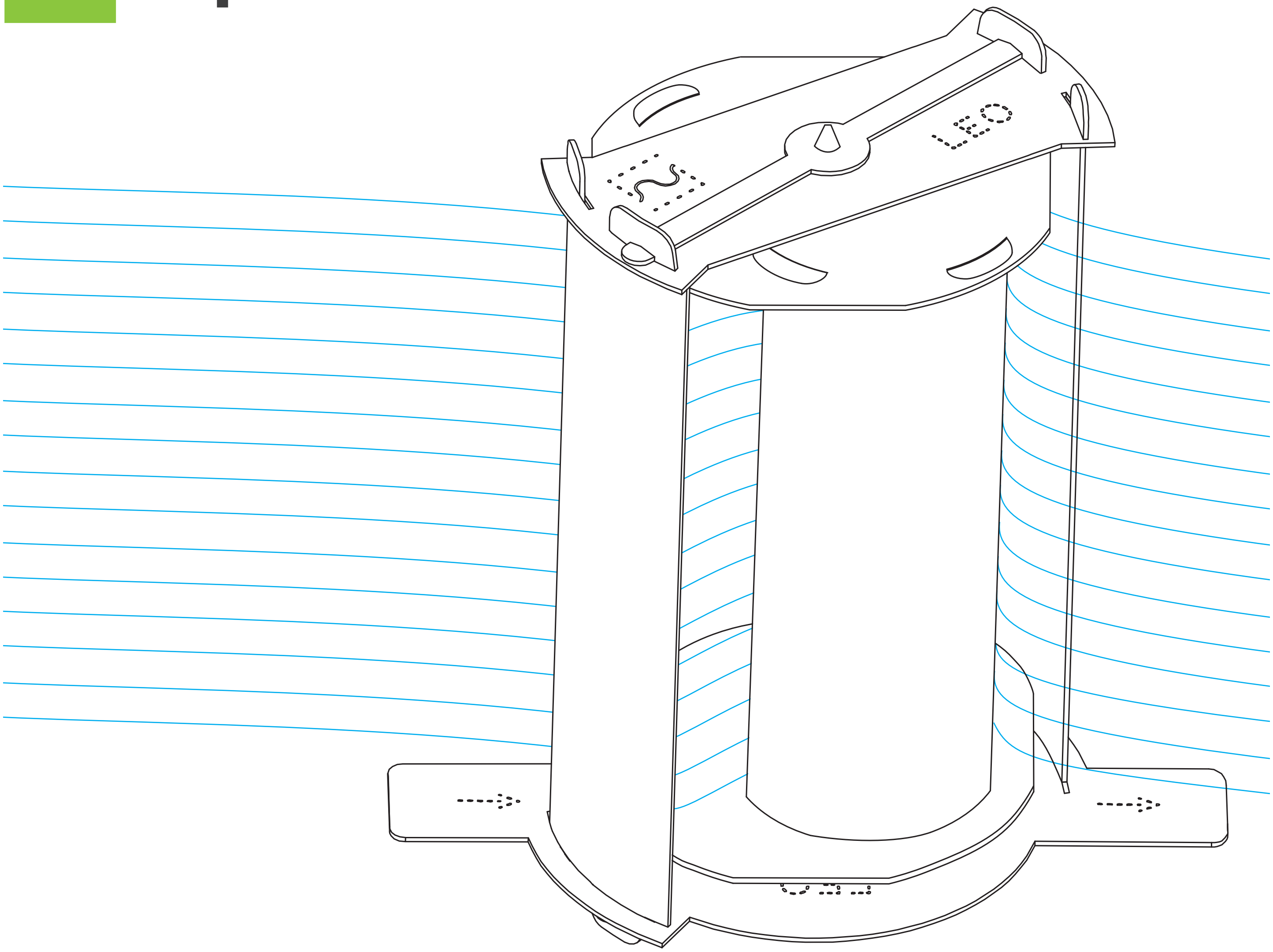
squaresine[SM]



LEO Turbine™

Vertical Axis Wind Turbine Kit

Assembly and Activity Guide

Kit Version: 22E

Updated: January 23rd 2011

http://squaresine.com

About squaresine[SM]

squaresine, LLC was founded by Scott A. Hanneman, a graduate of the University of Wisconsin-Stout with a B.S. in Technology Education. Scott's passion for electricity and electronics influenced his drive to provide low-cost, meaningful, hands-on opportunities for his students, allowing them to engage and apply math and science in a fun and relevant manner.

squaresine is always looking for more help from educators interested in creating new opportunities for students to engage electricity and electronics by sharing ideas, lesson plans, and more. Please visit our website, http://squaresine.com, or email scott at scott@squaresine.com.

Note on Reproduction

The design of the LEO and LEO+ Turbine kits are patent pending.

About LEO Turbine

The LEO (Learning Engagement Opportunity) Turbine™ is a savonius-based vertical-axis turbine kit designed to be a low-cost solution to provide students with a meaningful, hands-on opportunity to experience wind energy. The LEO Turbine™ has been used by students from 5th grade through higher education. The LEO Turbine can be assembled in less than five minutes without the use of tools or adhesives. It can be set in motion when provided with a source of wind (such as blowing on it, a windy day outdoors, or a table fan). It is small enough to be placed within common educational wind tunnels, and if necessary, can be disassembled into a flat state for storage. As the kit is designed to be recyclable, it may not be durable enough for heavier use exceeding one or two class periods.

