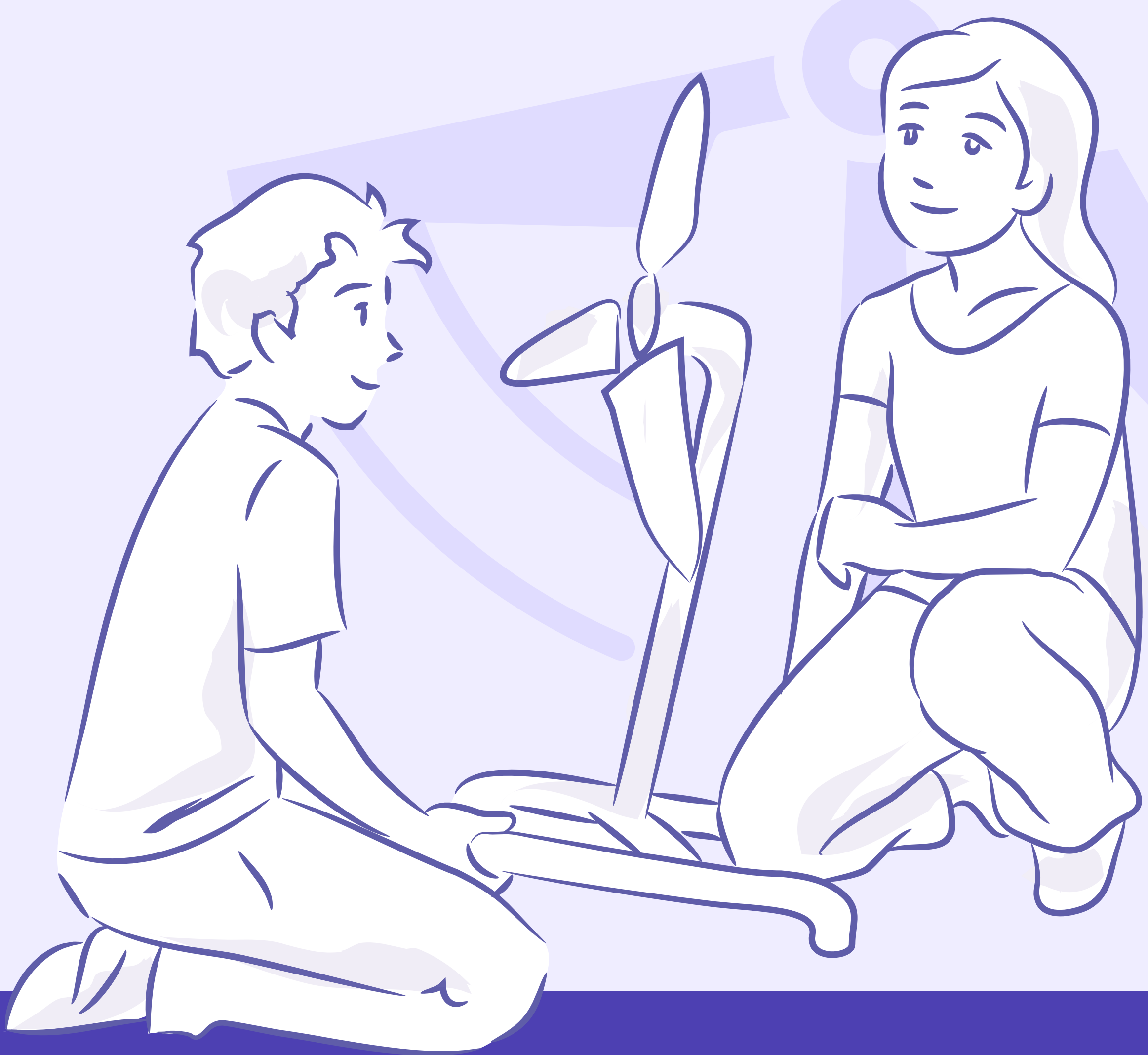
PVC Wind Turbine Assembly Guide



KidWind PROJECT

This guide was created in collaboration with the Wright Center for Science Education at Tufts University, National Wind Technology Center, and the Department of Energy.

