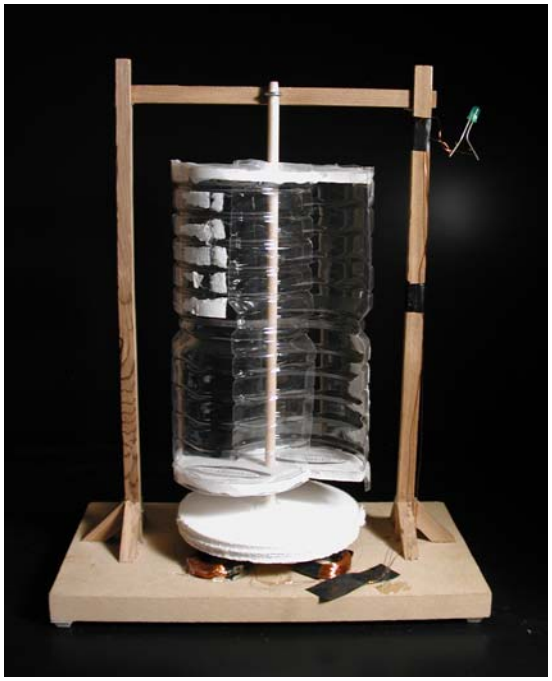


Build Your Own

Wind Turbine

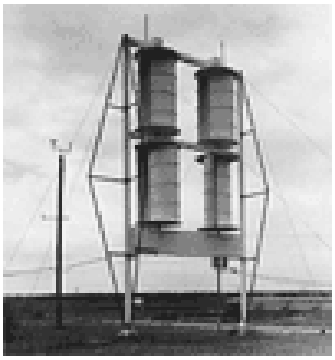
Designed by Dave Mussell

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Introduction

The Savonius Wind Turbine



These plans are for the construction of vertical axis wind turbine, modelled after a design by the Finnish engineer S.J. Savonius in 1922. His idea was to mount two half-cylinders on a vertical shaft. It was simple to build, and could accept wind from any direction. However, it was somewhat less efficient than the more common horizontal axis turbine. The reason for the difference has to do with aerodynamics. Horizontal axis turbines have blades that create lift to spin the rotor, whereas the vertical axis design we are using here operates on the basis of drag—one side creates more drag in moving air than the other, causing the shaft spin.

Permanent Magnet Alternator

This wind turbine model makes its electricity with a simple generator which produces pulses of current, or alternating current. It does so by passing strong magnets over coils of fine wire. Each time a magnet passes over a coil, the coil becomes energized with electricity. With 4 coils connected together in series, the result is a quadrupling of the voltage.

This is the simplest and possibly most efficient way to generate electricity, and is the same basic principle used in almost all wind turbines, even the large scale commercial ones. The electricity from a wind turbine varies with the wind speed, so to make practical use of it, you must be able to store it in batteries, or change it into a form that gives a stable, constant voltage. Usually, electricity from wind turbines is converted from alternating current to direct current, which can be used for battery charging. You can find plans on the Internet for simple electronic devices called ***bridge rectifiers***. Bridge rectifiers consist of just 4 diodes, and can be made for just a few dollars.

Safety Precautions

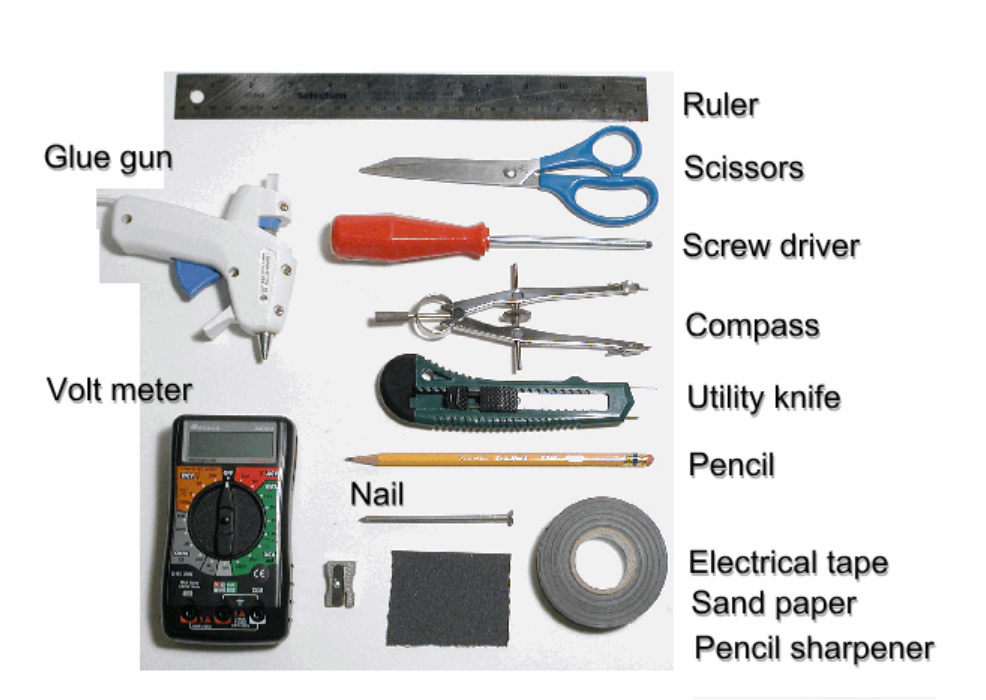
- Utility knives and scissors can be dangerous! Use caution when cutting materials using them. The blades of most utility knives can be extended and locked in place. Extend the blades only far enough to cut all the way through the material, no farther. Be sure they are locked in position while cutting.
- Hot glue guns can cause serious burns, as can the glue if it comes in contact with your skin.
- The magnets you will be using can cause serious damage to computers or other electronic devices. Be sure to keep them away from credit cards, computer disks, audio tapes, or any other materials on which information is stored magnetically.



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Build It!

