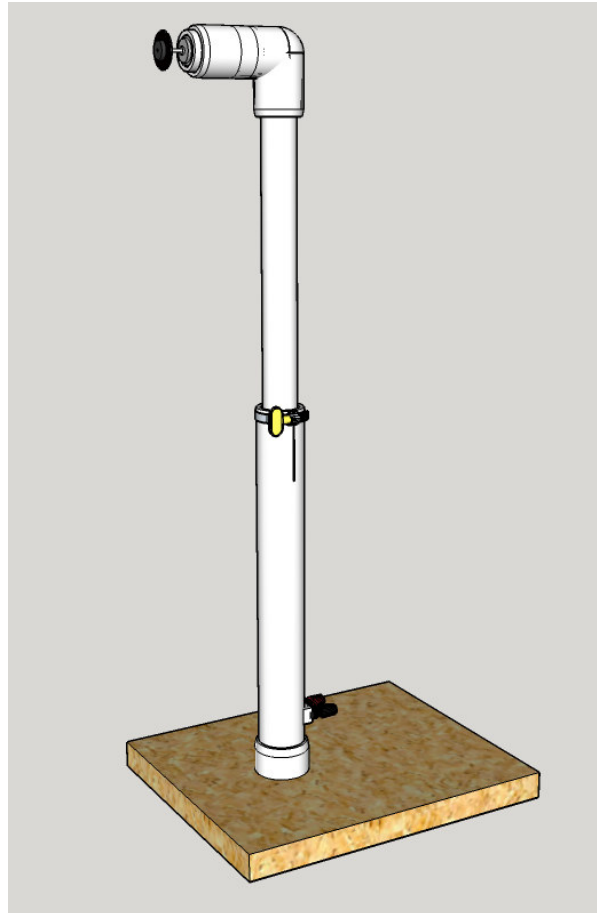


Wind Power Test Stand

This instruction describes the construction of a test stand that can be used to test a Wind Power blade assembly. This design is intended for use with a fan having a center 21 inches high, but may be adjusted to support other fan heights.



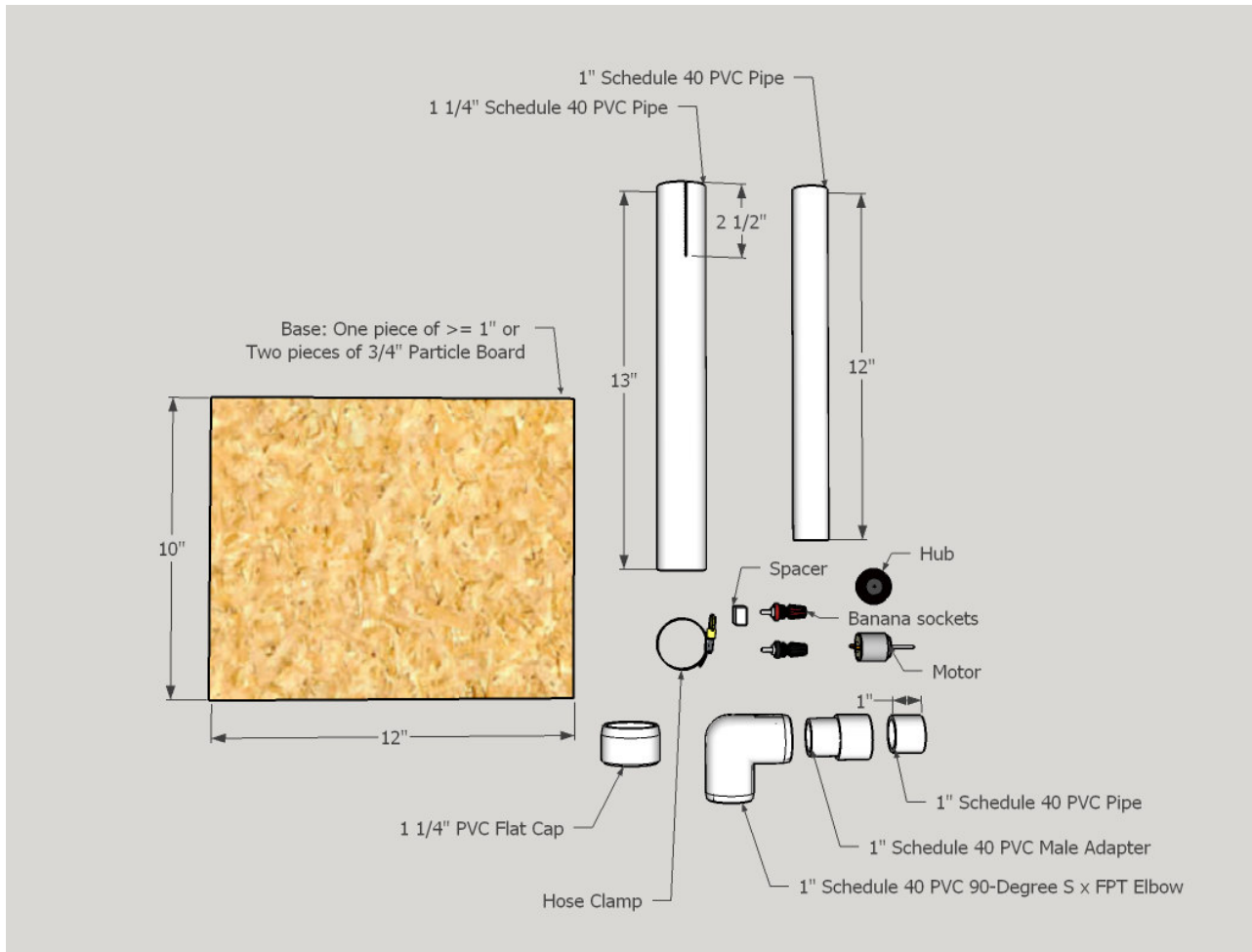
The recommended design enables the center of the blade assembly to be from 16 to 26 inches high.