Materials

For a classroom of 25 kids, we recommend having at least three turbines for blade testing. Below is a parts list for building one wind turbine.

Safety note: Always wear safety glasses when the rotor is spinning! You could be hit if our blade flies off during testing.

PVC PIPE FITTINGS

Head to your local hardware store for PVC pipe and fittings. KidWind also gets fittings from www.PlumbingStore.com. All pipes and fittings are Schedule 40 - 1" in diameter. This turbine has:

- (5) 1" PVC 90° Fittings
- (4) 1" PVC T Fittings
- (5 ft) 1" PVC Pipe
- (1) 1" PVC Coupler

DC MOTOR, WIRES & CLIPS

A local electronics shop will have wire, clips and multimeters. There are also a variety of online vendors. You can use any small DC motor as a generator. Our partners at Vernier stock the standard KidWind generator that we use at our workshop and kits. It is great because it comes with the wires attached! If you want to experiment, you can use any DC motor any DC motor, as long as it fits inside of the 1" PVC used in this design. Just attach your meter to the generator, spin with your fingers, and if you get measurable output you can use it.

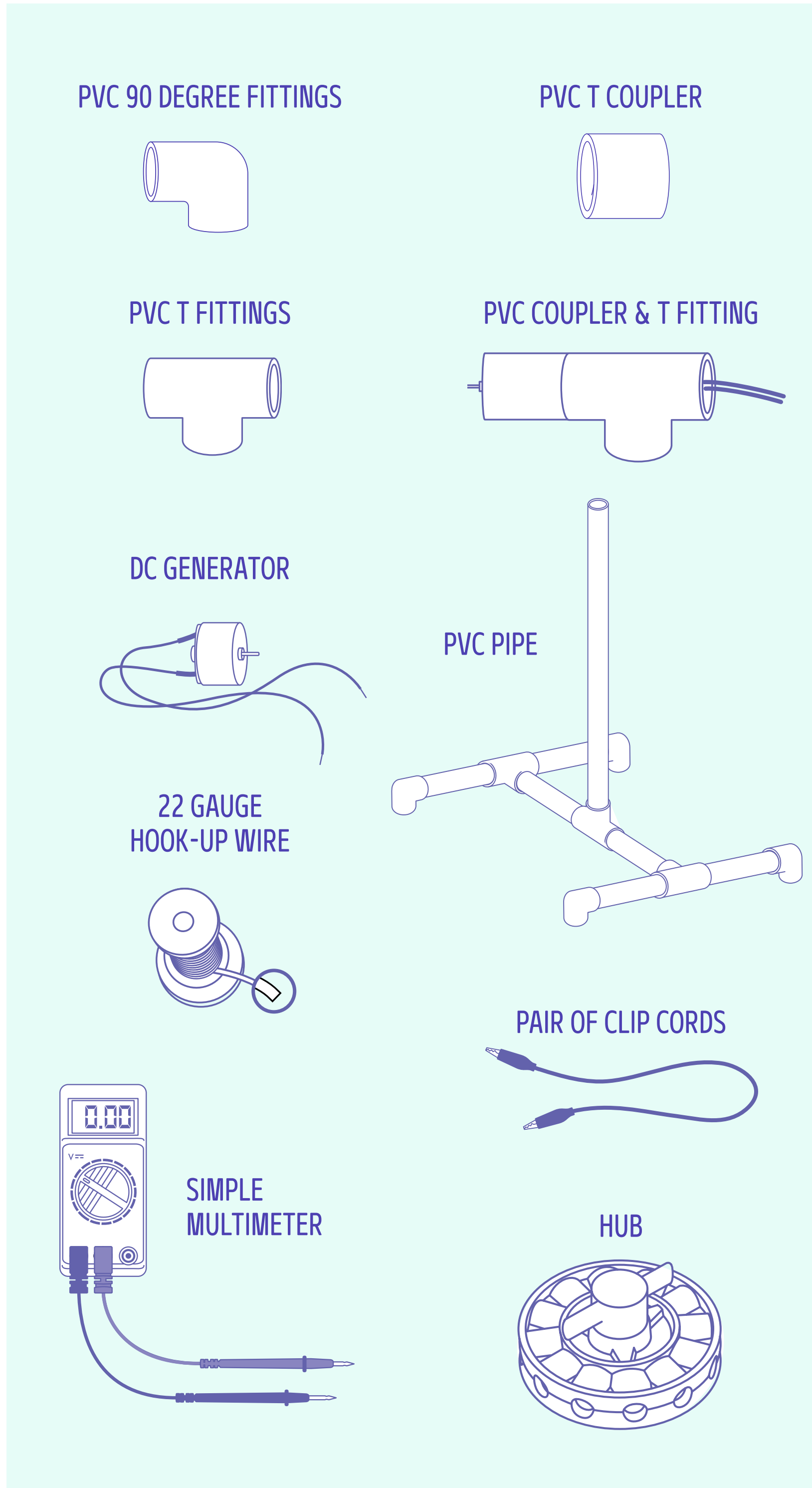
- (1) DC Motor
- (4 ft) 22 Gauge Hook Up Wire
- (2) Clip cords
- (1) Simple Multimeter to Record Power Output

