How to Build a Vine Robot: Pre-Formed Vine Robot
# How to Build a Vine Robot

## Table of Contents

1. Prepare the Robot Body  
2. Make Holes in the Plastic Container  
3. Insert the Push-to-Connect Tube Fitting  
4. Insert the D-Shaft into the Spool  
5. Assemble the Robot Spool  
6. Tie a Loop Around the Spool  
7. Attach the Robot to the Spool  
8. Wind the String and Vine Robot  
9. Insert the Bearing into the Bearing Base  
10. Attach the Bearing Base to the Container Cap  
11. Attach the Motor to the Motor Base  
12. Add a Spider Coupler to the Motor  
13. Assemble the Base Station  
14. Checkpoint #1  
15. Add the Aligning Shaft to the Outlet Tube  
16. Add the Outlet Tube to the Base Station  
17. Attach the Robot to the Outlet Tube  
18. Attach the Hapkit and Upload Code  
19. Run and Control the Robot  
20. Connect to Air Compressor and Run
Step 1: Prepare the Robot Body

1. Cut 9 feet and 3 inches of plastic from the roll

2. Using a permanent marker, mark straight line at 1” from both ends. One of the ends must be marked all around (as shown by the right end in Figure 2).

3. Heat seal the not-all-the-way-around end to create a 1” thick rectangular pocket

4. Cut a 10 feet long length of string (about 1 foot longer than your plastic’s length)

Quality Check:
- Make sure your 1” pocket is actually sealed completely (must be airtight)
- You can inflate the tube to check, if necessary
Step 2: Make Holes in the Plastic Container

1. Using a permanent marker, sketch a 2” circle, 0.5” circle, and a 0.125” circle in the locations shown in Figure 1.

2. Drill holes using the corresponding bits for each hole. Use the largest bit available to you for the 2” circle.

3. Use a Dremel to expand the 2” hole to the appropriate size.

Quality Check:
- Have the edge of the 2” hole about an inch from the lid lip.
- The locations of the holes are very forgiving.
- It is fine if the holes are a bit oversized, since we will be sealing them with hot glue.
Step 3: Insert the Push-to-Connect Tube Fitting

1. Align the tube fitting with the 1/4" hole made on the side of the container
2. Screw the fitting into the container until it is flush with the side (for your first time, you are threading the plastic by doing so)
3. Apply hot glue around the fitting to create an airtight seal at the connection point with the plastic.

Quality Check:
- Pull lightly on the fitting to see if it has been secured
- Check around the edges of the glue for any gaps
- Once we pressurize the chamber, it will be clear if the glue sealed correctly
Step 4: Insert the D-Shaft into the Spool

1. Insert the D-shaft through the spool’s center.
2. Leaving about 0.25” of shaft coming from the other side.
3. Add one of the spider couplers to the end with the 0.25” shaft extrusion and tighten the set screw.

Quality Check:
- The flat part of the shaft must be facing the set screw
- Don’t forget to tighten the set screw

*Mallet may be useful
Step 5: Assemble the Robot Spool

1. Apply hot glue along the surface of the spool's main body.

2. Insert the circular disk (or spool cap) into the shaft and press down to glue the two spool parts together.

Quality Check:
- Minimal gaps between the glued disk and main spool body
- Use the string to test that it doesn’t get caught in the gap where we applied glue.
Step 6: Tie a Loop around the Spool

1. Loop one end of the string around the body of the spool in an “X” shape
2. Pass the end over and through to close the loop. Repeat once more to seal the knot.
3. Pull the other end of the string to tighten the knot until it touches the spool body

Quality Check:
- Pull the string as shown in Figure 3 to make sure the knot does not become undone.
- Make sure you cannot slip a pencil between the string and the spool body.
Step 7: Attach the Robot to the Spool

1. Using a permanent marker, mark two points about 0.25” from the edge of the rectangular pocket.
2. Puncture the plastic at the marked points.
3. Insert the string through one of the holes and through the back of the other hole. Create a loop for a knot.
4. Tighten the knot and make a second knot if necessary.