Two variants of the design are also described:

- 1) The base is made using a flat ended 1 ¼" PVC flat cap that is screwed to the base. An alternative design uses a 1 ¼" PVC coupler which is glued into the base.
- 2) The top section of the stand uses a PVC threaded adapter to attach the motor to the top of the stand. This allows motors to be easily exchanged in case of problems with the motor, or if other motors are to be evaluated. An alternative design permanently attached the motor to the top of the stand.

Materials:

The majority of the materials are shown in the diagram below, and all are listed in the following tables:



<u>Materials</u>	<u>Description</u>
>= 1" Particle board – one 10" x 12" piece or 3/4" Particle board – two 10" x 12" pieces	These form the base of the stand. A single board may be used if it is >= 1" thick. The alternative base design uses two pieces of particle board at least 3/4" thick.
1 1/4" Schedule 40 PVC pipe, 13" long	This is the lower section of the extendable stand
1" Schedule 40 PVC pipe, 12" long	This is the upper section of the extendable stand
1" Schedule 40 PVC pipe, 1" long (or 3" long)	The top section is 1" long for the main detachable design but 3" long if making the alternate fixed top design
1 1/4" Schedule 40 PVC flat end cap (or 1 1/4" coupler)	The base uses the flat end cap (or in the alternate design the 1 1/4" PVC coupler)
1" Schedule 40 PVC elbow, S x FPT (or S x S)	This elbow attaches the top section to the upper extendable section. In the main detachable design one end is threaded (FPT) while in the alternate fixed top design both are slip joints (S x S)
1" Schedule 40 PVC Male Adapter	This is only used for the main detachable design. It is not required for the fixed top design.