SPECIAL PARTS

Vernier custom builds hubs for KidWind turbines. For years we used to fashion our own hubs from Tinkertoys. While they definately have some drawbacks, you can head to your local toy shop or an online vendor to get yourself a barrel of Tinkertoys and see what you can do!

- (1) Hub (Wind Turbine Hub from Vernier)

Our partners at Vernier have a great kit that includes dowels plus a KidWind DC generator and hub.



Remember, you can always purchase a KidWind Turbine Kit if you don't feel up for cutting PVC!

Mini Turbine | **Basic Turbine** | **Advanced Turbine**

BLADE MATERIALS

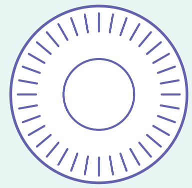
You can make blades, out of a variety of materials—wood, cardboard, felt, fabric. Students have made blades out of styrofoam bowls, pie pans, paper and plastic cups. Anything you find around the classroom can be made into blades!

- → You'll also need dowels to connect your blades to your turbine. We suggest 1 pack of 4" dowels that are 3/8" in diameter (or Tinkertoy rods). These will fit perfectly in the KidWind Hub.

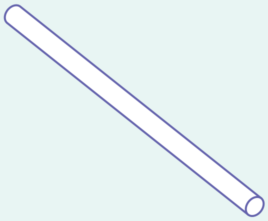
TOOLS

To build this turbine from scratch you'll need at minimum a drill, PVC cutter or saw, wire strippers, soldering iron, solder, duct tape, ruler, and glue.

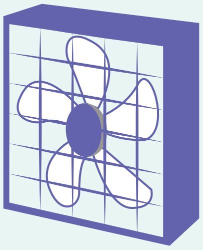
BLADE MATERIALS
(paper plates and bowls, plastic cups, cardboard or cardstock)



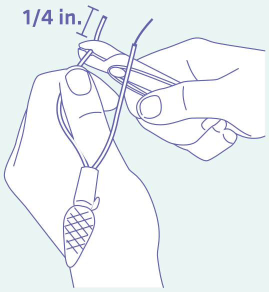
DOWELS



BOX FAN

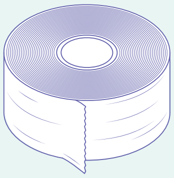


WIRE STRIPPERS



RULER

DUCT TAPE



AND:

- HOT GLUE
- 5 FT PVC PIPE
- SOLDERING IRON (IF CREATING YOUR OWN GENERATOR)
- SOLDER
- PVC CUTTER

Building the Basic PVC Wind Turbine

This is the first wind turbine developed at KidWind. The idea was adapted from a design we found from our pals at Otherpower.