Tools



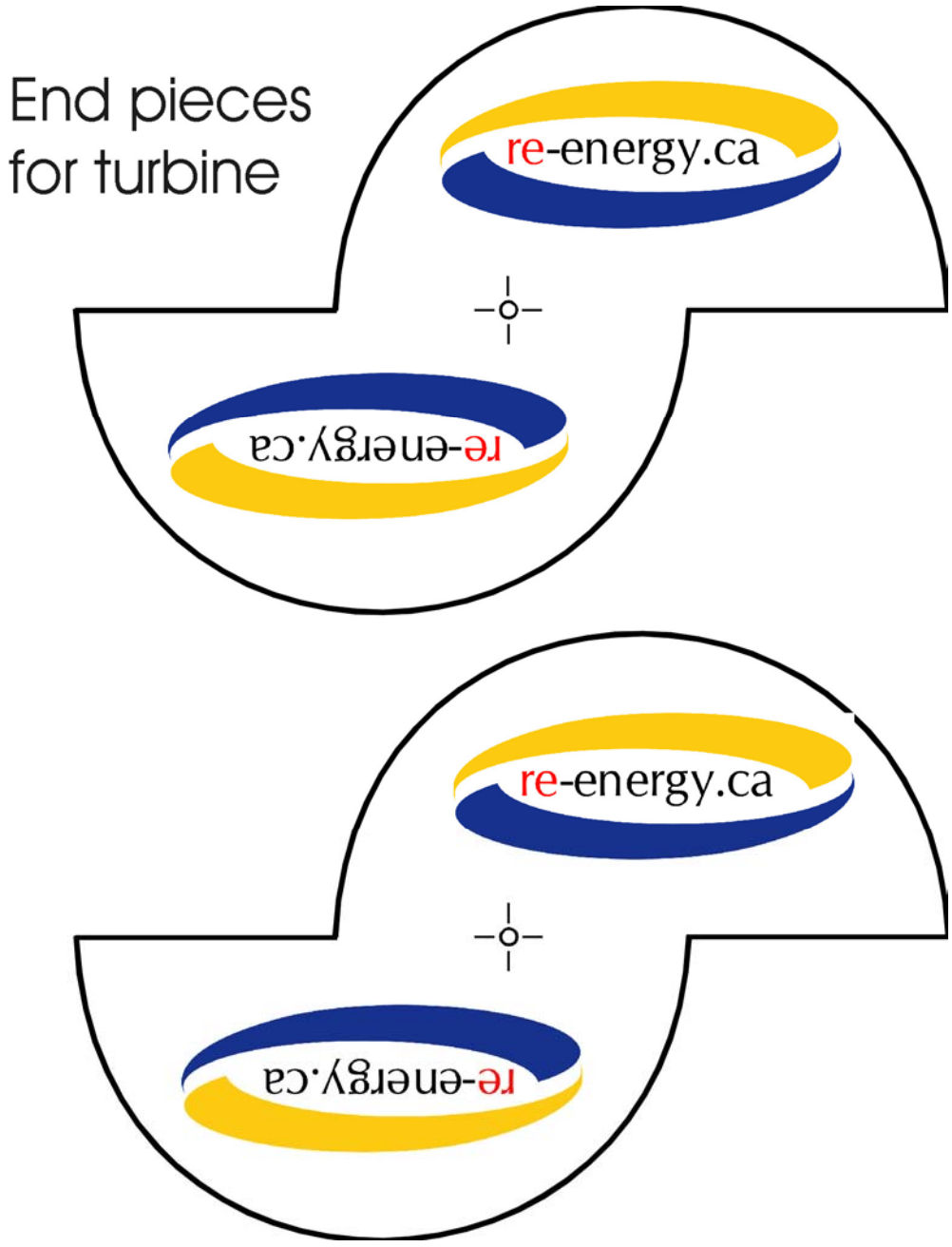
Materials

Quantity	Item	Sources
1	Clear plastic water bottle, 1.5L size	Grocery and convenience stores, recycling bins
1	Base 14cm by 25cm, 2cm thick, plywood, particle board, or lumber (1x6)	Hardware or home improvement store, or wood scraps
120m (approx.)	28 gage enamelled magnet wire	Electric motor repair shops, electrical supply houses.
4	Rare earth disk magnets (2-2.5cm dia.)	Lee Valley Tools (www.leevalleytools.com); eBay.
80 to 100cm	Square dowels: 2 pcs. 30cm long, and 1 piece 20cm long	Most hardware and home improvement stores.
1	Round wooden dowel (6mm or ¼") 30 cm long	Hardware or home improvement store.
1	Light emitting diode (LED 5mm size,	Electronics supply store (in Canada: The Source / Circuit City)
4	Fender washers (3cm diameter)	Hardware store
1	Wood screw (#8, 5/8ths inch, square recess)	Hardware store
1	Screw eye (25mm or 7/8")	Hardware store
1	Corrugated cardboard or foamboard, 60 cm by 20 cm (approximately)	Recycling bin or stationery store, or art supply store.
6	Braces (3cm pieces of square dowel, both ends cut at 45 degrees)	Cut from a short length of square dowel, or substitute other material. For supporting the uprights.
1	White glue (small bottle)	Stationery or hardware store

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Templates

Instructions: glue this page to cardboard and cut out the shapes with utility knife.



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Construction Steps

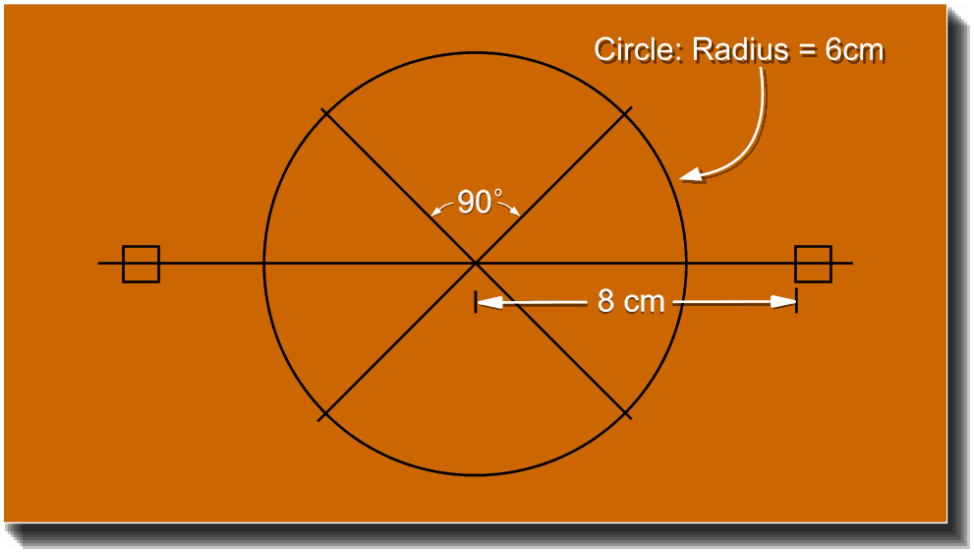
Part A. Frame and Base

For this part, you will need:

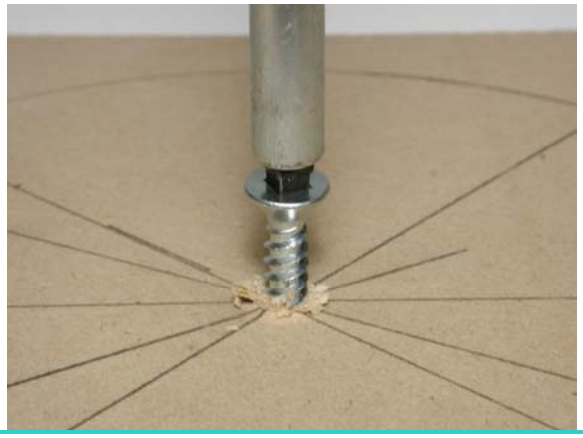
Tools:
- Hot glue gun, glue sticks
- Pencil sharpener
- Screw driver
- Ruler
- Compass

Materials:
- Base board (14cm x 25cm)
- Uprights (30 cm square dowel, 2 pieces)
- Crossbar (20cm square dowel, 1 piece)
- Screw
- Braces
- Round Dowel

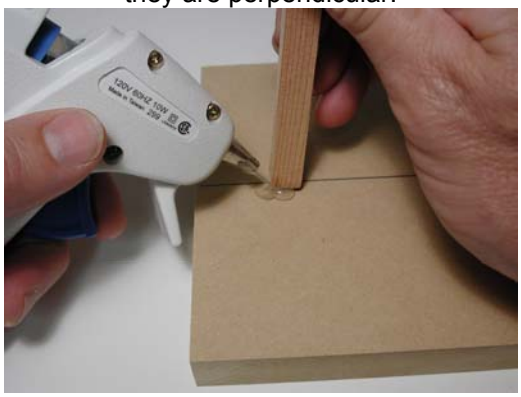
1. Use a pencil, ruler, and compass to mark the base board according to the dimensions in the diagram below:



2. Drive the screw into the center point of the base board.



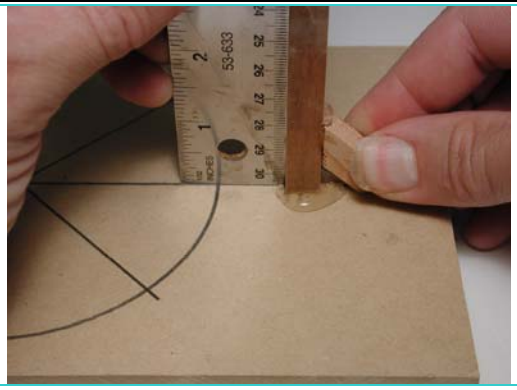
3. Using hot glue, fasten the 30 cm long square dowels to the frame as shown. Use a ruler or square to ensure they are perpendicular.

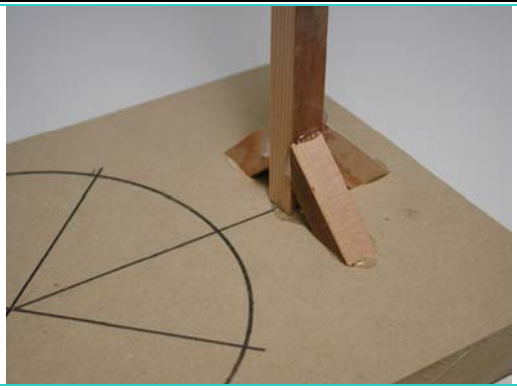


4. Add braces to support the frame, as shown.

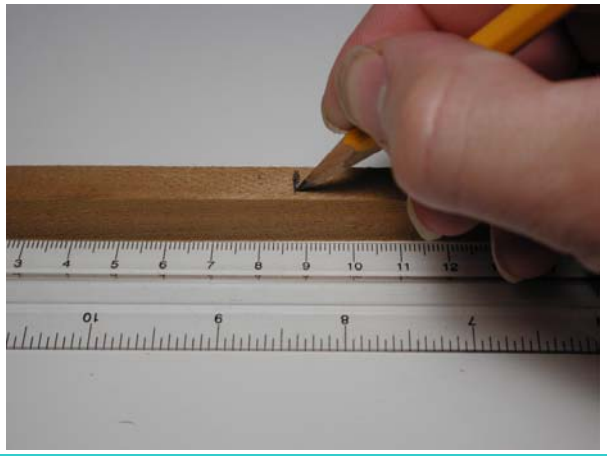
5. A fully braced upright.

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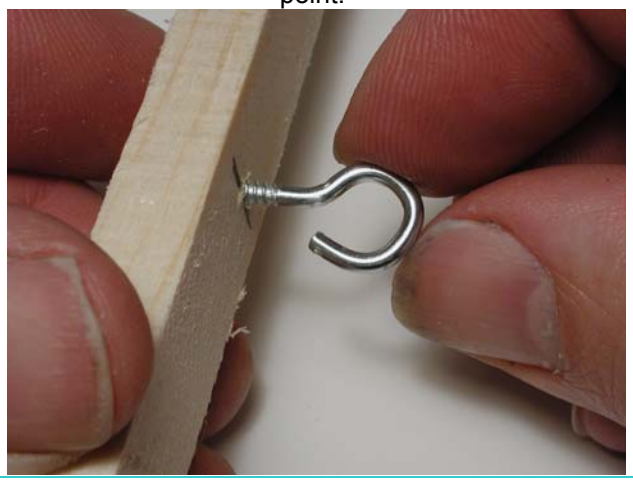
6. Using the ruler, find and mark the center of the cross bar.



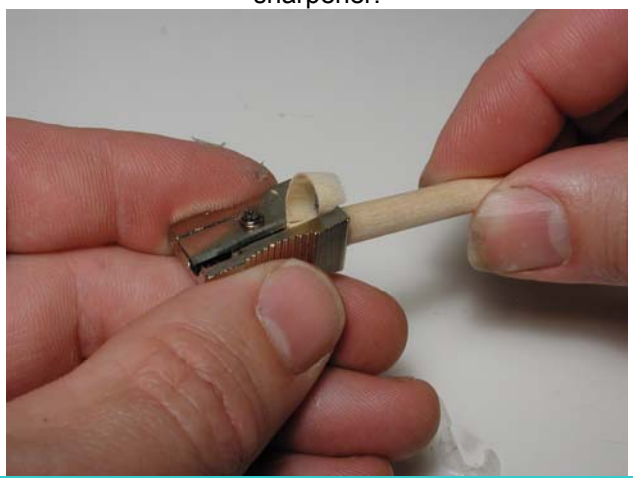
7. Test the dowel in the screw eye for fit. It should be loose, but with little play. Resize the screw eye as necessary.