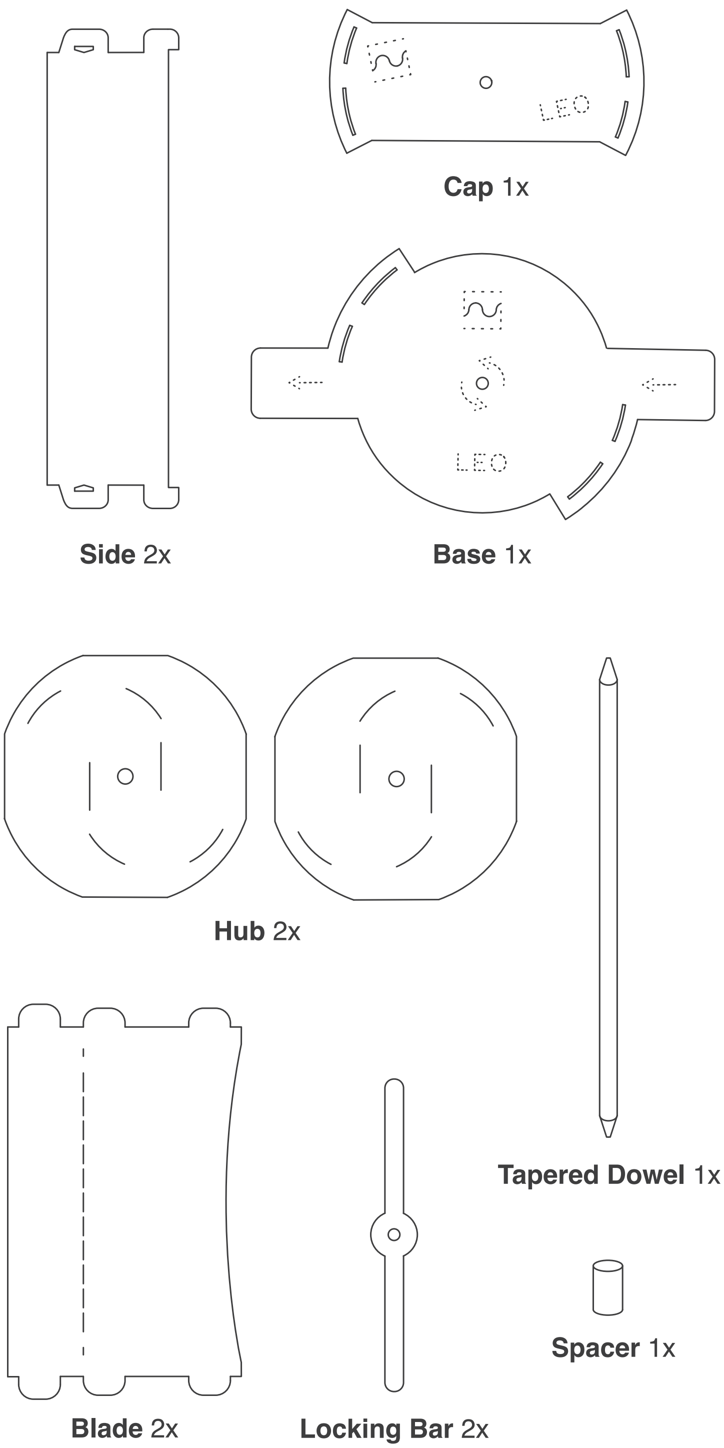
The LEO Turbine is a non-electric turbine without electricity generating capacity. squaresine offers a more advanced model called the LEO+ Turbine,™ a similar small-scale turbine with the ability to produce alternating current electrical output. The LEO+ Turbine includes the added opportunities of experiencing magnetism, induction, alternating current, Faraday's Law, Lenz's law, series/parallel circuits, and more.

⚠ Safety Considerations

The LEO Turbine was designed with the goal of being assembled without the use of hand tools in order to create a safer experience for students.

To ensure the most safest possible enviroment for students, it is important to note that responsible adult supervision and the use eye protection is always required. Also, the kit may contain small parts that could be a choking hazard; kit is not intended for students younger than 5th grade.

Kit Contents



Part List (12 Total)

- 1 Cap
- 1 Base
- 2 Sides
- 2 Hubs
- 2 Blades
- 2 Locking Bar
- 1 Tapered Dowel
- 1 Spacer

Please Note:

Each LEO Turbine Kit is packaged in a paper envelope featuring a simple illustrated assembly instructions, making it easy to share with students. The envelope can also be use to store kit parts after initial use.

The majority of parts are grouped on a single sheet of chipboard and must be punched out for assembly.

Damaged or Missing Part?

We continuously strive to achieve the best quality for our kits, and personally inspect each part as we package it. If you have a damaged or missing part, please email support@squaresine.com for a replacement.

Assembly and Setup Instructions

Before beginning assembly, please note that a list of kit parts is located on the previous page. Ensure that all required parts are present.

