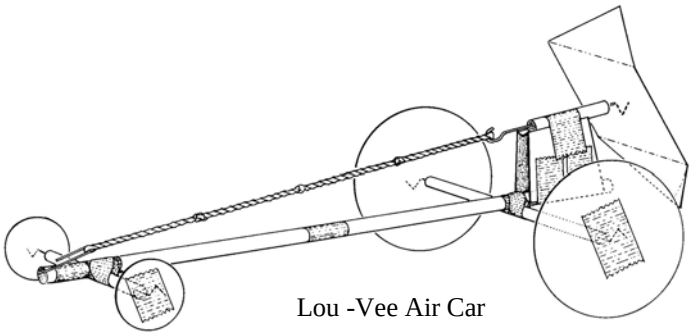
Taking concepts from the Lou-Vee Air Car, the Propelleracer is sturdier and faster with more reliable results.

Virtually any material can be used to build this simple concept car. However, a simple concept car does not mean a simple-to-build car. Top mechanical design is needed to create a powerful working racer that will beat its competitors.



Lou -Vee Air Car

Basic Components/ Materials List

Propeller	Straws
Wheels	Tape
Wheel Axles (inner axle)	Hot Glue
Wheel Axles Cylinder	Scissor
Structural Frame	Ruler
Motor and Batteries	Pliers (optional)
Toggle Switch (optional)	

This workshop spans two weeks and consists of two main phases: design and construction.

Week 1: You have **30 minutes** to design your racer and decide on what materials to use.* The remaining time will be used to begin construction on your Propelleracer.

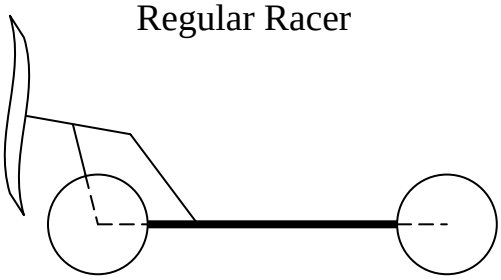
Week 2: You will have **50-60 minutes** to finish building your racer and test it. In the remaining time, each group will compete against the other to find the ultimate Propelleracer.

* You are welcomed to use more time to design, but you reduce your chances of completely finishing and/ or testing your racer before competing against the other groups.

The following information shows the standard designs you would find in a racer. Combine these different choices to create your very own unique Propelleracer. Feel free to modify these patterns or come up with something original.

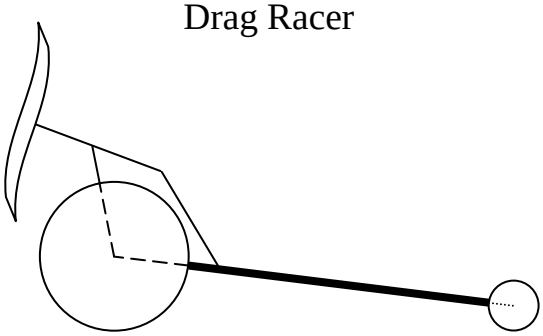
Model Designs

Regular Racer



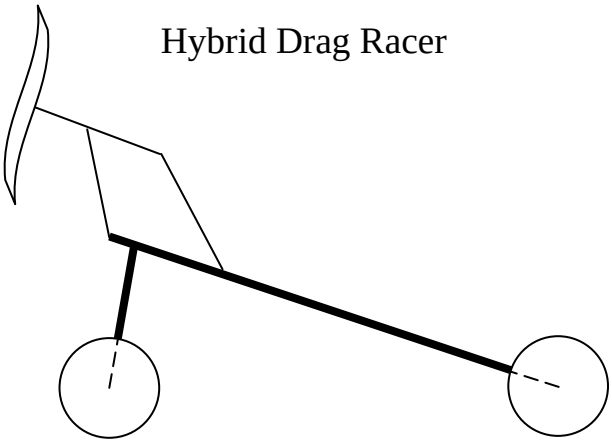
same size wheels for front and back, frame is parallel to ground