8. Turn the screw eye into the cross bar at the center point.

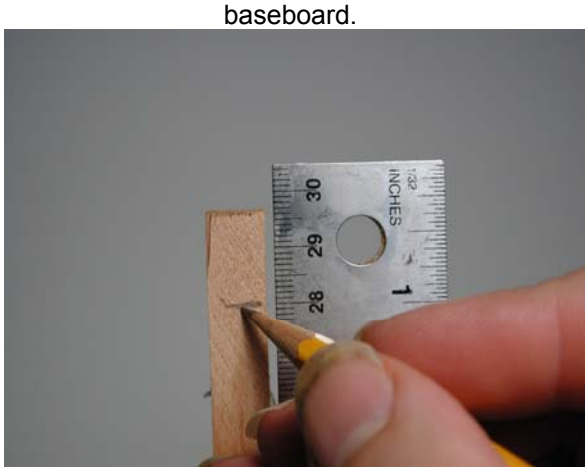


9. Sharpen the end of the dowel using the pencil sharpener.

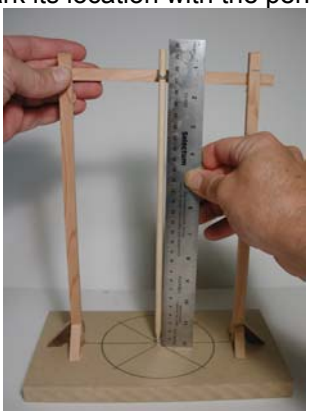


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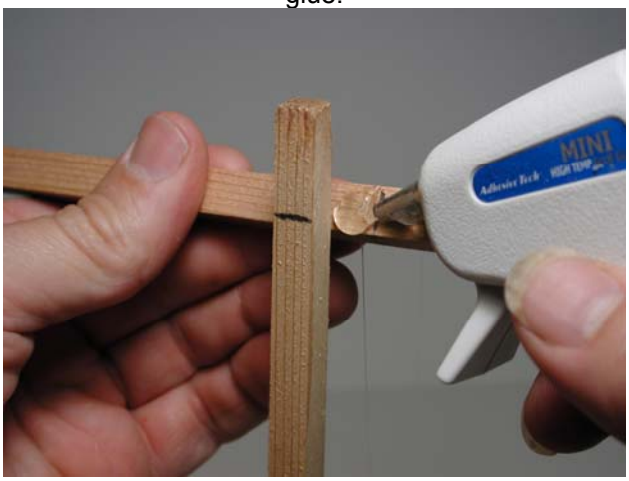
10. Place marks on the uprights 28 cm above the baseboard.



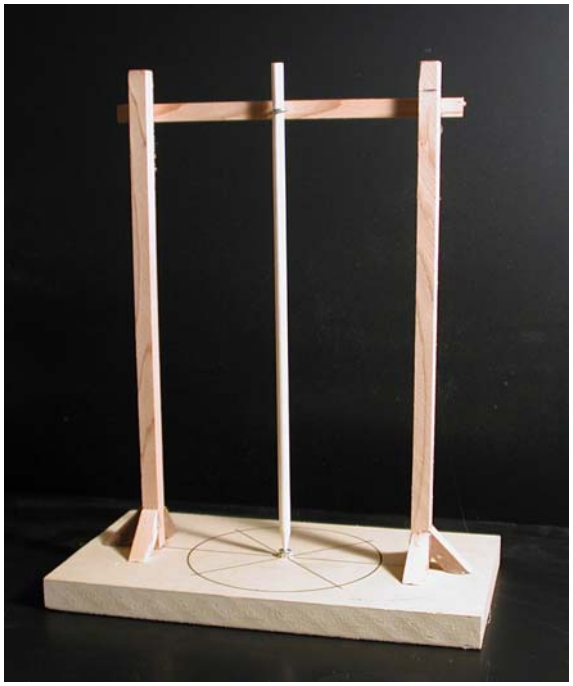
11. Slip the dowel through the screw eye on the crossbar, and hold the crossbar in position on the uprights so that the dowel is perpendicular to the base. Mark its location with the pencil.



12. Secure the cross bar with generous amounts of hot glue.



13. The finished frame!



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Part B. The Coils

You will need:

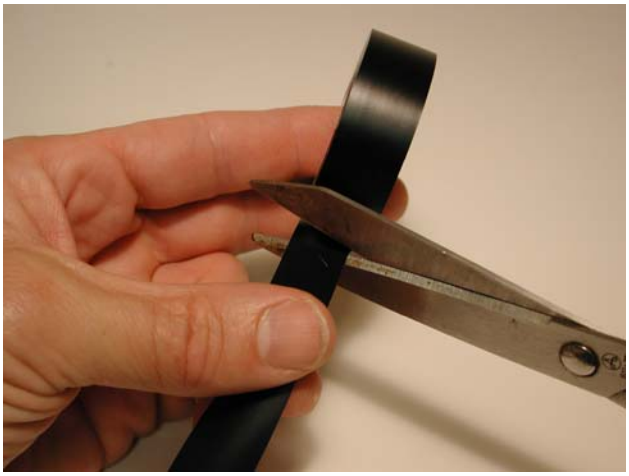
Tools
- Pliers
- Sandpaper
- Scissors
- Digital volt meter

Materials
- Enamelled copper wire (28 gage, 100m)
- Corrugated cardboard
- Electrical tape

1. Make a winding jig by folding a small piece of corrugated cardboard over itself 3 times. The jig should be 3 cm wide by about 20 cm long. Secure with tape.



2. Cut 8 pieces of electrical tape, 4cm long each, and have these ready for the next steps.



3. Wind the wire onto your jig, as shown. Make 4 coils each with 200 turns of wire, making sure there is a wide gap between each coil, and leaving about 40 cm of wire before the first coil, and after the last coil. This should use up about 20 meters of wire per coil.

