

# Advanced Wind Experiment Kit

(Order Code KW-AWX, KW-AWXC)

These instructions show you how to build the Advanced Wind Experiment Kit. While some parts come pre-assembled, you will have to put a few things together. This turbine allows for maximum variability and experimentation while dramatically increasing power output through the use of a gear box.



## What's Included

### Advanced Wind Experiment Kit

- Gear Set with Spool (1)
- Wind Turbine Generator with Wires (1)
- High Torque Generator with Wires (1)
- Motor Mount Pack (2)
- Wind Turbine Hub (1)
- Power Output Board (1)
- Main Body Half (2)
- Tower Base Leg (3)
- Tower Base Locking Ring (1)
- Tower Base Hub (1)
- Plastic Weightlifter Bucket (1)
- 250 ml Graduated Cylinder (1)
- Blade Pitch Protractor (1)
- 20" Wood Tower (1)
- 1/2" Washer (25)
- Small Water Pump (1)
- 12" x 1/4" Clear Tubing (1)
- 8" Hex Shaft with Hub Quick Connect (1)
- 1/4" x 5" Dowels\* (25)
- Power Output Pack\* (1)
- 3" x 12" x 3/32" Balsa Wood Sheet\* (5)
- 3" x 12" Chipboard Blade Sheet\* (10)
- 4' String\* (1)

### Classroom Pack

- Gear Set with Spool (3)
- Wind Turbine Generator with Wires (3)
- High Torque Generator with Wires (3)
- Motor Mount Pack (4)
- Wind Turbine Hub (8)
- Power Output Board (1)
- Main Body Half (6)
- Tower Base Leg (9)
- Tower Base Locking Ring (3)
- Tower Base Hub (3)
- Plastic Weightlifter Bucket (3)
- 250 ml Graduated Cylinder (1)
- Blade Pitch Protractor (3)
- 20" Wood Tower (3)
- 1/2" Washer (75)
- Small Water Pump (1)
- 12" x 1/4" Clear Tubing (1)
- 8" Hex Shaft with Hub Quick Connect (3)
- 1/4" x 5" Dowels\* (150)
- Power Output Pack\* (3)
- 3" x 12" x 3/32" Balsa Wood Sheet\* (25)
- 3" x 12" Chipboard Blade Sheet\* (50)
- 4' String\* (3)
- 8 1/2" x 11" Chipboard Sheet\* (25)

**NOTE:** Vernier products are designed for educational use. Our products are not designed nor recommended for any industrial, medical, or commercial process such as life support, patient diagnosis, control of a manufacturing process, or industrial testing of any kind.

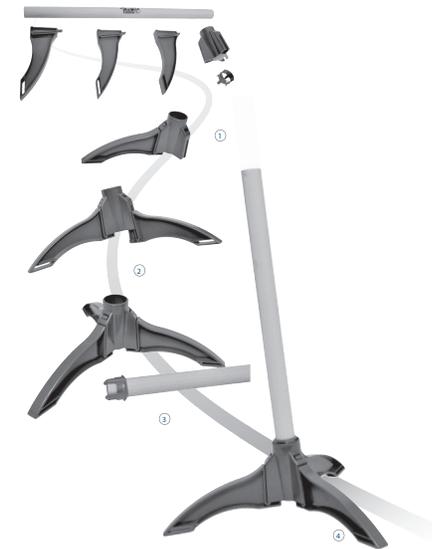
## Construction

### KidWind Tower Assembly

The turbine tower is made of six pieces:

- 1 Wood tower
- 1 Center hub
- 1 Locking disk
- 3 Legs

1. Lock one leg onto the center hub.
2. Attach the two other legs in the same way.
3. Slide the locking disc onto the tower about 6" from the bottom end. *Note: If it is a tight fit, lightly sand the tower.*
4. With the teeth of the locking disc pointing down, insert the tower into the center hub.
5. Slide the locking disc down the tower and into the hub, locking the tower in place.



To disassemble the legs, use one of your 1/4" dowels as a lever. Insert it into the gap on the leg below the hub, and push it away. The leg will pop off.

► Check out online videos for help!

For help with assembling and disassembling the tower and base, watch a short video at [www.KidWind.org/videos](http://www.KidWind.org/videos)

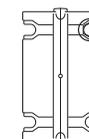
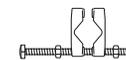
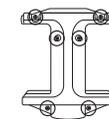
### DIY PVC Tower

A tower and base can be constructed from polyvinyl chloride (PVC) pipe.

Complete instructions are available: [www.vernier.com/tit/3198](http://www.vernier.com/tit/3198)

### Building the Nacelle

1. Fit the two identical molded nacelle parts together. Each side has three small holes. Secure the two sides together by screwing six small screws into these holes.
2. Thread a hex nut about 2/3 of the way up the 4" bolt. Next, slide the two motor mount sections up the bolt such that the two concave sections are facing each other (see picture). Then thread another hex nut onto the bolt under the mounts.
3. Notice that the top of the nacelle has cutouts shaped for the top of the bolts.