The goal of this project is to help you construct a simple classroom scale wind turbine, learn how to make blades and measure the output. This rugged and cheap to build device will allow you to perform a variety of experiments and explore the science of wind power.

STEP 1: PREPARE YOUR MATERIALS

Prepare Your Materials

1. Cut your 5' long piece of 1" PVC pipe into the following pieces:
   - → (6) 6" long pieces
   - → (1) 20" long piece
   - → (1) 3" long piece

You will have 1" of PVC pipe leftover

2. Decide if you want to bring your wires out of the bottom of the tower or off the side of the nacelle.

3. If you decide to bring your wires out of the bottom of the tower, drill a hole at the center of 1 of the T fittings. Be sure it is big enough to fit your wires through it!

STEP 2: BUILDING THE PVC TOWER BASE

1. Gather (2) 6" PVC pipes and (1) PVC T fitting to build the middle bar of the base. If you are pulling your wires out of the bottom of the tower, be sure you have the T fitting with your hole already drilled in it!

2. Fit the parts together without using glue (PVC glue is really nasty stuff). To make them fit snuggly, tap them together with a hammer or bang them on the floor once assembled. See figure 1 for help!

3. Now gather (4) 90° PVC fittings, (2) PVC T fittings, and (4) 6" PVC pipe to construct the two sides of the PVC turbine base. Fit these parts together. See Figure 2 for help!

4. Next, connect to the two sides of the base using the middle bar, forming a letter H. See Figure 3.

HOW MANY SHOULD I BUILD?

In a typical class of 25 students it would be a good idea to have 3 turbines. You'll want each turbine to be located at a station with it's own fan and multimeter, making 3 stations in your classroom. You should also have enough hubs so you students can work in pairs.

Looking for Lesson Plans?

Head to kidwind.org/activities for lots of lessons about wind turbines!

If you want to pull your wires out of the bottom of the tower, you'll need to drill a hole in the bottom of this T fitting so that you can slide your wires out!

Figure 1.

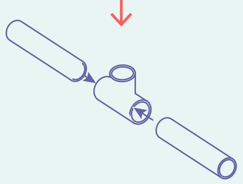


Figure 2.

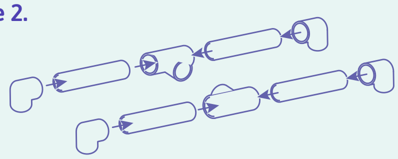
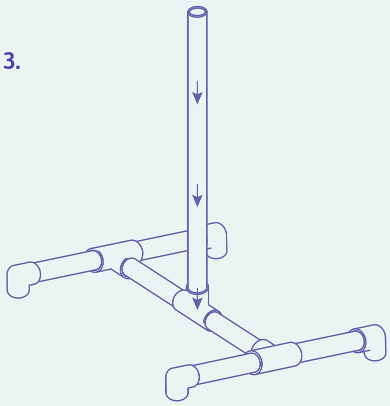


Figure 3.



STEP 3: BUILDING THE NACELLE

1. You will need to solder some wires (4' long) to your DC motor. Wrap a piece of duct tape around the outside of the motor. This piece of tape should be about 1/2" wide and 18" long. This will help the motor fit securely into the PVC coupler.
2. For this step use (1) PVT T fitting, (1) PVC coupler, (1) 3'' piece of PVC pipe and the DC generator. The best DC generators will be close to 1" in diameter so they fit tight in the coupler.
3. Arrange the pieces as they look in the image to the right. Push them together to form a solid piece. On a large wind turbine this is called a nacelle; it holds the generator, gear boxes, and other equipment.
4. Insert the wires attached to the DC motor through the nacelle. They should come out of the 90° PVC fitting. The motor will rest in the coupler.
5. Insert the motor into the coupler. It should fit very snuggly. If it is too loose or tight adjust by wrapping or unwrapping duct tape around the outside. As the motor is pushed on frequently by students, it must be TIGHT! You can glue this in to make it secure.
6. Insert the motor making sure that it is straight and not too far in. If it looks cockeyed, straighten it out as it will cause your hub and blades to wobble while spinning.
7. Once the motor is secured attach the hub you have decided to use. Press the hub onto the drive shaft. It should fit very snuggly.