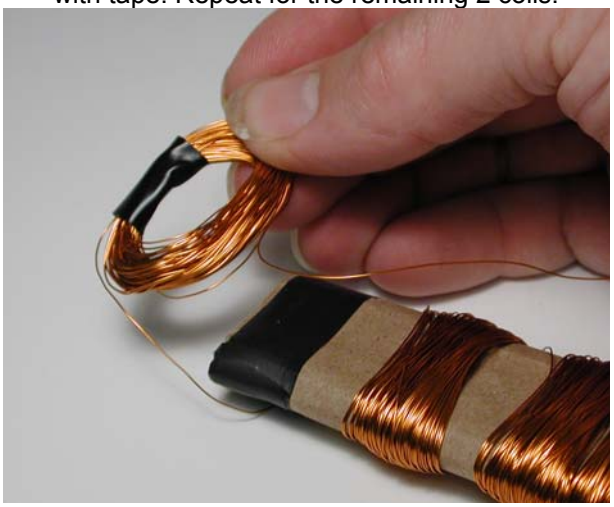


4. Slide the first coil off the jig and secure it tightly with 2 of the 8 pieces of electrical tape.

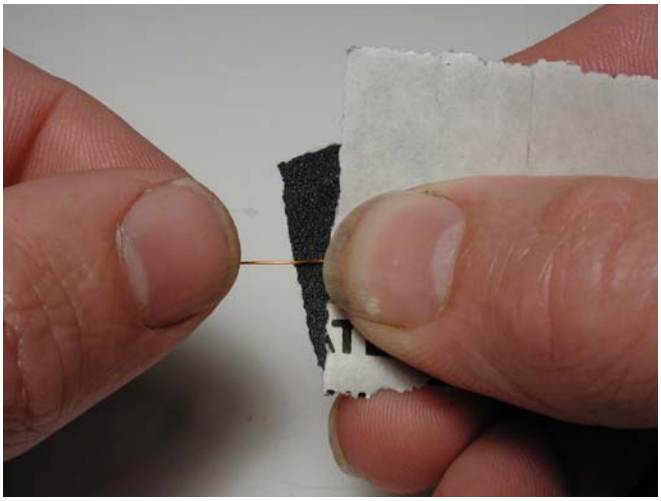


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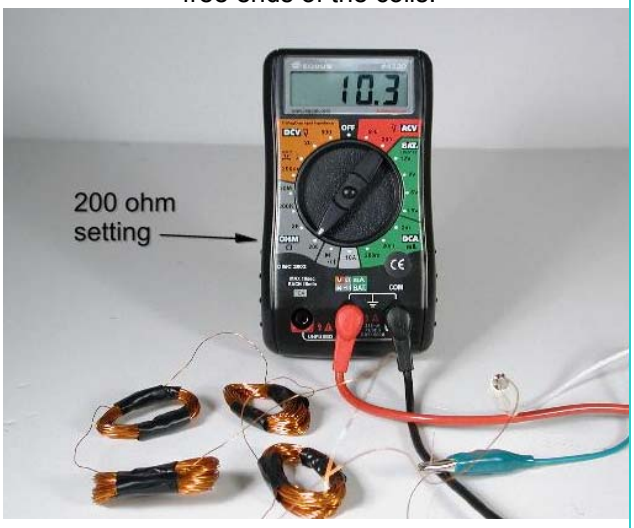
5. Slide the next off the jig and secure both sides with tape. Repeat for the remaining 2 coils.



6. Carefully sand or scrape off 15mm of the enamel insulation from the free ends of the wire.



7. Test the coils to ensure electricity can get through all of them: set the voltmeter for ohms (the 200 ohm range) and connect the test leads to the free ends of the coils.



8. What the finished coils should look like:



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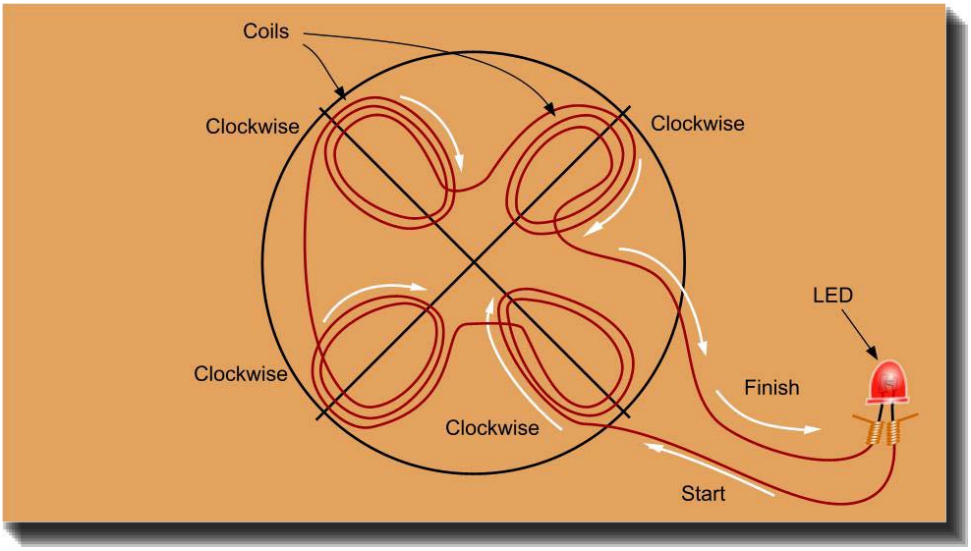
C. The Stator

You will need:

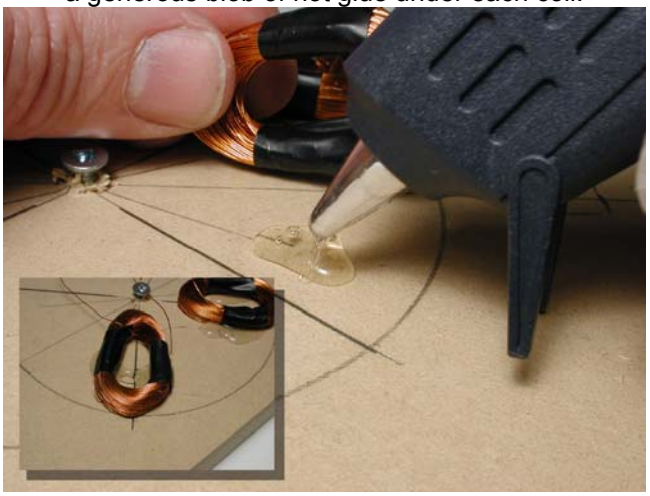
Tools
- Hot glue gun and glue sticks
- Electrical Tape
- Pliers or scissors

Materials
- Completed coils
- Light emitting Diode

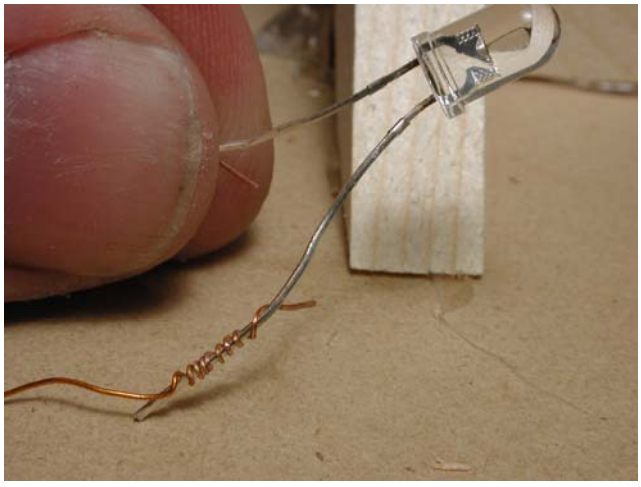
1. Loosely position all 4 coils on the base as shown in the diagram. Be sure the turns of wire can carry electrons in a clockwise direction in each coil.