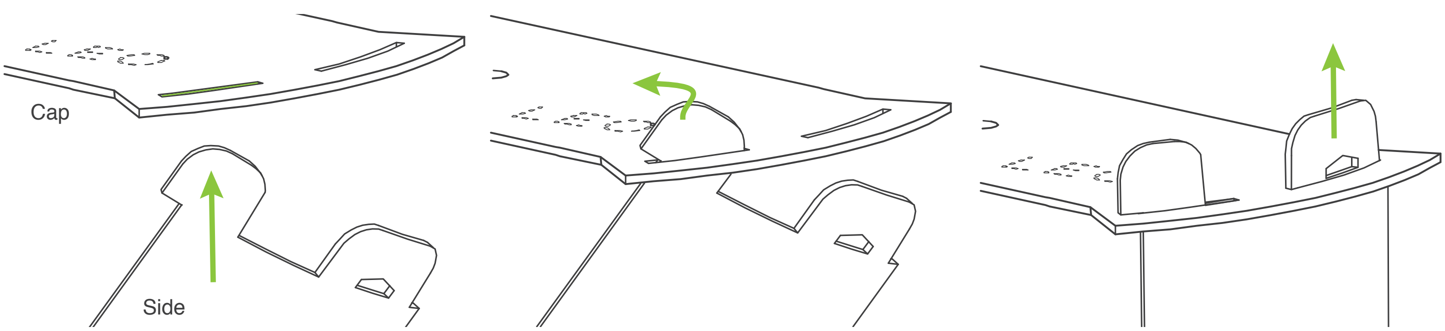
- Pages 5-9 detail the construction of the LEO Turbine
- Pages 10-15 detail the recommended use of the LEO Turbine
- Page 16 features troubleshooting information

A video of the assembly and setup process, illustrations, PDFs, PowerPoints, lesson plans, and more, can be found at http://squaresine.com.

Please read and fully understand all safety considerations (page 3) before assembling or using this kit.

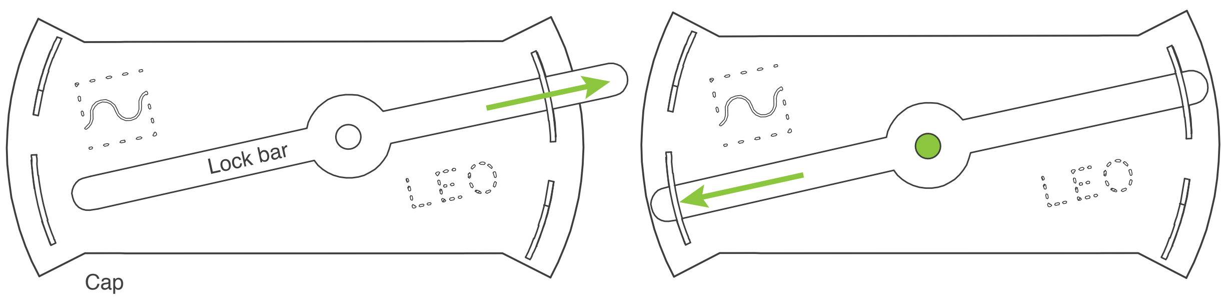
STEP 1

Frame Assembly: Locate the cap and one side component. Insert one set of side tabs into slots located on the cap, with the text LEO facing away. Slide the hook tab fully in and over before inserting the slotted tab. You may need to pull the slotted tab to fully insert it. Repeat the process with the remaining side component and slots on the cap.



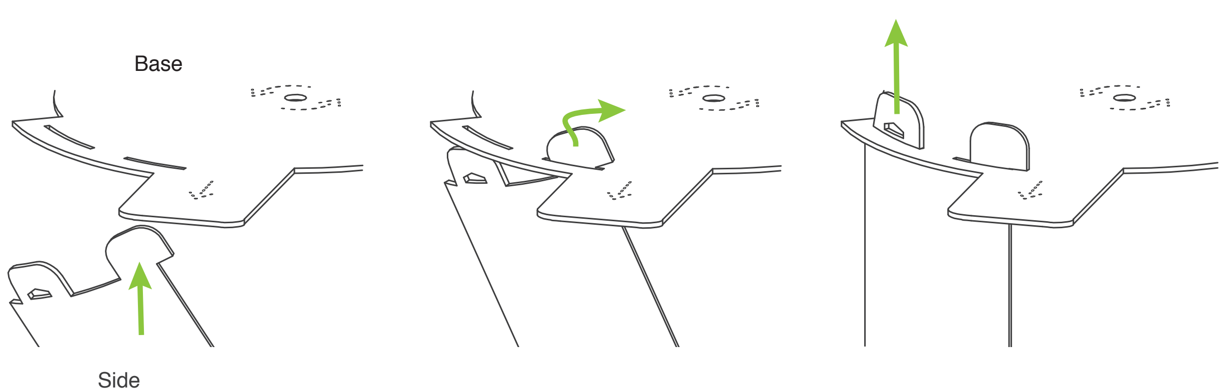
STEP
2

Next, locate a lock bar. Insert each end of the lock bar through the slots in the slotted tabs, then align the center holes of the lock bar and the cap.



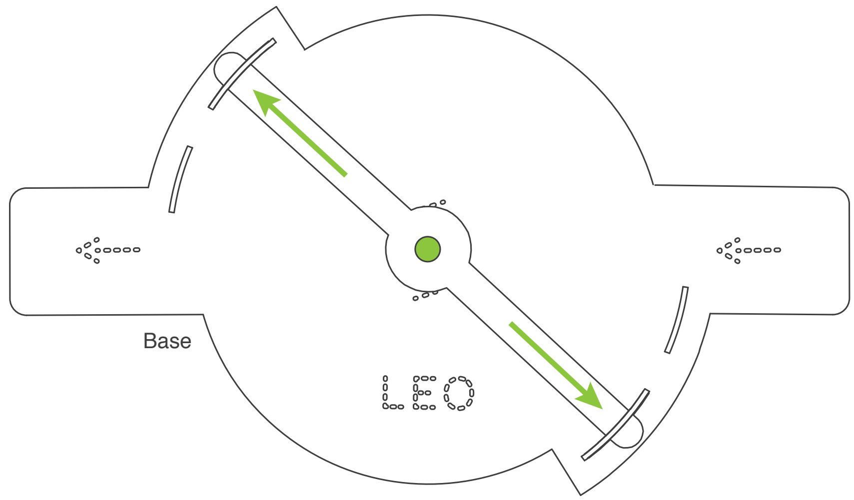
STEP
3

Locate the base component. Insert one set of side tabs into a set of slots located on the base, with the text LEO facing away. Slide the hook tab in and over before inserting the slotted tab. You may need to pull the slotted tab to fully insert it. Repeat the process with the remaining side component and the open set of slots on the base.