Quality Check:
- Pull the string as shown in Figure 4 to make sure the knot does not become undone.
Step 8: Wind the String and Robot

1. Hold the string or plastic roll taught while winding

2. Keep the plastic as flush as possible to the main body of the spool

---

**Quality Check:**
- The rolled up robot should not have visible wrinkles when fully rolled as shown below
- Except for the plastic-to-string knot area shown in Figure 2
Step 9: Insert the Bearing into the Spool Base

1. Insert the bearing into the large, circular disk’s center. It is a press fit, so it might require some force.

Quality Check:
- The bearing must be flush with the surface of the disk

*Mallet may be useful*
Step 10: Attach the Bearing Base to the Container Cap

1. Add a healthy amount of hot glue to either side of the bearing base

2. Find the center of the bearing and cap. Align the two centers.

3. Press the two parts together

---

**Quality Check:**

- Do not let the bearing come into contact with the hot glue. This could mess up your bearing.
- Make sure your 3D printed part is leveled and not angled
  - You want full contact with the cap
Step 11: Attach the Motor to the Motor Base

1. Slide two wires through the base’s outer holes and strip them as shown in Figure 1
2. Loop them through the motor leads
3. Solder the wires to the motor
4. Insert the motor into the base

Quality Check:
- If you opted to make a side hole for the wiring rather than at the top, slide the wire’s through the base’s side hole to keep things together
Step 12: Add a Spider Coupler to the Motor

1. Insert the spider coupler into the motor shaft while making sure that the set screw and the flat side of the shaft are together.
2. Tighten the set screw
3. Push the coupler’s rubber insert into the spider coupler as shown in Figure 3

Quality Check:
- Twist the spider coupler to make sure it is NOT free spinning
- If it is, check that you have tightened the set screw on the flat side of the motor shaft
Step 13: Assemble the Base Station

1. Pass the motor wires through the 1/8” hole at the bottom of the container
2. Add hot glue to the bottom of the motor base and press the base flush with the bottom of the container. Check that the motor shaft is centered with respect to the container
3. Insert the non-coupler side of the spool into the bearing

You should now have:
Step 13: Continued

4. Connect spider couplers to add the spool to the base station

5. Put on and twist the cap until the container is sealed
Checkpoint #1

1. All parts, except for the motor, should be on the same vertical axis
2. The spool shaft must be inserted in the bearing and the cap tightly screwed on
3. No parts come loose
4. Seal the top wires with hot glue
Step 14: Add the Aligning Shaft to the Outlet Tube

1. Insert the wooden dowel piece into the straw to make a makeshift bearing
2. Add two drops of crazy glue (one drop at each end)
3. Press the dowel into extruder until it is flush with the edge

Quality Check:
- Make sure that the dowel does not budge when pressed
- Add crazy glue after step 3 as you see necessary
- Make sure the straw is not glued down and can rotate freely
Step 15: Add the Outlet Tube to the Base Station

1. Insert the outlet into the 2” hole you made in the container. About 1/8” of insertion should be enough to have a grip on the other side.

2. Rotate the extruder until the shaft is vertical. Hot glue all around the edges of the extruder to make an airtight seal.

Quality Check:
- Make sure that the extruder does not budge when moved.
- If there are sharp edges on the extruder, use sand paper to remove them.
- Not doing so may puncture the robot.
Step 16: Attach the Robot to the Outlet Tube

1. Pull the plastic roll through the outlet tube. If your spool unrolls on the left, pass it on the right side of the shaft as shown in Figure 1.

2. Open up the plastic roll

3. Turn the plastic inside out and fit it over the extruder.

4. Pull the plastic back to remove any crumpling.
Step 16: Continued

1. Align the circular marking on the plastic roll with the edge of the extruder, as shown.

2. Use the string-backed tape to create an airtight seal and set the robot in place.
Step 17: Attach the Hapkit and Upload Code

1. Connect the motor to the Hapkit by using the onboard motor driver as shown on the left (white wire first, followed by the black wire)

2. Download Arduino and upload the “PreformedVine_KeyboardControl.ino” code to the board

Quality Check:
- Pull lightly on the wires to make sure they have been set in place
- You can download the Arduino program here
Step 18: Run and Control the Robot

1. While the USB cable connects your computer to the Hapkit, open the serial monitor.

2. You can control the robot by sending single, capitalized characters through the serial monitor:
   - “W” is forward growth (the motor rotates to help release the stored material). Growth requires the compressor to provide pressure.
   - “S” is retraction (the motor rotates in the opposite direction to store the extruded material)
   - “D” increases the speed of the motor
   - “A” decreases the speed of the motor
   - “ ” stops the motor

Quality Check:
- If “S” unspools the material or “W” pulls the material in, then your black and white cables are flipped.
Step 19: Connect to Air Compressor and Run

1. Attach the clear tubing to the push-to-connect tube fitting on the side of the base station
2. Connect the clear tubing you just used to the air regulator and the air regulator to your air supply
3. Set the pressure to ~1.5psi for growing the Vine Robot

Quality Check:
- Once you have pressurized the chamber, listen for any air leaks
- Use hot glue or an epoxy to seal the leaks