1 3/4" Thumb (Turn-key) Hose Clamp	Hose Clamp with a thumb paddle that opens to 1 3/4". The thumb pad makes it easy to adjust. E.g.: Part# 1XHE3 from Grainger.com Part# 5Y020 from zoro.com
Banana Sockets / Terminal Binding Posts	Banana terminal posts support normal test cables as well as clamping the resistor. E.g.: https://www.amazon.com/Female-Banana-Socket-Binding-Terminals/dp/B00BM1HXD8 http://www.ebay.com/itm/8pcs-Binding-Post-Speaker-Cable-Amplifier-4mm-Banana-Jack-Plug-Connector-Colrs/170792024099
Spacer	Optionally used to seat the Banana Sockets against the 1 1/4" pipe so that the ends of the posts don't touch at the center of the pipe. This can be shaped from wood or 3D printed.
CD/DVD Motor	A CD/DVD type motor. Can be extracted from a used portable CD player, but recommend this one: https://www.jameco.com/z/RF-310TA-11400-2-5V-DC-Motor-2200-RPM_238465.html
CD/DVD Hub	Can be extracted from a portable CD player, with care not to bend the plate. They can also be found as 'PS1 replacement hub', e.g.: http://www.ebay.com/itm/Replacement-CD-Spindle-for-Sony-Playstation-1-PS-One/262435916683
<u>Other Materials</u>	
Connection Wire, 6 feet	Recommend 18 AWG with multiple strand wires
Plug / Socket Connector	This is only needed if the recommended top design is used where the motor can be unscrewed from the stand. Any connector pair will work. JST is small and flexible, e.g.: http://www.ebay.com/itm/1pair-150mm-20AWG-Silicone-Wire-JST-SYP-R-2P-Male-Female-Connectors-battery-/271556371215
Heatshrink / Electrical tape	Used to cover the connection between the wires and the connector pigtails.
Soldering Iron / Solder	Used to attach the wire to the motor connectors, the terminal posts and the connector pigtails.
Epoxy glue	Used to attach the 1 1/4" PVC coupler to the base (for the alternate design), and the motor to the 1" PVC pipe.
Wood Glue / Four 1 1/4" wood screws	Used to attach the two pieces of particle board together for the base.
Three 1" wood screws	Used to attach the PVC flat cap to the base.
Plastic Shim Strip 1/2" x 3" x 0.03"	Cut from a plastic container to attach the CD motor.
Resistor	1 Watt to 2 Watt, resistance as desired (10 ohms).

Instructions:

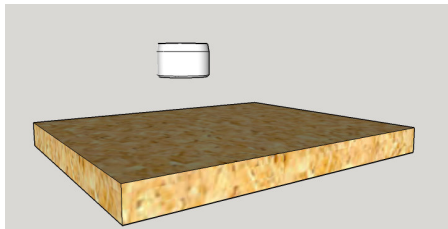
The instructions for each section of the stand are shown below.

Stand Base

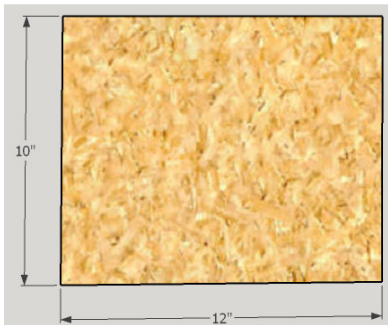
Two possible designs are shown for the base. The primary design is shown in the drawings, while an alternate variant is described. The coupler used in the alternate design is easier to find at local stores.

Primary Base Design

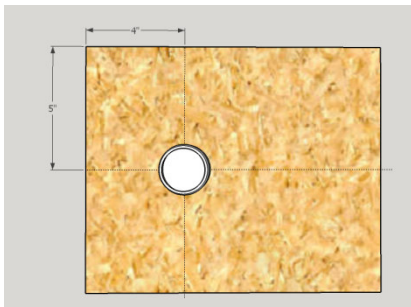
The primary base design uses a PVC flat end cap (not a rounded end cap sold by most hardware stores) which avoids using epoxy glue.



1. The base comprises one or two 10" by 12" pieces of particle board. The total thickness should be ≥ 1 " to provide enough weight.

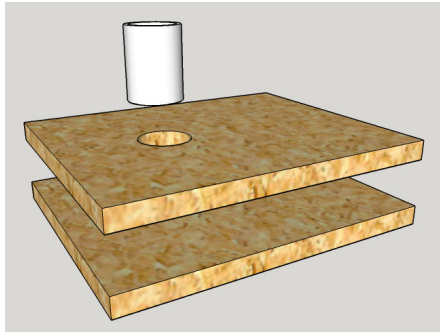


2. If two pieces of particle board are used then glue them together to form the base. Use four screws to hold the pieces together while the glue sets. I would leave the screws in, but make sure that they do not protrude from the bottom of the base (to avoid damaging the table surface) by either countersinking the screws into the wood and/or putting the screws into the top side of the base.
3. Use three screws to attach the PVC end cap to the base. Choose screw lengths ensuring that they will not penetrate through the bottom of the base board. Center the end cap in the middle of the 10" side and 4" from the 10" edge.