2. Once you are confident the coils are properly positioned, glue them down on the stator disk. They should just touch the circle you drew on the base. Use a generous blob of hot glue under each coil.

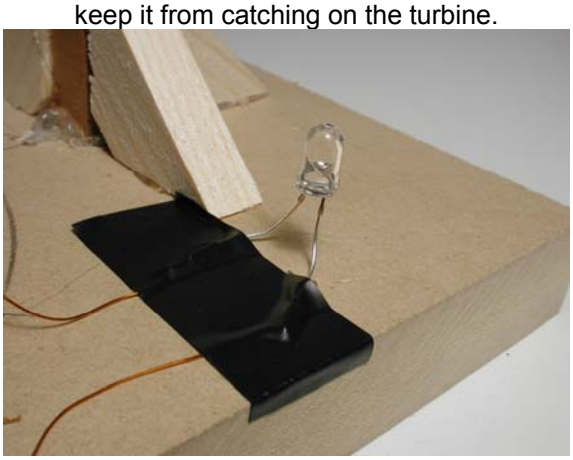


3. Connect the free ends of the coil wires to the light emitting diode.

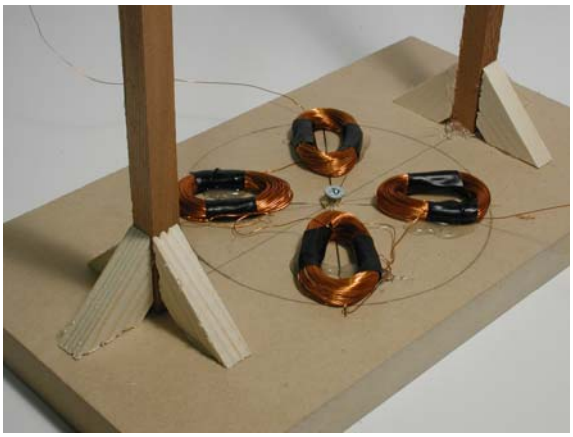


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4. Tape or glue any loose wire to the base or frame to keep it from catching on the turbine.



5. The finished stator.



D. The Rotor

Tools

- Geometry Compass
- Utility knife
- Nail
- Hot glue gun
- Ruler
- Pencil

Materials

- White glue
- Corrugated cardboard or foamboard
- Magnets (1” diam. Rare earth, 4)
- Washers (4)

1. Using the geometry compass, mark 2 circles 12cm in diameter on the cardboard or foam board.

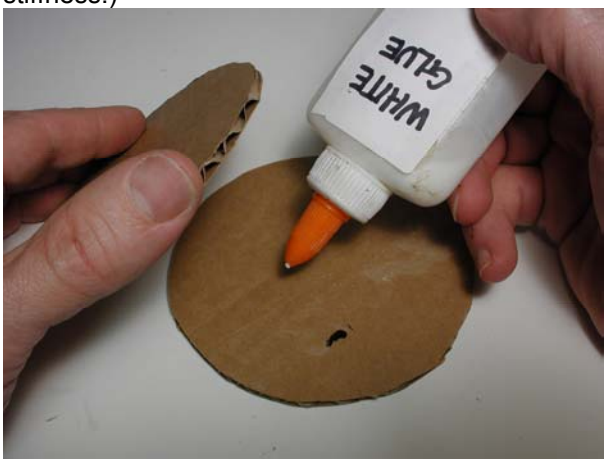


2. Cut these circles to make disks from the cardboard using the utility knife.



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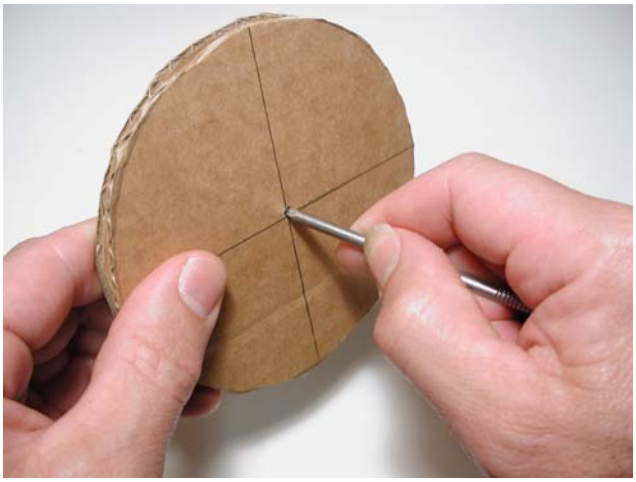
3. Use the white glue to laminate the two larger disks together. (Tip: if you are using corrugated cardboard, orient the corrugations in the disks so they are perpendicular to each other, to increase the rotor disk's stiffness.)



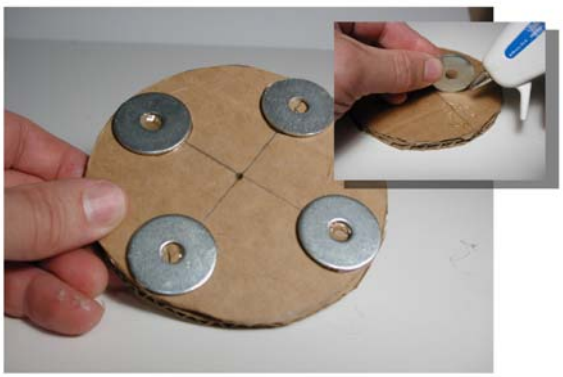
4. Using a ruler, mark one side of the rotor disk with perpendicular lines. Be sure the two lines are 90 degrees apart. Use a geometry square or the corner of a piece of paper to help you locate the second line.