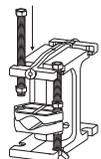


\*This part is a consumable and is excluded from the warranty.

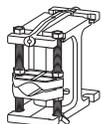
4. Slide the bolt (with nuts and mount) into the cutouts. Then attach a hex nut onto the bottom of the bolt so that it is secured to the nacelle.



5. Thread a wingnut about 1/3 of the way up the second 4" bolt. Slide that bolt into the top cutout and through the motor mounts. Thread a hex nut onto the bolt under the mounts. Thread the wingnut up the bolt so that you can slide the bolt all the way down to the bottom cut-out. Now secure the second bolt with another hex nut as you did with the first bolt.



6. Secure all the nuts and bolts so that the nacelle is tight and secure. Be careful not to over-tighten the wingnuts on the bottom of the nacelle, or you will bend the nacelle. Over tightening may not break anything, but can make your turbine less efficient.



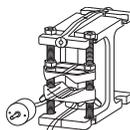
The wingnuts and hex nuts may be used interchangeably in constructing the nacelle. While wingnuts are easier to adjust, the smaller size of the hex nuts allows for more variable configurations.

► Check out online videos for help.  
For help with assembling the Advanced Wind Experiment Kit nacelle, watch a short video at [www.KidWind.org/videos](http://www.KidWind.org/videos)

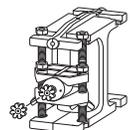
### Advanced Wind Experiment Kit Gears and Motors

1. Loosen the motor mounts on the Wind Turbine Generator or the High Torque Generator. Then tighten the nuts down onto the motor mount to hold the generator securely in place.

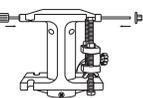
*Optional: If you are using a PVC tower, you can snake the wires from the motor through the slot in the nacelle behind the motor mount. Then the wires can go down through the PVC pipe. On a wood tower, the wires can go out the side of the nacelle. You can attach the wires to the wood tower with zip-ties or tape.*



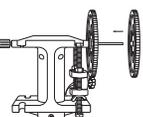
2. Attach the smallest gear (pinion) to the drive shaft of the generator. The small hole in this gear should friction fit on the generator drive shaft.



3. Slide the hex shaft with attached Hub Quick Connect into the hole at the top of the nacelle. You may need to wiggle or rotate the hexshaft as you push it in. Slip a hex lock onto the hex shaft with the collar facing the nacelle.



4. Attach the 16-, 32-, or 64-tooth gear onto the hex lock. You can choose to mount the gear on either side of the nacelle, but we recommend mounting your gears on the opposite side of the nacelle. This makes it easier to interchange gears and



manipulate the blade pitch. The final step is to move the generator up or down so that the pinion gear meshes with the gear on the hex shaft.

5. The completed nacelle will slide right onto your tower. Secure the nacelle in place by screwing in one or two more small screws in the holes at the bottom of the nacelle.

### Using the 64-Tooth Gear (Largest Ratio)

If you are using the largest gear size, you will notice that it will only fit with hex nuts under the motor mounts, as wingnuts are too tall. If you are using the smallest gear size, you will have to use hex nuts above the motor mounts. Give the hub a spin to make sure that the gear turns and rotates the small pinion gear on the motor.

### Using the 16-Tooth Gear (Smallest Ratio)

Since the 16-tooth gear is so small, it is challenging to get the generator high enough in the main body to mesh gears. In order to use this small ratio, you have to use the High Torque Generator. Remove the upper half of the motor mount and slide a small cardboard or folded paper shim in between the generator and the main body housing. You will have to adjust the width of this shim to get the gears to mesh perfectly.

Tighten the nuts below the motor mount to secure the generator in place. If the gears do not mesh well, adjust the shim.

### Hex Lock and the Hub Quick Connect

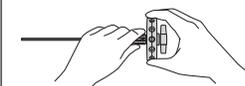
1. The hex-shaped driveshaft allows you to connect the hex lock to the driveshaft. If you mount your gears or a weightlifting spool on the back of the nacelle, the hex lock will not slip on the driveshaft.
2. The Hub Quick Connect (HQC) allows for easy removal and attachment of the hub. This enables users in busy classroom environments to change blade configurations quickly and easily.

Strong wind, large or out of balance turbine blades, and wear can make the HQC.

The HQC ships with a small screw holding the hub in place. If the hub is still slipping, adjust your blades to make sure their weight, pitch, size, and shape are all equal so that your rotor is well balanced. Push the hub in as far as you can. Glue the hub into the HQC.