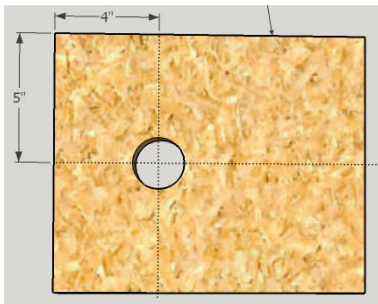


Alternate Base Design

If it is hard to find a flat end cap then an alternate base design can be used:



1. Use two $\frac{3}{4}$ " thick pieces of 10" by 12" particle board.
2. Drill a 2" diameter hole 5" from the long side and 4" from one of the short sides in one of the pieces of particle board

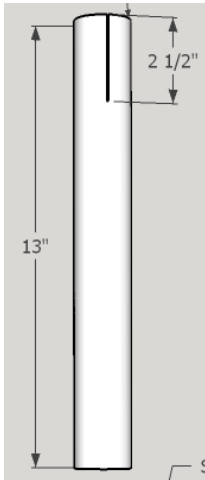


3. Glue the two boards together as described in the primary design step 2.
4. Sand / file the lower $\frac{3}{4}$ " of one end of the 1 $\frac{1}{4}$ " coupler to roughen the surface so that the epoxy glue can key to it.
5. Use 2 part epoxy glue around the lower $\frac{3}{4}$ " of the coupler to glue the coupler into the 2" drilled hole.

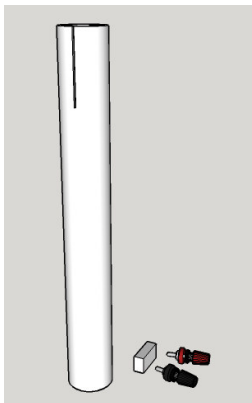
The base can be sanded to give a cleaner finish and remove any sharp edges.

Lower Stand Section

1. Cut a 13" length of the 1 ¼" PVC Schedule 40 pipe.
2. Cut two 2.5" long slots on opposite sides of one end of the pipe. Each slot is 1/16" wide.



3. Drill two holes in the other end of the PVC pipe. The diameter of the holes should be chosen to fit the base of the banana terminals. The holes should be 1 ½" from the end of the pipe and placed approximately 60 degrees apart around the circumference of the pipe. Drilling the holes at a horizontal angle helps avoid the tips touching inside the tube. This can be helped by using an optional spacer where the outside surface has less curvature than the 1 ¼" PVC pipe.



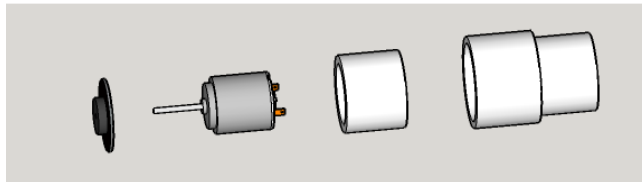
4. Solder the wire to the ends of each of the banana sockets.
5. Sand the PVC pipe where the spacer will attach to improve the glue adhesion.
6. Thread the wire from the banana sockets through the holes and up the PVC pipe.
7. Glue the banana sockets, spacer and PVC pipe together. Aligning the holes in the terminal posts vertically will make it easier to attach the resistor later.

Upper Stand Section

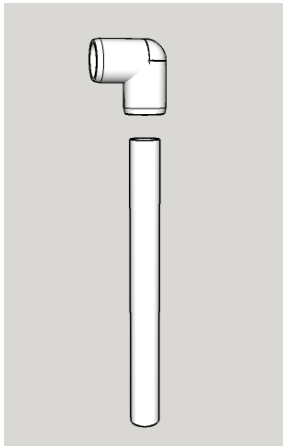
Two possible designs are used for the upper section of the stand. The primary design enables the motor to be removed and exchanged, which can be useful if there are problems with the motor or if an alternate motor is evaluated. The alternate variant fixes the motor so the top section would have to be replaced if the motor failed but uses less materials such as the JST connectors.

Primary Upper Stand Design

1. Cut a 1" length of 1" PVC pipe. Use PVC cement to glue the 1" long section of 1" PVC pipe into the 1" PVC Male Adapter.
2. Solder the leads from one of the JST connectors to the terminals on the motor. If you have heat shrink tubing then you can slide it over the wires before soldering and then after soldering slide it over the tabs on the motor and shrink it.
3. The motor is slightly narrower than the 1" PVC tube so cut a ½" by 3" section out of a plastic container to create a plastic shim which can be wrapped around the motor to make a tighter fit.
4. Sand both sides of the plastic shim and the inside of the PVC pipe to roughen the surface to give better glue adhesion and check that the shim and motor fits into the PVC pipe.
5. Spread epoxy on the inside of the PVC pipe, around the shim and the outside of the motor. Wrap the plastic shim around the motor ensuring that it is covered by epoxy, then slide into the end of the 1" PVC pipe until the outside edge of the motor is flush with the PVC pipe. If you don't want to use epoxy then you can wrap painters/masking tape around the motor until it fits tightly into the PVC pipe.
6. After the epoxy has set, slide the CD/DVD Hub onto the end of the motor shaft and push it on until the outside of the hub is aligned with the end of the motor shaft.



