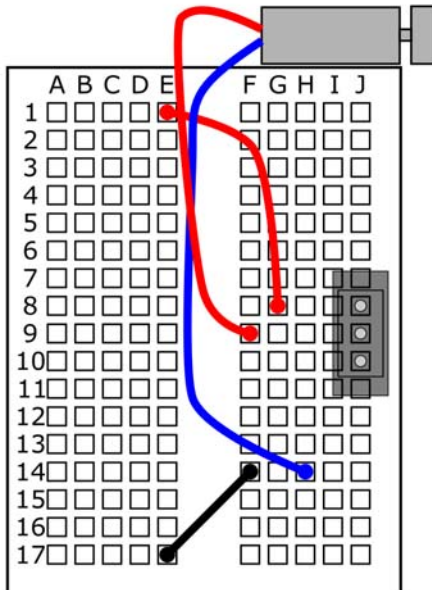
7. Connect the top motor's red lead to F9 and the blue lead to H14.
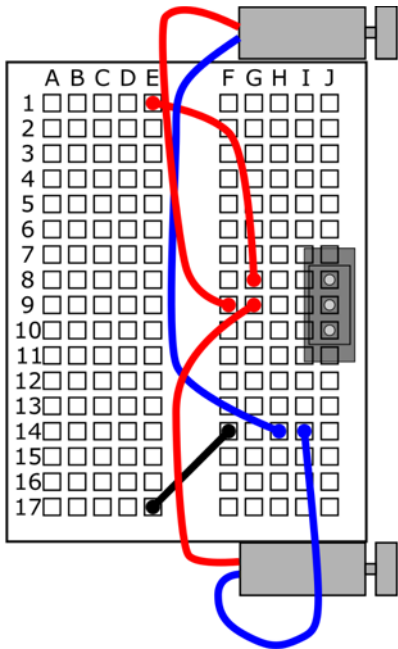
8. Connect the bottom motor's red lead to G9 and the blue lead to I14.