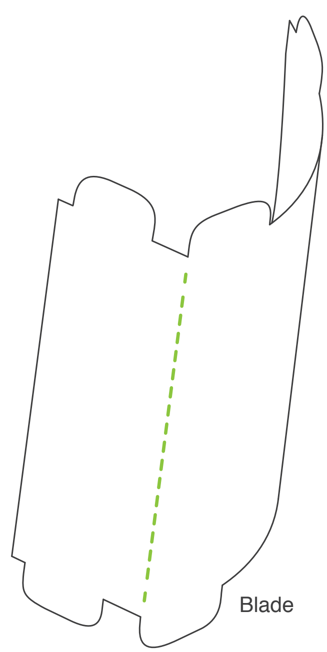
STEP
4

Next, locate a lock bar. Insert each end of the lock bar through the slots in the slotted tabs, then align the center holes of the lock bar and the base.



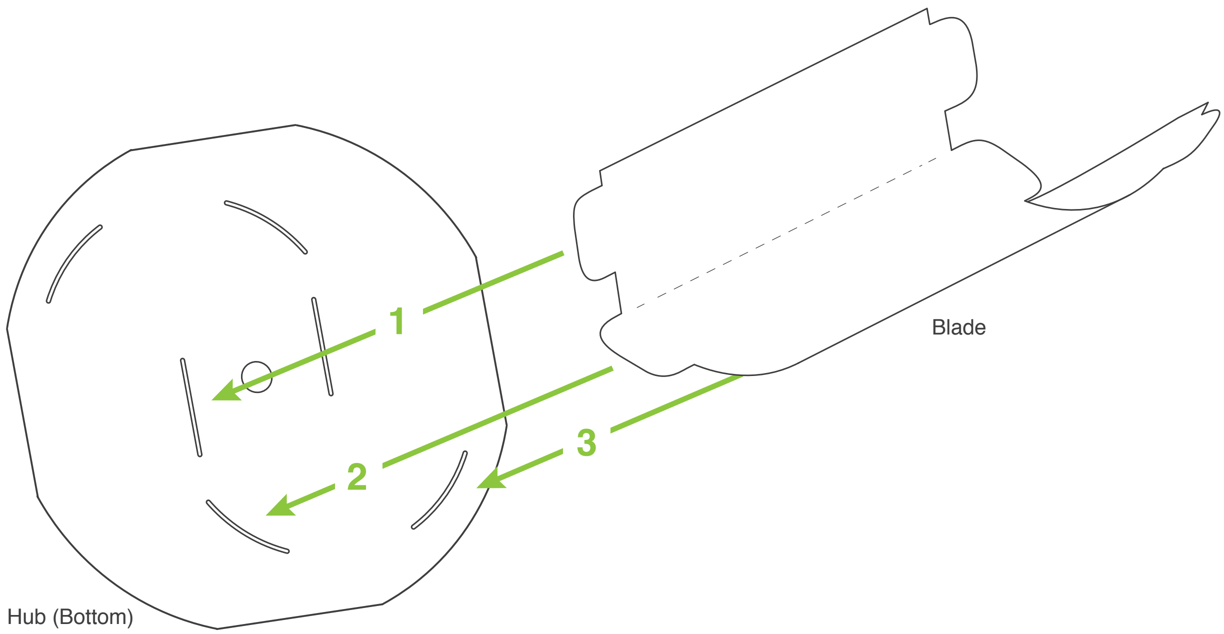
STEP
5

Hub & Blade Assembly:
Locate the two blades. Fold each blade along the perforation.



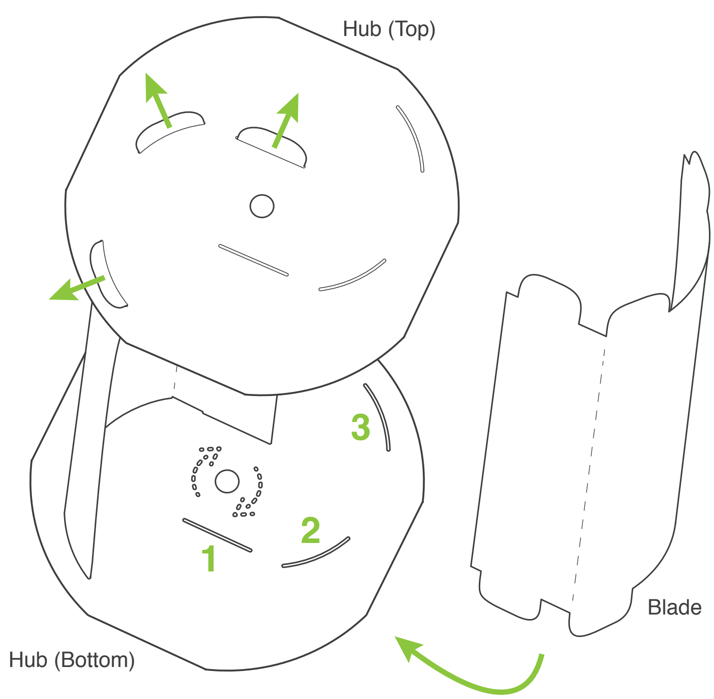
STEP 6

Next, locate the two hubs. Begin by inserting the end of one blade into the **bold** side of a hub (the side with darker, thicker holes), as illustrated, moving from the center outward. Once the tabs have been inserted, firmly pull on them, then fold them flat, away from the center. Insert the other end of the blade into the **bold** side of other hub in the same manner.