7. Cut a 12" length of 1" PVC pipe.
8. The 1" PVC elbow has one end slip joint and the other is threaded. Use PVC cement to glue the 12" section of pipe to the slip joint in the elbow.

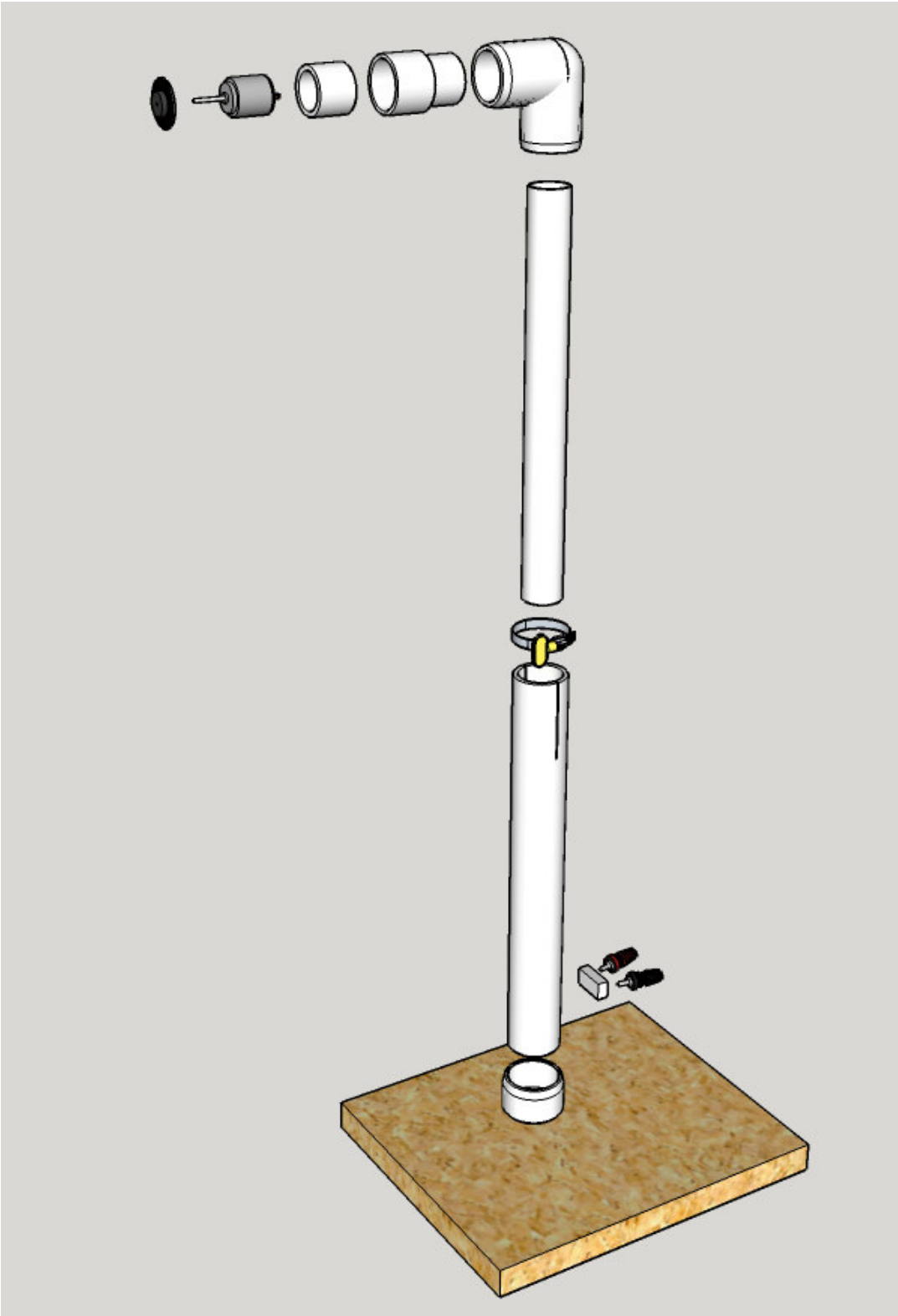


9. Place the upper section next to the end of the lower section and measure the wires so that they reach the top of the upper section, then cut the rest of the wire off.
10. Solder the end of the wire to the other JST connector and use heat shrink tubing or electrical tape to cover the joints.
11. Slide the hose clamp onto the end of the 1 ¼" PVC pipe where the slots are and tighten it up until it doesn't slide freely down the pipe.
12. Thread the JST connector and wires from the lower section through the upper section so that the connector comes out of the threaded end of the PVC elbow, sliding the upper section 1" PVC pipe fully into the lower section 1 ¼ " pipe then tighten the hose clamp to hold it in place.
13. Plug the JST connector from the motor into the JST connector on the wires and then screw the PVC adapter into the PVC elbow until the joint is tight (There will still be thread showing).

Alternate Upper Stand Design

1. Slide the hose clamp onto the end of the 1 ¼" PVC pipe where the slots are and tighten it up until it doesn't slide freely down the pipe.
2. Cut a 3" length of 1" PVC pipe and a 12" length of 1" PVC pipe.
3. Use PVC cement to glue the 12" length into the PVC elbow that has slip joints on both ends.
4. Thread the wires from the lower section through the upper section so that the connector comes out of the PVC elbow, sliding the upper section 1" PVC pipe fully into the lower section 1 ¼ " pipe then tighten the hose clamp to hold it in place.
5. Thread the wires through the 3" length of 1" PVC pipe and glue the pipe into the other end of the PVC elbow.
6. Fully extend the upper section so that it is at the end of the lower section and cut the wires so that they just come out of the 3" long pipe, then slide the upper section back into the lower section and tighten the clamp.
7. Solder the wires to the terminals on the motor. If you have heat shrink tubing then you can slide it over the wires before soldering and then after soldering slide it over the tabs on the motor and shrink it.
8. The motor is slightly narrower than the 3" PVC tube so cut a ½" by 3" section out of a plastic container to create a plastic shim which can be wrapped around the motor to make a tighter fit.
9. Sand both sides of the plastic shim and the inside of the PVC pipe to roughen the surface to give better glue adhesion.