Figure 4.

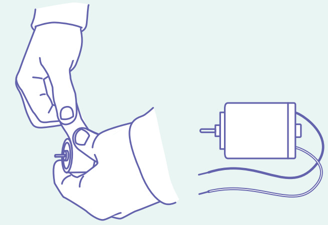
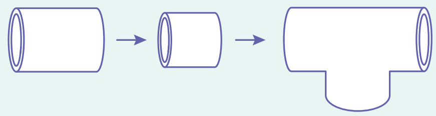


Figure 5.



Since we are using a PVC T fitting as a part of the nacelle, you can choose to pull the wires out of the back of the PVC T as shown here. Alternatively, if you have drilled a hole in your bottom PVC T fitting, you can pull the wires down the tower and out of the bottom of the base like in the below image.

STEP 4: ATTACHING THE TOWER TO THE BASE

1. You can either snake the motor wires down the tower and out your drilled hole in the base of the wind turbine, or you run them out of the back of the nacelle through the PVC T fitting and down the side of the tower. You can attach the wires to the tower using some tape.
2. Attach the nacelle to the top of the tower.
3. Insert the bottom of the PVC tower into the tee at the center of the turbine base.
4. Ensure that the PVC pipe is seated tightly into the fittings by tapping it together with a hammer or by banging on the floor.
5. Do not use any glue so that you can take it apart and store it once you are finished.
6. Attach clip cords to the wires coming out of the turbine to help to hook your turbine up to a multimeter!

SUCCESS!! Wind Turbine Completed!

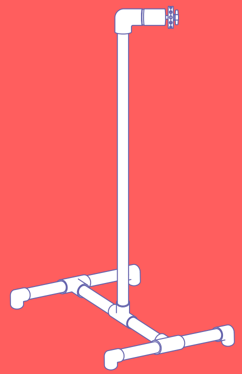
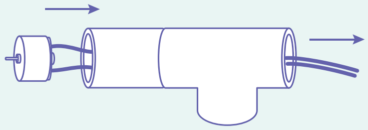
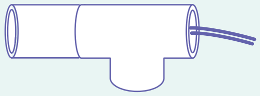


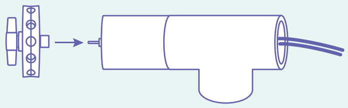
Figure 6.



Make sure the wire comes out the back!



Motor secured into the coupler. Straight!



Nacelle complete.

CAUTION

NEVER make blades using metal or any sharp edged material as these could cause injury during testing. Blades tend to spin very fast (400-600 RPM) and they can easily cut people if they have sharp edges.

Again, DO NOT USE sharp metal or very hard plastic to make blades as blades can spin at very high speed (500RPM) and could cause injury.

STEP 5: BLADE DESIGN

1. To make blades, carve or cut different shapes and sizes out of a variety of materials (wood, cardboard, felt, fabric) and hot glue them to the dowels. Students have made blades out of styrofoam bowls, pie pans, paper and plastic cups. Anything you find around the house or classroom can be made into blades! We do not suggest using tape as it will not hold during testing.
2. Before testing, check that the blades are securely attached to the dowel. If not secured properly, they may detach or deform as you test your turbine in high winds. We recommend using a combination of tape and hot or regular glue.
3. Insert the dowels into holes on the Wind Turbine Hub. It is important to tighten the hub when inserting the blades so that they do not come out at high speed.
4. When attaching the blades to the hub consider a few important questions:

- How close is the root (the part that connects to the rotor) of your blade to the hub? What do you think is optimal?
- Are your blades about the same size and weight? Blades that are not balanced will cause vibrations that can reduce the efficiency of your turbine
- Are the blades equally distributed around the hub? If not you can also have a set up that is out of balance.
- Have you secured the hub after you inserted the blades? If not they can fly out at high speed!

Figure 7.