9. Connect the top solar panel's orange lead to C1 and the black lead to C9.

10. Connect the bottom solar panel's orange lead to D9 and the black lead to C17.

11. Connect the battery pack's red lead to G10 and the black lead to J14.

End of Slideshow Images

Comparing Solar and Battery Power

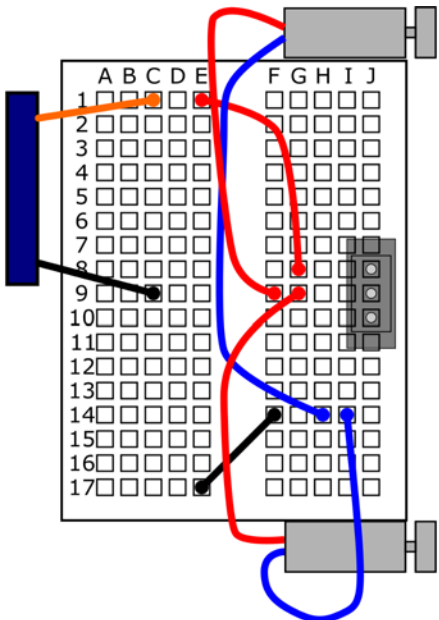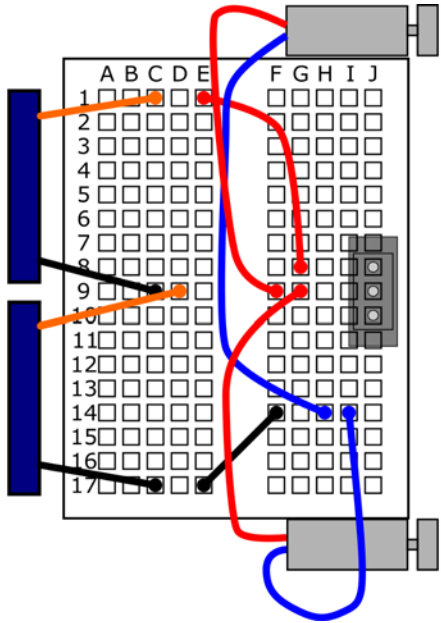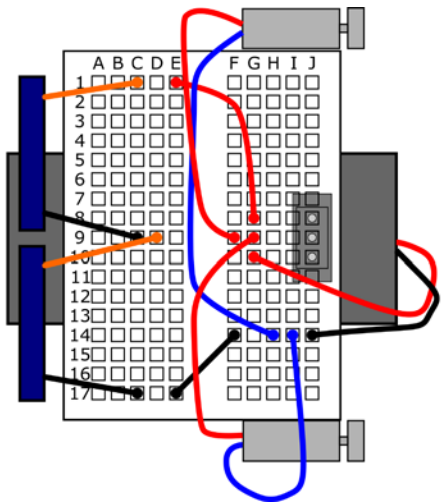1. Use household materials to set up a "chute" to force your robot to go straight, like the one shown in Figure 2. Make sure you use a smooth, flat surface (the bristles will get stuck on rough surfaces like carpet).
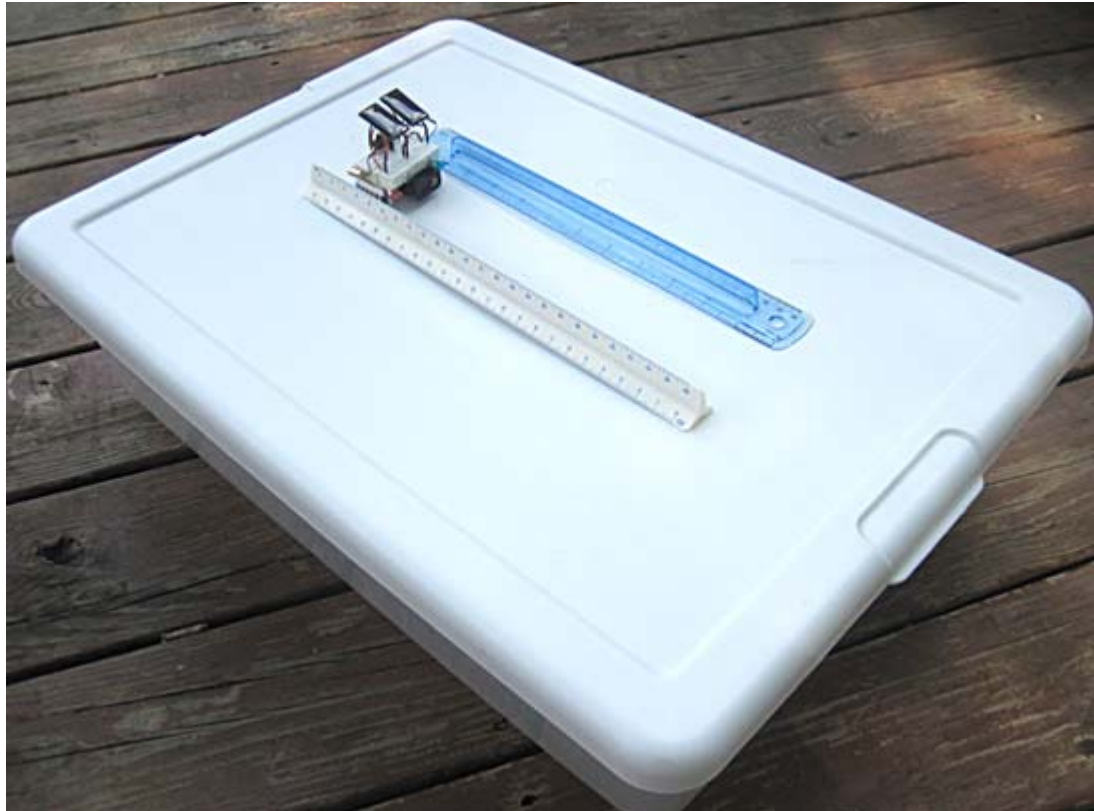
Figure 2. An example course for the robot to drive on. The lid of the plastic container provides a smooth, flat surface, and the rulers act as walls to help the robot go straight.

2. In your lab notebook, set up a data table like Table 1. You will use the data table to record how long it takes the robot to go from one end of the course to the other in seconds (sec).
    a. The exact weather conditions you are able to test may depend on the time of year and the climate where you live. However, remember that you need to test the project outside, in natural sunlight. The solar panels will not work under artificial light.
    b. The order in which you do the following steps might also depend on the weather. For example, if you build your robot on a cloudy day, you can do the cloudy day trials first, and then the sunny day trials later.

Power Source	Weather Conditions	Trial 1 (sec)	Trial 2 (sec)	Trial 3 (sec)	Average (sec)
Battery	Full sunlight				
Battery	Cloudy				
Battery	Nighttime				
Solar panels	Full sunlight				
Solar panels	Cloudy				
Solar panels	Nighttime				

Table 1. Example data table to record how fast your robot can drive through the course.