10. Spread epoxy on the inside of the PVC pipe and the outside of the motor. Wrap the plastic shim around the motor ensuring that it is covered by epoxy, then slide into the end of the 1" PVC pipe until the outside edge of the motor is flush with the PVC pipe.
11. After the epoxy has set, slide the CD/DVD Hub onto the end of the motor shaft and push it on until the outside of the hub is aligned with the end of the motor shaft.

Exploded Assembly Drawing of the Primary Design



Preparation

A new CD motor may generate inconsistent readings when it is first used because the brushes have not worn in to match the commutator. These can be worn in by attaching a CD to the motor, remove the load resistor from the banana jacks, and then connect a 3 volt power source to drive the motor. This can be left running for 20 minutes to settle the brushes.

Operation

1. Unscrew the ends of the banana socket binding posts and insert one end of the load resistor lead into the hole through the middle of each binding post and then tighten the binding posts again. You may trim the resistor leads or just wrap them around the binding posts.
2. Place the end of the lower stand section 1 ¼" PVC pipe into the PVC coupler / cap and tighten gently until the upper section is vertical and held rigidly. If the stand does not have to be portable then PVC cement can be used to make this joint permanent.
3. Place the stand next to the fan, loosen the hose clamp and slide the upper section until CD/DVD hub is at the desired height. (Remember to hold the upper section of the stand when you loosen the hose clamp so that it doesn't fall abruptly)
4. Use banana cables to connect the banana sockets on the stand to a voltmeter that should be able to read over 1V. If an analog voltmeter is being used then the connections may have to be swapped if a negative voltage is generated.

Effect of the Load Resistor

The voltage (EMF) generated by the motor/generator is proportional to the rotational rate of the motor shaft, and is relatively independent of the load resistor, however the voltage that is measured across the load resistor changes with the load resistor value because it forms a voltage divider with the internal resistance of the motor. This motor has an internal resistance of approximately 10 ohms. The table below shows what percentage of the EMF generated by this motor is measured across the load resistor for different load resistor values:

Load Resistance (ohms)	Load Voltage as a percentage of Motor EMF
5	33%
7.5	43%
10	50%
15	60%
20	67%