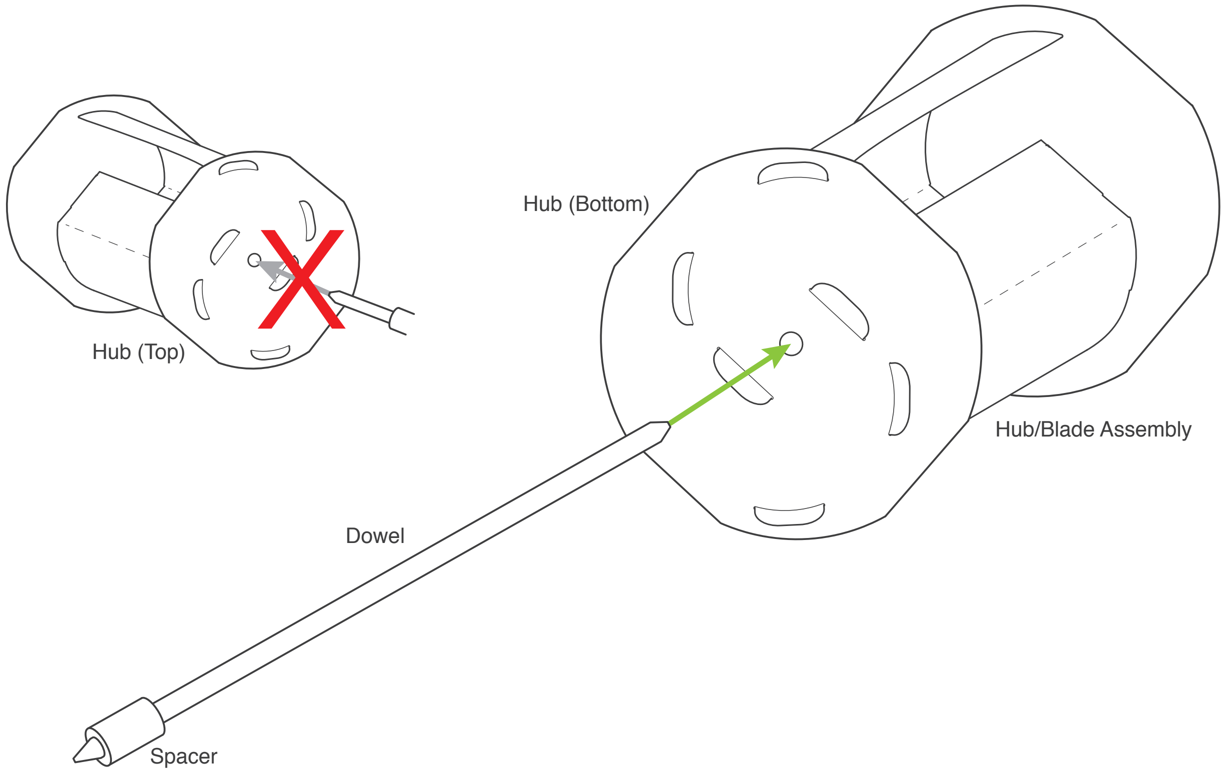
STEP 7

Next, repeat the process for the second blade. Remember to insert tabs from the center outward and firmly pull on them while folding them flat away from the center.