3. Take the robot and your test course outside on a sunny day.
   a. Get your stopwatch ready.
   b. Slide the power switch "down" (toward row 17 of the breadboard) to set the robot to battery power.
   c. Set the robot down on one end of your course. As soon as you do, start the stopwatch.
   d. Watch your robot as it goes down the course. If it gets stuck against one wall, quickly give it a gentle nudge to knock it loose. If your robot consistently turns sharply to one side and always gets stuck as a result, see the Help (#help) section for suggestions.
   e. As soon as the robot reaches the other end of the course, stop the stopwatch.
   f. Record the time in your data table in the row for "battery power" and "full sunlight".
   g. Repeat step 3 two more times and record the data in the appropriate trial columns.
4. Switch the robot to solar power by sliding the power switch "up" (toward row 1 on the breadboard). **Important**: Make sure the robot's solar panels are aimed directly at the sun, as shown in Figure 3. This will ensure that they receive the maximum amount of solar power possible. The wires connected to the solar panels are flexible, so you can bend them slightly to aim the panels toward the sun.
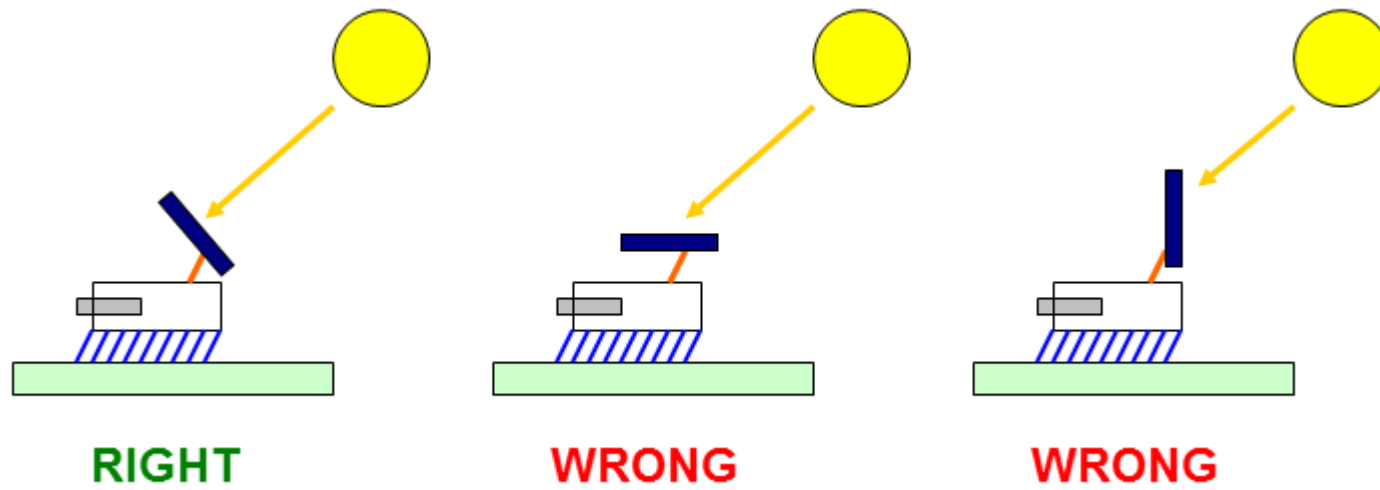
Figure 3. Make sure the solar panels are pointed directly toward the sun.

5. Repeat step 3 with the robot set to solar power instead of battery power.
6. Wait for a cloudy day, and repeat steps 3–5.
   a. Optional: If you live in an area with a lot of sunlight during certain times of the year, it might not be feasible for you to wait for a cloudy day. Instead, try doing your test very early in the morning or very late in the evening, when the sun is low in the sky and not as strong as it is during the middle of the day. Adjust the labels of your data table if necessary (for example, from "cloudy" to "early morning").
   b. Do your best to aim the solar panels directly at the sun through the clouds. You can guess where the sun is based on the time of day (ask an adult if you need help).
   c. Make sure you record all your results in the appropriate row of your data table.
   d. If the robot does not move at all, write "did not move" in the appropriate cell of the data table.
7. Take your robot and test course outside at night, and repeat steps 3–5. Remember to record all your results in your data table and write "did not move" if the robot does not move at all.
8. Analyze your data.
   a. For each row of your data table, calculate an average for the three trials. For example, if the trials were 8 s, 10 s, and 12 s, the average would be (8 + 10 + 12) / 3 = 10 s. Do not include "did not move" data points in an average, since they do not have a numerical value. If the robot did not move for all three trials, also write "did not move" for the average.
   b. Make a graph for the battery-powered data with the weather condition on the x (horizontal) axis and the average time to complete the course on the y (vertical) axis.
   c. Make a second bar graph for the solar-powered data with the weather condition on the x (horizontal) axis and the average time to complete the course on the y (vertical) axis. If the robot did not move for all three trials for a certain data set, write "N/A", which stands for "not applicable," meaning you could not record any times.
   d. Answer the following questions:
      i. Did weather impact the robot's speed using solar power? If so, in which weather condition did the robot move fastest? What about slowest?
      ii. Did weather impact the robot's speed using battery power? If so, in which weather condition did the robot move fastest?
      iii. What are the advantages and disadvantages of running the robot on solar power compared to with the battery?
   e. Now, it might be tempting to think about which power supply is "better" just based on the results of your experiment, but remember, there are some other factors to consider.

    i. Which power supply is renewable? (*Note:* You did not use *rechargeable* batteries in this project, but even if you did, such batteries are not considered renewable because they need electricity from a wall outlet to be charged, and that electricity likely came from a power plant using fossil fuels.)

    ii. What challenges would you need to overcome to use different energy sources at night or when it is cloudy? Could you build a robot with rechargeable batteries that can store energy for later use? See the Make It Your Own (#makeityourown) section for more details.

    iii. In this project, you are restricted to using the solar panels and battery pack that comes with the kit, but do you think you could use larger solar panels or battery packs to make the bristlebot run faster? How could this change your results?

Frequently Asked Questions (FAQ)

FAQ for this Project Idea available online at https://www.sciencebuddies.org/science-fair-projects/project-ideas/Robotics_p026/robotics/build-a-solar-powered-bristlebot#help (http://www.sciencebuddies.org/science-fair-projects/project-ideas/Robotics_p026/robotics/build-a-solar-powered-bristlebot#help).