Drag Racer



front wheels are smaller than back wheels

Hybrid Drag Racer

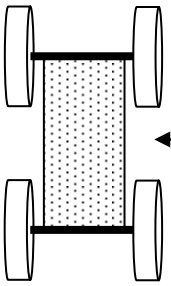


same size wheels for front and back, back wheels are suspended up

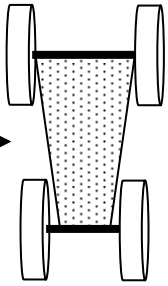
Another common Model Design is the Monster Truck. It is not listed because it is not typically associated with racing. The Monster Truck is simply a Regular Racer with the back and front wheels suspended up like the Hybrid Drag Racer.

Structural Frame

Rectangular Frame



Triangular/ Trapezoidal Frame



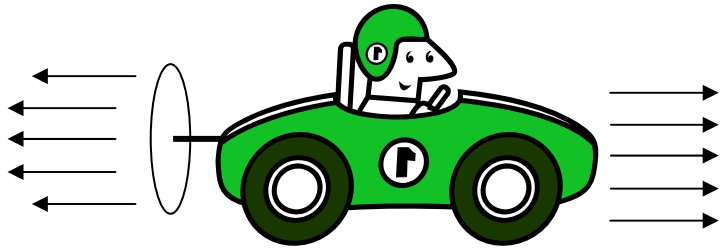
Structural Frames (aerial view)

(front of racer)

Propeller Power

Geometry plays a key role in how much propeller power you get.

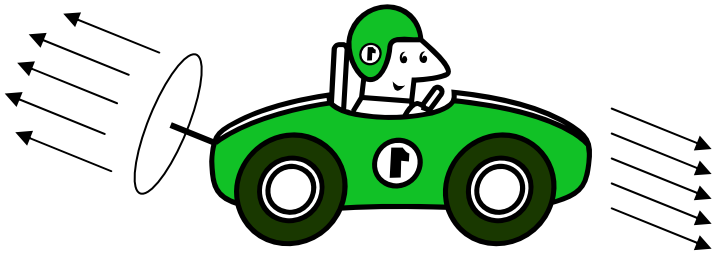
The spinning of the propeller causes a force pushing ***backwards***, which in turn causes the SAME amount of force pushing ***forwards*** on the racer. This is the concept in Physics known as Conservation of Energy or Conservation of Momentum.



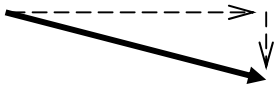
force pushing backwards

equal force pushing forwards

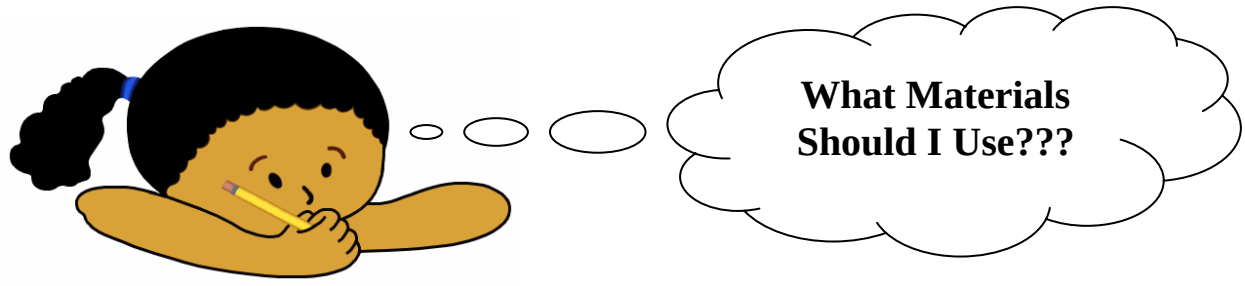
Now, if the propeller is slanted **upwards**, then the force is pushing the racer at a slant **downwards**.