*Note: The hub is designed to have a very tight fit to the Quick Connect, but if your blades are unbalanced or your turbine is not directly facing the wind, it may come loose. Be careful with blades that are out of balance.*

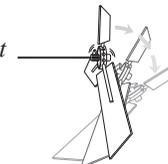
Hold the HQC with one hand, while pulling off the KidWind Hub.



Like this!



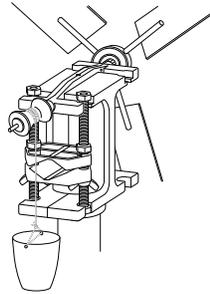
Not like this!



## Configuring the Advanced Wind Experiment Kit

### Advanced Wind Experiment Kit Weightlifter

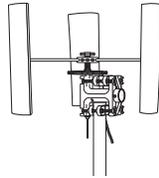
Lifting weights with the wind turbine is another great way to explore wind energy. Convert the Advanced Wind Experiment Kit to a weightlifting turbine. Remove the generator and its mount. Leave the hub and driveshaft attached to the nacelle, and push one hex lock onto the driveshaft. Push the wooden spool to lock into this hex lock, then insert the second hex lock behind the spool. The flange of the hex lock will fit inside the drilled hole of the spool. Tie and tape a string onto the spool. Attach the other end of the string securely to the cup. This cup will hold the weights; a set of metal washers are provided for this purpose.



*The Advanced Wind Experiment Kit can also be set up as a weightlifter. Compare the mechanical and electrical power of wind.*

### Vertical Axis (VAWT)

Convert the Advanced Wind Experiment Kit into a Vertical Axis Wind Turbine (VAWT). You will need two motor mounts—one on each side of the nacelle. Place the tower in the rear motor mount, and connect the gears and generator on the same side as the hub. You will have to construct different blades for your VAWT machine—like the H-rotor style shown.

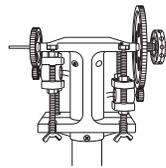


*The Advanced Wind Experiment Kit converted to a vertical axis turbine*

### The Advanced Wind Experiment Kit Dual-Generator System

The Advanced Wind Experiment Kit can be set up with a dual-generator system. If you buy another set of motor mounts and nuts and bolts (order code, KW-MTRMNT), you can attach a DC motor to the front and back of the nacelle.

The two generators can be wired in series or in parallel. If wired in series, the voltage will increase. If wired in parallel, the amperage will increase. Before connecting the generators, determine their polarity.



*The Advanced Wind Experiment Kit can be set up with two generators.*

#### ① Determine Polarity

To determine the proper polarity of the turbine, connect it to a voltage probe or a multimeter. If the voltage reading is positive, the lead connected to the red voltage probe or multimeter wire comes from the positive terminal. If the voltage reading is negative, the lead connected to the red voltage probe or multimeter wire comes from the negative terminal. It is a good idea to mark the wires with tape so you know which is positive and which is negative.

### Advanced Wind Experiment Kit GENPack Option

With the optional GENPack kit (order code, KW-GP), you can construct your own generator instead of using one of the stock generators. Explore Faraday's law, AC power generation, and electromagnetism to learn about how electricity is generated.

The GENPack fits into the Advanced Wind Experiment Kit nacelle. It includes a powerful neodymium magnet, copper magnet wire, and a housing to build your generator.

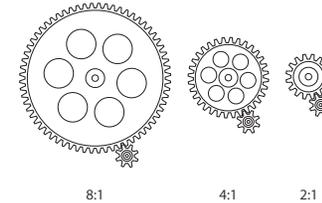
A well-constructed GENPack generator can vastly outperform the stock generators included in your kit!

### Generators

The DC generator in the wind turbine is a DC motor that spins using the energy in the wind. The magnets and wires in the generator transform the energy in the wind into electricity. By manipulating the strength of the magnets used and coils of wire inside the generator, we can affect the power output. In this kit, we provide you with two generators with different technical qualities.

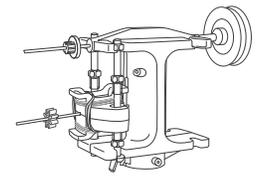
### Gear Ratios

To generate the type of electricity used every day, the generator has to spin very fast. To summarize the process, the faster the coils rotate near the magnet, the more electrons will be pushed along the wire. If you've seen a utility-scale wind turbine, you probably noticed that the blades spin pretty slowly. To get the generators to spin fast enough, they use gears. Gears give a wind turbine mechanical advantage and multiply the mechanical force of the turning blades. This is done by using gears with different numbers of teeth. When the larger gear makes one full revolution, the smaller gear has to spin faster to keep up.