5. Use a nail to punch a hole through the center of the rotor disk.



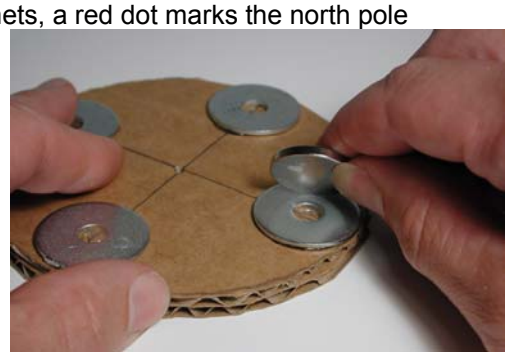
6. Hot glue the 4 fender washers to the disk, centering them over the lines and bringing their edges up to the edge of the disk. Tip: be sure the washers are clean and free of all grease and dirt, otherwise, they may not stick to the disk.



7. Carefully separate your magnets by sliding them off the stack, one at a time.



8. Carefully place a magnet on each washer with the same pole facing up (north or south). On many magnets, a red dot marks the north pole

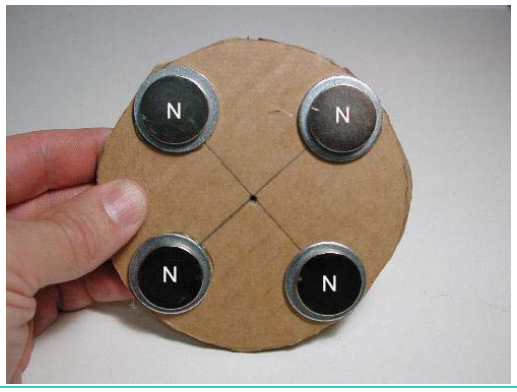


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9. Tip: If you are unsure of the polarity of the magnets, you can use a magnetic compass to confirm that all the magnets are either north or south.



10. The completed rotor.

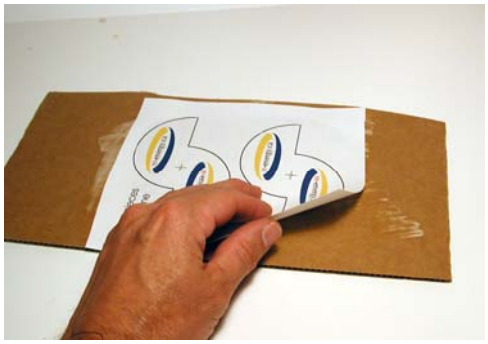


E. The Turbine

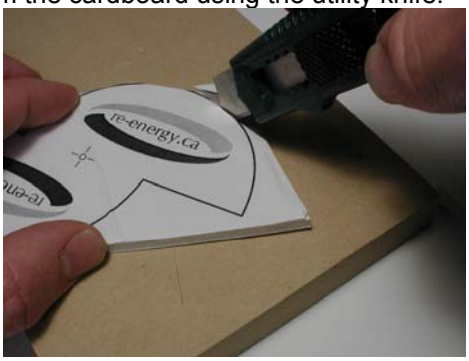
You will need:

Tools	Materials
• Scissors • Utility knife • Hot glue gun • Nail • Sand paper	• 1.5L water bottle • Corrugated cardboard • Turbine end piece template •

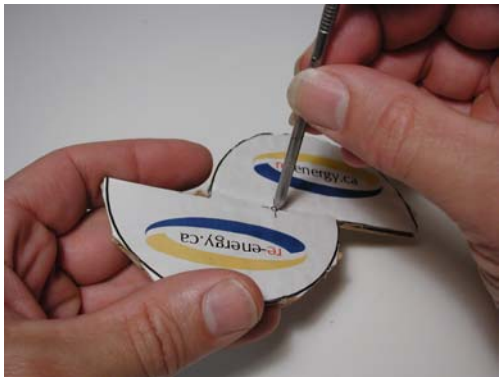
1. If you have not already done so, glue the templates for the turbine end pieces onto corrugated cardboard or foam board.



2. When the glue is dry, cut the two turbine end pieces free from the cardboard using the utility knife.



3. Using a nail, punch a small hole in



4. Using scissors or a utility knife, cut the top and bottom off the water bottle, then cut the cylinder into two equal halves.

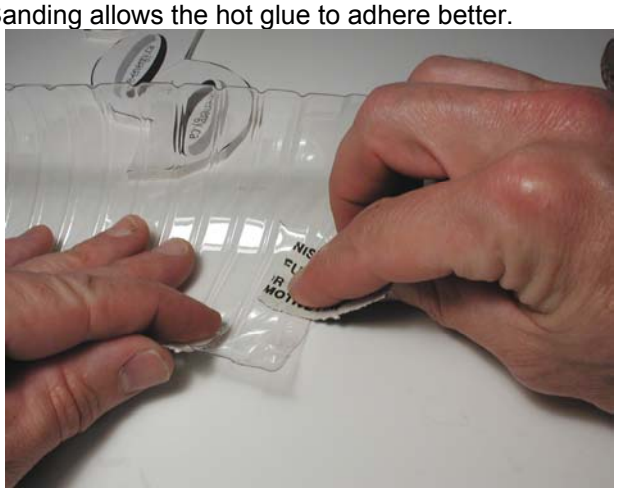


5. Use the sand paper to buff the inside edges of each

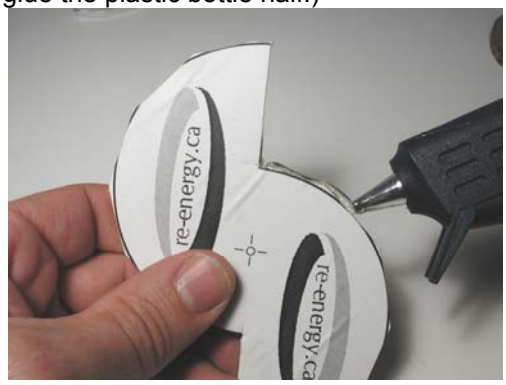
6. Apply hot glue to one of the curved edges of one of

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bottle half where they will attach to the end pieces. Sanding allows the hot glue to adhere better.



the turbine end pieces. Quickly position a plastic bottle half on this edge, holding it steady for about 20 seconds while the glue cools and hardens. (Do NOT apply glue the plastic bottle half!)



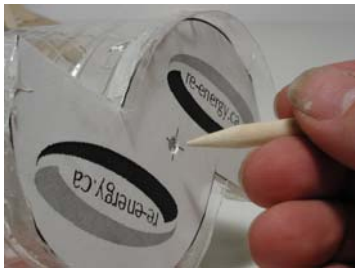
7. After checking for fit, apply glue to the edge of a second turbine end piece and fasten it to the first bottle half as shown.



8. Squeeze hot glue onto the remaining edges of the end pieces, and quickly apply the second bottle half to complete the turbine.