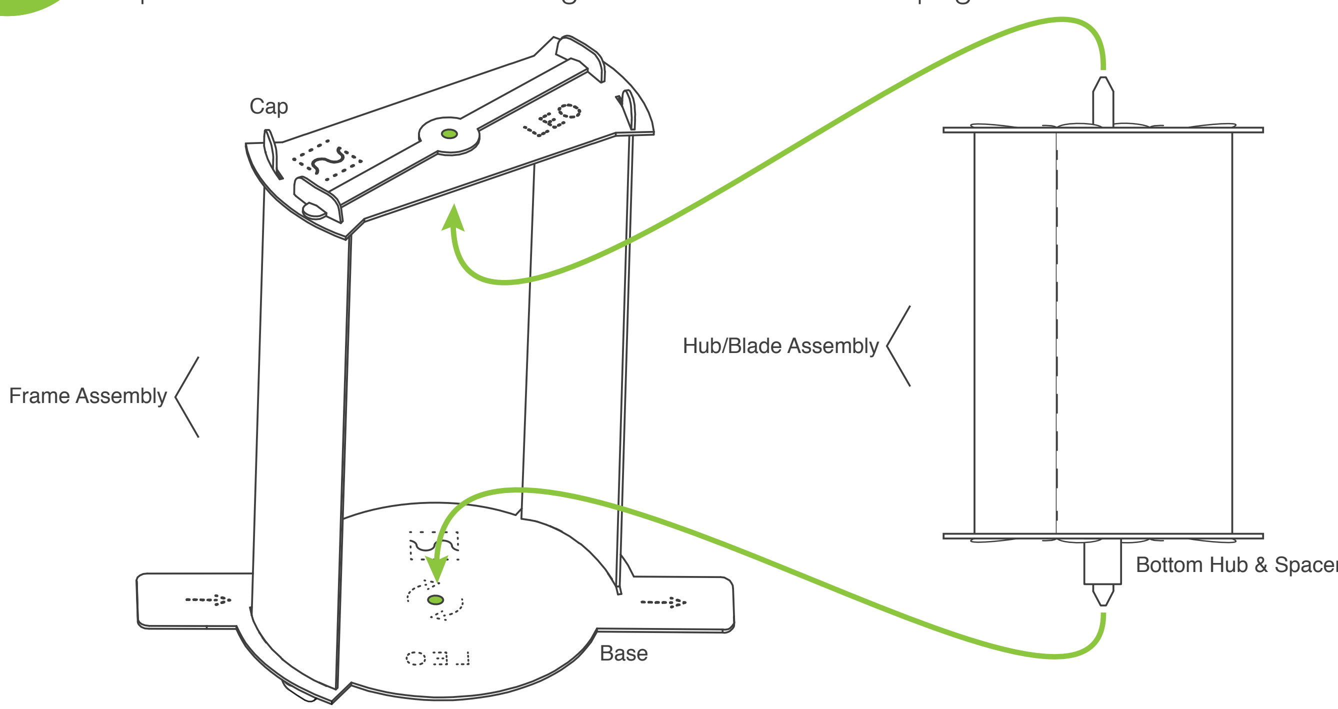
STEP 8

Locate the tapered dowel and spacer. Insert the dowel through the center holes on the top and bottom hubs. The spacer should be placed on the dowel below the bottom hub. The bottom hub can be identified by the **S** shape, (created by the blade tabs as viewed from the outside) and not the "2" shape created by the top hub.



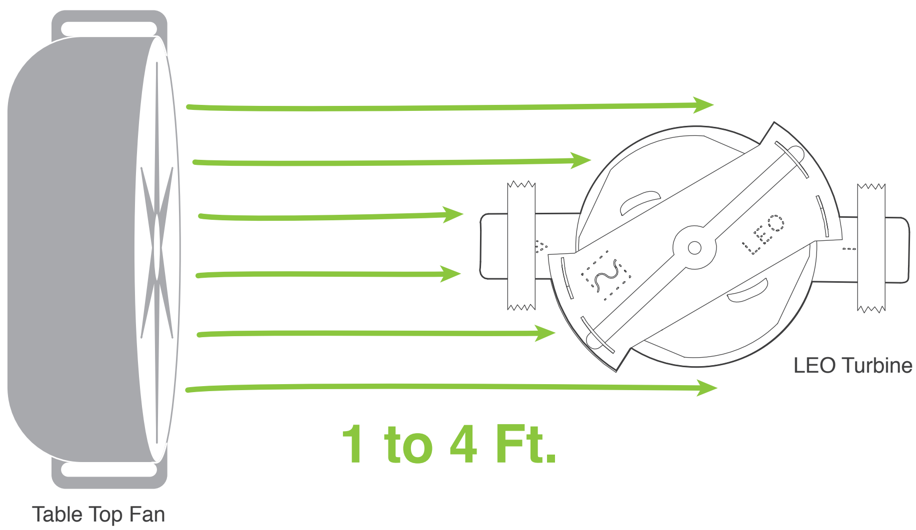
STEP 9

Insert the hub/blade assembly into the frame assembly by inserting the ends of the dowel into the center holes located on the cap and base. Congratulations! You have finished assembling the LEO Turbine. It should now spin if you blow into it. If not, please see the troubleshooting information located on page 16.



Recommended Use

For basic experimentation with your completed LEO Turbine, we suggest that you place it one to four feet away from the front of a table top fan. Two to three turbines should be able to share a single fan during classroom use. If necessary, use text-books to raise the height of the turbine and center it with the fan. Use masking tape to secure the bottom of the turbine to a sturdy surface. The tabs on the base should be parallel with the most efficient wind direction.



If you are looking for ideas on what type of fan to use, we prefer the "Table Top Air Circulator Fan" by Honeywell. It can be found both online and in stores such as Walmart and Target for approximately $10-20. *Model number: HT-800 / HT-904*

Use in Wind Tunnels

One advantage of the LEO Turbine's compact size is that it can be used in experiments with common educational wind tunnels. *Wind tunnels must have variable speed adjustment and should be opperated at no higher than 15 mph. Tubine must be properly secured to a sturdy surface. Please check the wind tunnel's internal chamber measurements to ensure proper fit of the LEO Turbine.* LEO Turbines measure approximately 5 in. long by 3.25 in. wide and 5.25 in. tall. You may also want to try the LEO+ Turbine Kit, as its electrical generation capability allows you to quantify/observe its output.

ACTIVITY A

Changing Wind Speed

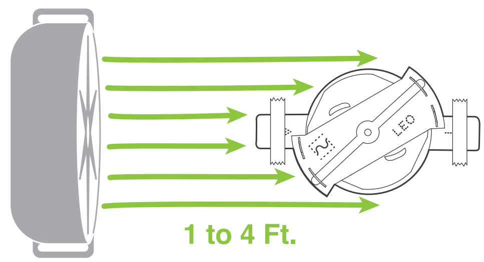
Wind is naturally caused by the uneven heating of the earth's surface by the sun. The heating is uneven due to many factors including ground type (such as land or water) cloud cover, and the earth's rotation. When an area of the earth is warmer, the gases in the atmosphere expand, resulting in a higher pressure. Higher and lower pressure areas want to balance out to be the same pressure. Therefore, wind is the movement of air as it flows from high to low pressure areas. Turbines require certain amounts of wind in order to perform work. We can apply different amounts of wind to the LEO Turbine and observe the amount of turbine rotation that is produced.