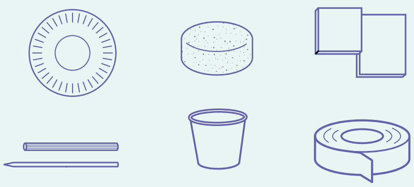


Figure 8.

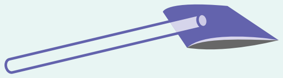
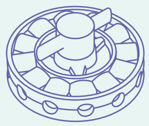


Figure 9.



HOW TO IMPROVE YOUR BLADES

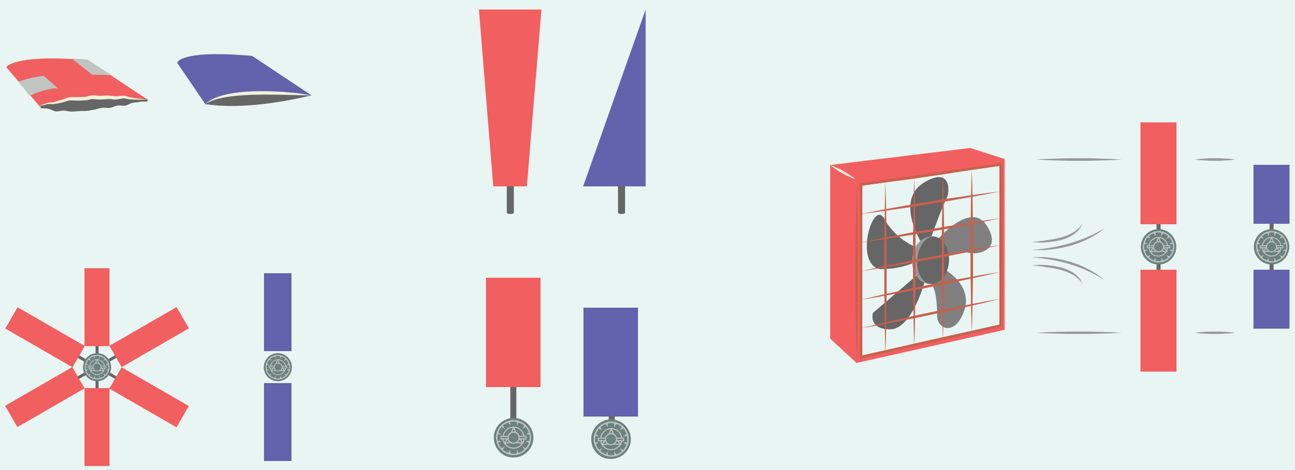
Having efficient blades is a key part of generating electricity from a wind turbine. Sloppy, poorly made blades will never generate enough electricity to power any objects. It takes time and thought to make good blades.

One thing you must always think about when making turbine blades is: "How much drag are my blades encountering?" Sure, your blades are probably catching the wind and helping to spin the hub and motor driveshaft, but could they be spinning faster? If they are adding drag, your whole system will slow down. In most cases, low RPM means less power output. The faster the blades spin, the more power you make.

Quick tips on improving blades

- Shorten blades: Many times, student make very long blades, thinking bigger is better. That is sometimes true, but students and teachers have a very hard time making long blades without adding drag. Try shortening them a few centimeters.
- Change the pitch: Often, students will set the angle of the blades to around 45⁰ the first time they use the turbine. Try making the blades more perpendicular to the wind flow. Pitch dramatically affects power output. Play with it a bit and see what happens.
- Use fewer blades: To reduce drag, try using 2, 3, or 4 blades more perpendicular to the wind flow. Pitch dramatically affects power output. Play with it a big and see what happens.
- Use lighter material: To reduce the weight of the blades, use less material or lighter material.
- Smooth surfaces: Smoother blade surfaces experiences less drag. A blade with lots of tape and rough edges will have more drag.
- Get more wind: Make sure you are using a decently sized box or room fan, one with a diameter of at least 14"–18".
- Blades vs fan: Are your blades bigger than your fan? This could be a problem, as the tips of your blades are not catching any wind and are just adding drag.
- Blade shape: Are the blade tips thin and narrow or wide and heavy?

Figure 10.