9. Push the sharpened round dowel through the center of the turbine, leaving about 6 cm projecting from the top.



10 Check the turbine for fit inside the frame. Spin it or blow on it to ensure it turns freely.



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F. Final Assembly

You will need:

Tools
- Hot glue gun
- Screw driver

Materials
- Completed rotor disk
- Turbine
- Frame
- Electrical tape

1. Carefully push the pointed end of the turbine shaft through the top of the rotor disk at its exact center. The magnet side should face down. Slide the disk so that about 2.5 cm of the dowel projects from the cardboard.



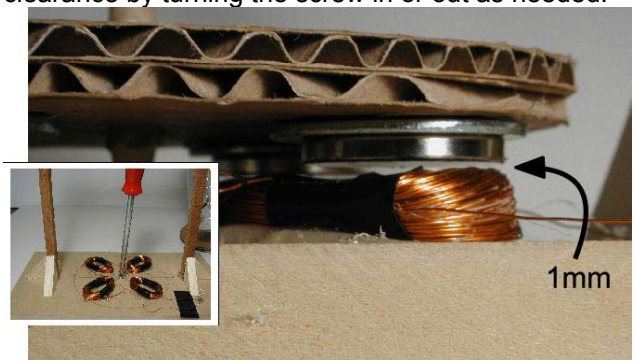
2. Test fit the turbine / rotor assembly in the frame: slide the top of the shaft through the screw eye and locate its sharpened point in the screw. Spin the rotor and ensure that:
   a) The turbine turns freely without striking the frame;
   b) The rotor disk does not wobble as it turns
   c) The gap between the magnets and the coils is about 3 millimeters or less.



3. Hot glue the rotor disk in to position so that it does not move on the dowel.



4. Final adjustments: You can “micro-adjust” the clearance by turning the screw in or out as needed.



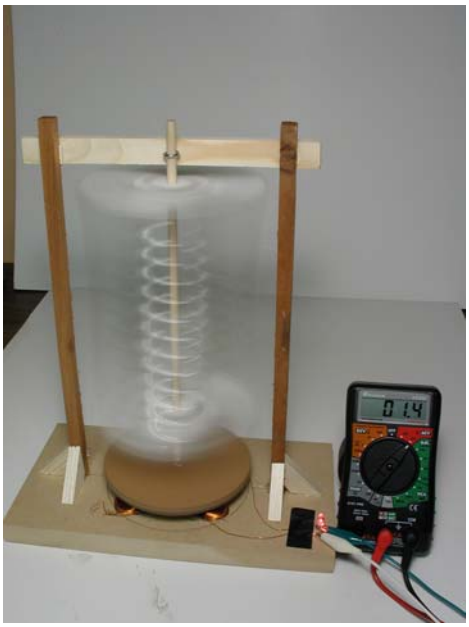
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G. Test It!

You will need:

Tools	Materials
• Digital voltmeter with probes and clips	• Completed turbine

1. Connect the leads from the volt meter to the two wires where they connect to the LED.



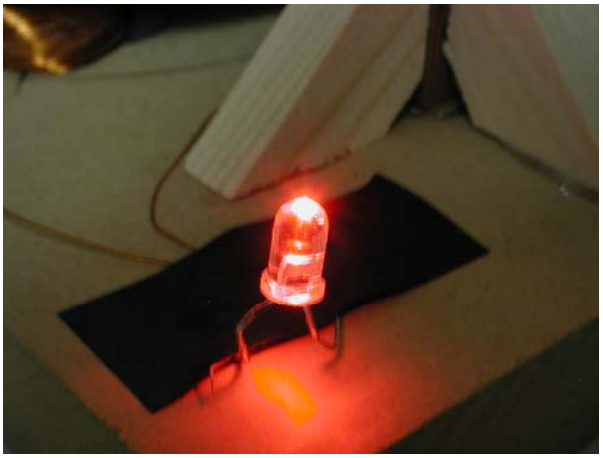
2. Set the volt meter for AC (alternating current) volts, as shown.



3. Blow on your turbine to cause it to spin. You should be able to get at least 1 volt, and as high as 4 volts.



4. You should see the LED light up. It should flash rapidly (a consequence of alternating current).



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Troubleshooting Tips

Problem	Probable Causes	Suggested Solutions
Turbine turns too slowly, or turns with difficulty	The screw eye is too tight	Use pliers to enlarge the screw eye, or replace it with a larger one.
	The pointed end of the dowel is binding in the screw	Re-sharpen the dowel, or smooth it with sandpaper.
No voltage reading on voltmeter, or readings are erratic	Magnets are too weak	Substitute stronger magnets. Use the ultra-strong rare earth magnets NIB available through various Internet sources, hobby shops, or Lee Valley Tools.
	Volt meter is set for DC, or you are using a volt meter that has no AC setting	Set voltmeter for alternating current (AC), or switch to a digital volt meter with AC setting.
	Magnets are not oriented correctly	Remove the rotor and re-check the magnets. They should all be either North or South (not a mix of both).
	Coils are not oriented correctly	Re-check coil orientation. Following the wire through the circuit, it should spiral through the first coil in either a clockwise or counter-clockwise direction, and should go the same direction in each of the other coils.
	Poor connection with the volt meter	Re-sand the ends of the wire where they join the LED. Connect to the volt meter with alligator clips.
	Gap between magnets and coils is too large	Use the screw to lower the height of the rotor disk to with 1 mm of the coils.
	Rotor is turning too slowly	Check the screw eye, frame, coils, and screw to ensure nothing is binding or causing excessive friction. Adjust or re-size as necessary to get a the turbine to spin freely.
Readings are greater than 1VAC on the meter, but the LED doesn't light up	The LED may have too high a voltage range.	Substitute an LED that activates at 900 millivolts or less.
	There is a poor connection on one or both LED leads	Untwist the wire from the leads, re-sand, and twist on tightly, or use solder.
Magnet and / or metal washer falls off rotor	Poor bond between the washer and the rotor disk	Use rubbing alcohol or soap and water to remove grease from the washer. Scrub the surface of the washer with sandpaper and re-glue it with a generous blob of hot glue.
	Poor adhesion between magnet and washer, caused by a weak magnet	Substitute a stronger magnet, or add some hot glue or instant cyanoacrylate glue to attach the magnet permanently.

Acknowledgements

The inspiration for the design of this model comes from the ingenious "Pico-turbine", published as a free project plan from http://www.picoturbine.com. PicoTurbine.com is one of the best sources of ideas and resources for renewable energy education on the Internet.

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