Resources:

Table Top Fan (optional)

Masking Tape (optional)

Wind Speed Meter (optional)



Setup:

If you choose not to use a fan, make sure students are instructed to take turns blowing on the turbine and/or take frequent breaks before becoming light-headed.

The distance from the wind source should remain constant throughout this entire activity. It is suggested that the turbine be mounted with masking tape to a secure surface. The tabs on the base should be parallel with the most efficient wind direction.

Procedure:

By changing the speed of the fan, or by moving the turbine closer or farther from the wind source, observe how the turbine reacts to a change in wind speed. Try blowing as lightly as possible, then slowly increasing the intensity until the turbine begins to move. If you have access to a wind speed meter, use it to quantify your observations.

Questions:

What happens to the turbine when it is subjected to faster or slower wind speeds?

Is there a minimum wind speed required for the turbine to move?

ACTIVITY **B**

Changing Wind Direction to Examine the Savonius Turbine

The LEO Turbine is considered to be a *Savonius* or *drag-type* turbine, since it utilizes drag (scoops) in contrast to using lift (wings) as its means for producing mechanical motion from the wind. The turbine blades can be thought of as scoops that are pushed by the wind to produce motion. We can change the wind direction applied to the turbine to help us observe how its design converts the kinetic motion of the wind into rotary mechanical motion.

Resources:

"Changing Wind Direction - Activity B" Handout (one per kit)
Masking Tape
Table Top Fan (optional)

Setup:

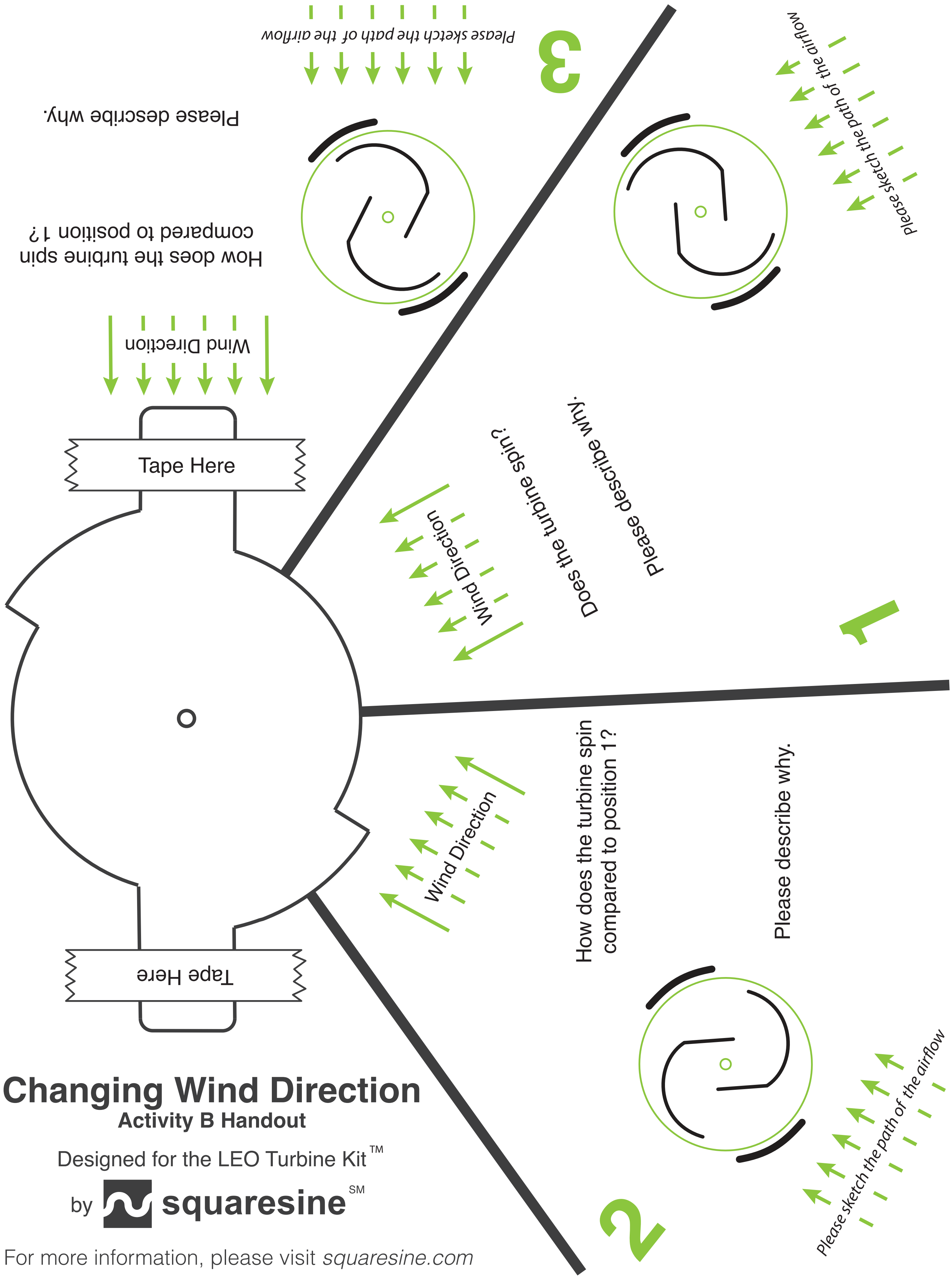
The wind speed and distance from fan should remain constant throughout this entire activity. It is suggested that the turbine be mounted with masking tape to the "Changing Wind Direction - Activity B" handout (located on page 13).