STEP 6: TURBINE TESTING

Attach a Multimeter

A multimeter is a tool that will allow you to quantify the voltage and/or current your turbine produces. Learning how to accurately measure the voltage and current for a range of situations will help you compare data when testing blades, comparing gearing, or changing any other variables on small turbines. You will also need this information if you want to calculate the power your turbine produces.

Setup for Testing

Safely set up your testing area as shown in Figure 12. It is important to clear this area of debris and materials. Stand in front or behind turbine. Make sure the center of the fan matches up with the center of the wind turbine. You may need to raise your fan with some books or a container.

Some things to note about fan wind that reduces the efficiency. Fans create:

→ Highly Turbulent & Rotational Wind—Blades may spin better one direction than another

→ Highly Variable Wind Speed—Wind speed is about 7-8 MPH on high for a $20 circular fan. Wind speeds near the middle will be much different than the edges.

→ Limited Diameter—Blades bigger than fan will not "catch" more wind. They will just add drag and slow down your blades.

How to Clean Up Wind?

Want some more "professional wind"? You can try to build a simple wind tunnel. One way to make more laminar—smooth, straightened—flow is to build a honeycomb in front of your fan using milk cartons, 2" PVC pipe or some other material.

Going Outside?

While you can use your wind turbine outside, you must make sure that you face it into the wind. This is because this turbine is not designed to YAW (or rotate) to face the wind. If the wind shifts, and the turbine cannot rotate, winds will hit the blades from the sides causing stress and inefficiency.

If you want to measure your wind turbine's power output for blade optimization, check out KidWind's Performance Calculator Guide.

Figure 11.

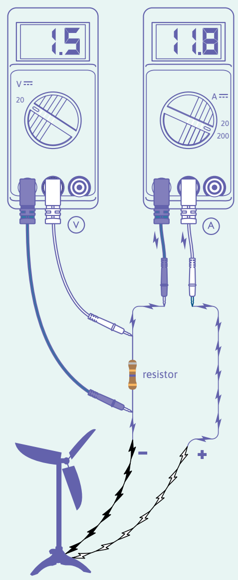


Figure 12.

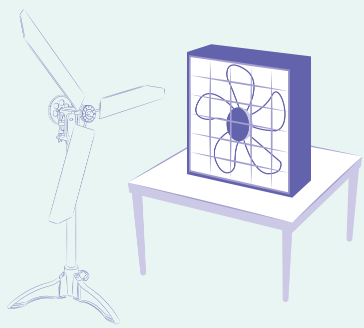
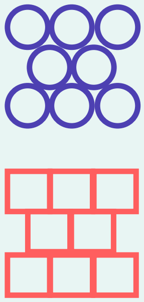


Figure 13.



VOCABULARY

GENERATOR
A generator is made of magnets connected to a shaft and conductive wire. When magnets are moved next to wire quickly, an electrical charge is generated that can power things like lights.

FORCE
Force is a push or pull.

FRICTION
Friction is the "pull" of a force. Friction is a force that resists the relative motion of two things in contact.

MOTION
The action or process of something moving or being moved. Wind is air molecules in motion. Wind acts as a force on the PVC turbine blades, causing them to move in rotation.

WIND TURBINE
A wind turbine is a human-made device that is designed to spin in the wind in order to generate electricity. Our PVC turbine spins and generates electricity that can be harnessed.

HUB
A hub is the central component connecting the blades to the generator shaft.

BLADES
The blades on a wind turbine are the parts that spin because of the way they catch the wind.

PLANE OF ROTATION
The plane of rotation is the area directly in line with the rotor. It is dangerous to stand in this area because a blade that is not securely fastened to the hub and detaches could hit a person standing in this zone.

BLADE PITCH
Blade pitch is the tilt or angle of the blades in the wind, with respect to the plane of rotation.

DRAG
For a wind turbine, this is also called wind resistance. Drag is the friction of the blades against air molecules as they rotate. Drag works against the rotation of the blades, causing them to slow down.

Questions? Scan this QR Code to view our Wind Turbine FAQ