*The KidWind Advanced Wind Experiment Kit offers three different gear ratios. The smallest gear attaches to the generator driveshaft and is called the pinion. The pinion gear has 8 teeth. The other three gears attach to the main hex shaft and have 16, 32, or 64 teeth.*

A “gear ratio” is the relationship between the number of teeth on two or more gears that are meshed. So when you ride your bicycle, the gear in front might have 48 teeth, while the gear in back has 16 teeth. That would mean every time your pedals spin around once, the back wheel spins three revolutions ( $48 \div 16 = 3$ ). This is called a 3 to 1 (3:1) gear ratio. Wind turbines work the same way except that they have much larger gear ratios. A modern wind turbine may have a gear ratio of



*Adding the GENPack expands the experimental value of the Advanced Wind Experiment Kit*

100:1 or more. So every time the blades make one revolution, the generator shaft spins 100 times.

► Check out online videos for help.

For help setting up your Advanced Wind Kit gears, check out a short video on the subject at [www.KidWind.org/videos](http://www.KidWind.org/videos)

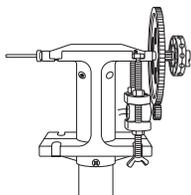
## Troubleshooting

### Why won't the rotor spin when I put my turbine in front of the fan?

Check the orientation of the blades. Are the blades oriented in the same direction? Are they flat? Are they hitting the tower? Look at some pictures of windmills to get some ideas about how to orient the blades.

### Why does the gearbox seem to turn slowly or feel stiff?

The addition of the gearbox adds some friction to the system. Because of this, you will need to make sure that the blades generate enough torque (turning force) to overcome this friction. You can also adjust the generator (move it up or down) to make sure the gears are meshing well. Make sure they are not too tight or too loose.



*If you are mounting your gear at the front of the nacelle, slide the Hex Lock and your gear up the driveshaft right behind the hub, as shown in the picture. Again, be sure to line up the main drive gear with the pinion attached to your generator.*

### Why does the turbine slow down when I attach it to a load (resistor, pump, bulb, motor)?

Electrical loads all have some resistance. Resistance “resists” the flow of current. This makes it harder to push electrons through the circuit. The more load that is added, the harder it is for the generator to turn, and the more torque must be generated from the blades. The best ways to do this are to increase blade pitch, make bigger blades, or find stronger wind.

### Why are the voltage readings all over the place?

Readings may fluctuate because the wind coming out of the fan is fluctuating. This can also be caused by blades that do not spin smoothly or change shape as they spin. Additionally, readings will be irregular if the blades are not balanced, evenly distributed, or are producing unequal amounts of drag.

### Is a fan a good wind source to test with?

While a fan will make a turbine spin, it is not exactly like the wind outside. The wind that comes out of a fan has a great deal of rotation and turbulence. It isn't very smooth. To see this turbulence, hold a short piece of thread in front of a fan and move it from the center out. It should head out straight all the time. Does it?

### Can I take my turbine outside? Can I leave it there?

You can certainly take, use, and test your wind turbine outside. But unless you have a yawing tower, it will not track the wind and may not perform optimally. To make it work well, you will have to continually face it into the wind. It is not a good idea to leave your turbine outside for too long. It is designed for basic lab tests, not to endure the rigors of the outdoor environment.

### Based on the power in the wind equation, it seems that longer blades should make more power. Why isn't this true on my turbine?

The blades on your turbine may be bigger than the diameter of the fan. If that is the case, the extra length is only adding drag so the blades will slow down. Additionally, large blades are designed poorly, they will have lots of drag near the tips and slow down. This will negate any positive effect of the added length. Also, short blades spin faster than long ones, so if you are just recording voltage they will seem better. Try short blades with a load in series and see if they have enough torque to spin. In many cases they do not.

### My tower is rocking or falling over. How can I stabilize it?

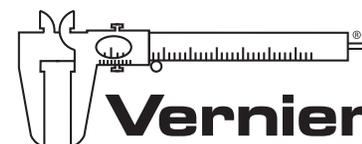
If your rotor is very large, a strong wind may force your tower to wobble or fall. Try taping the tower base to the floor or to the lab table. Weighting the base with sandbags or other weights can also help.

## Additional Resources

For more information about wind energy, see KidWind's document, *Learn Wind*, available at [http://learn.kidwind.org/sites/default/files/learn\\_wind.pdf](http://learn.kidwind.org/sites/default/files/learn_wind.pdf)

## Warranty

This kit contains many parts. The Generator and the High Torque Generator are warranted to be free from defects in materials and workmanship for a period one year from the date of shipment to the customer. Other parts in the kit, excluding consumables, are warranted for a period of five years. Consumables are clearly marked on Page 1 of the user manual.



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Vernier Software & Technology

13979 S. W. Millikan Way • Beaverton, OR 97005-2886

Toll Free (888) 837-6437 • (503) 277-2299 • FAX (503) 277-2440

[info@vernier.com](mailto:info@vernier.com) • [www.vernier.com](http://www.vernier.com)

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