Procedure:

Record observations of the turbine's performance as it is subjected to three different angles of wind direction. For each angle, you will answer two questions and sketch the path that you believe the air (represented by six arrows) is flowing as it interacts with the turbine.

Angle 1: The turbine should spin at a moderate speed. When explaining how the wind interacts with the turbine, please examine the answer located on the activity follow-up page (page 14). Teachers should share and explain the observations for Angle 1 before continuing, and it is suggested not to reveal the results for Angles 2 and 3 until students have finished recording all observations.

Next, continue to experiment with Angles 2 and 3 and record your observations. Once you have finished, please review the explanations located on the follow-up page (page 14).



Changing Wind Direction

Activity B Handout

Designed for the LEO Turbine Kit™

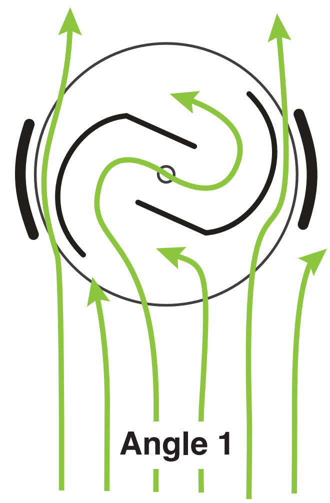
by squaresine℠

For more information, please visit *squaresine.com*

Follow-Up

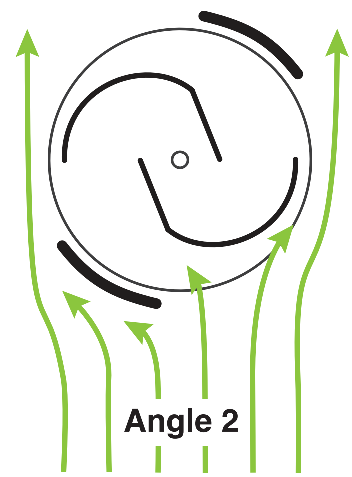
Angle 1:

The LEO Turbine uses a Savonius turbine design. Most Savonius turbines do not have any surrounding sides like the LEO; instead, they support the turbine solely by its central shaft (dowel). Angle 1 places the side components out of the path of the wind, allowing the LEO to represent convential Savonius turbines. As illustrated below, wind enters the forward opening (scoop) in the blades and pushes against it, resulting in rotation. In additon, some of the wind travels through the channel in the middle of the turbine and exits through the other side, creating a small amount of thrust. This thrust aids in rotating the blades.



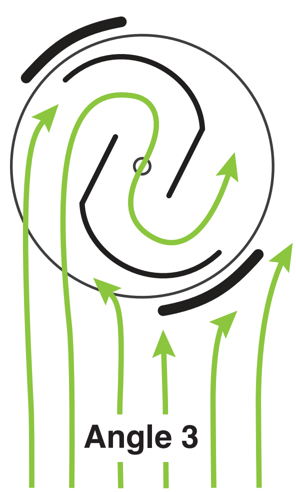
Angle 2:

In Angle 2, a side component of the kit blocks part of the wind. This prevents the wind from entering the opening (scoop) of the Savonius turbine. As you can observe, this causes the turbine not to experience the same rotation as in Angle 1. The turbine may "wobble" back and forth due to wind pushing against the outward part of the blade.



Angle 3:

Angle 3 allows the turbine to rotate the most efficently (fastest) by decreasing the resistance created by wind pushing against the outside of the blade. Looking back at Angle 2, wind pushing against the outward part of the blade resulted in the "wobbling" that pushed the turbine backwards. In Angle 3, this resistance is blocked by the closest side component. In addition, the farthest side component directs some wind into the turbine as it completes its rotation, allowing more force to be applied.



Going Beyond

Once you have experimented with your LEO Turbine kit, we encourage you to explore it further. Listed below are just a few of the ideas that you could try out. Please share your creations and discoveries with others at squaresine.com.

- Take the Turbine outside
- See how fast you can make the LEO turbine spin
- Modify the turbine blades or make your own
- Try making the sides of the kit larger or smaller
- Modify the kit to work sideways or upside down
- Use pipe cleaners to model how the airflow interacts with the turbine

Recycling Kits

The LEO Turbine is designed to be recyclable. Please consider sending the spacer from your kit back to us so we can use it in future kits and prevent it from ending up in a landfill. The remaing portions of the LEO Turbine kit can be easily recycled with common paper-recycling collections.

Spacers can be mailed to our manufacturer at the following address:

Attn: LEO Turbine Kit Recycling
KidWind Project
800 Transfer Rd., Ste 30B
Saint Paul, MN 55114

Troubleshooting

If you are having difficulty assembling or using your LEO Turbine, please review the troubleshooting tips listed below:

- Ensure the blade/hub assembly has not been installed upside down; bottom hub (identified by "S" shape as viewed from outside) should be located next to spacer and base. If necessary, flip blade/hub assembly over and reinstall.

- Ensure the blades have been inserted into the **bold** side of each hub.

- Ensure the spacer is located on the dowel between the bottom hub (identified by "S" shape as viewed from outside) and the base of the kit.

- If you have trouble inserting tabs, try inserting them one at a time.

- If a tab will not fully insert, try to pull it into place from the other side.

If you have any questions or concerns, please e-mail *support@squaresine.com.*