This means that the car will remain firm on the ground, but the force in the forward direction is less than before. Being at an angle, the force is made up of two components: one downward and one forward.



Thus, if the propeller were pointing straight up or down, the racer would not move forward.
** A racer with its propeller pointing straight backwards will get the most power moving forwards. **



Now that you understand the basic design of your car and how the propeller works, it is time to choose the materials. The topics on the next page provide guidelines and suggestions for the basic structural parts. It is recommended that you consider each part in the particular order listed.

Wheels

This is one of the most important concepts to consider. First, keep in mind what car model you chose.

- What size wheels will you use?
  The front wheels should always be the same size or smaller than the back wheels.
- What materials should the wheels be made of?
  In this project, the front and rear axles are designed to be free-moving. Thus, you want materials of LEAST RESISTANCE, such as CDs.
  In real life, the front and rear axles are part of the drive system of a car. Thus, you would want materials of the MOST TRACTION, such as rubber.
- How will you add stability, i.e. wheels won't wobble?
  You can make wider wheels or combine two/ more together.
  You can also add padding to hold the wheel in place on the axle. Consider using Styrofoam, cardboard, hot glue, etc.

Structural Frame

You should first decide on your structural frame design – Rectangular or Triangular/ Trapezoidal.

- What material(s) will you use to make the structural frame?
  Consider cardboard, paper, wood, etc.
  Lighter materials are preferable, but you want your car to remain on the ground or on the testing surface. Thus, if the material easily blows away, such as with paper, consider using something else.
- How long or wide does the structural frame need to be?
  Recommended dimensions are 1 ft. long by ~3 in. wide.
  If your structural frame is Triangular/ Trapezoidal, ~2 in. is recommended for the front portion.

Wheel Axle (inner axle)

This is what supports the wheels and allows them to spin.

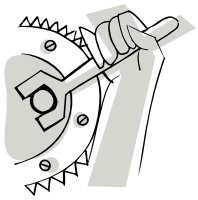
- What material is straight, round, and strong enough?
  Consider skewer/ bamboo sticks or dowel rods.
- Is the axle smooth enough to reduce the amount of friction?
- How big does the axle need to be in order to support the wheels?
  If it is too small in diameter, the wheels will not stay affixed and will not spin properly.
  However, axles with larger diameter tend to be heavier.
  Thus, try to find a medium-size axle. The Wheel Axle Cylinder (below) will mostly determine the wheel axle size you choose.

Wheel Axle Cylinder

This is what allows the inner axle to spin.

- What material is straight and hollow?
  Consider straws or any type of tubing.
- Is the wheel cylinder axle big enough to slide the inner axle through?
- Is the wheel cylinder axle too big such that the inner axle wobbles a lot when spinning?

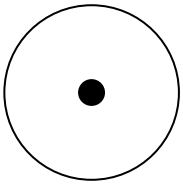
Assembling the Parts



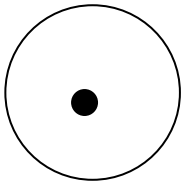
Read this entire page before jumping to building wheels and axles!!!

Wheels and Inner Wheel Axles

The axle needs to be centered as best as possible in the middle of the wheels. It is best to extend the axle a couple of centimeters outwards, as shown in the middle of this page. Further details and explanations will be provided later.

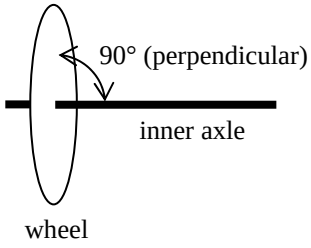


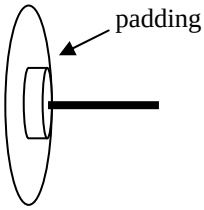
spins smoothly



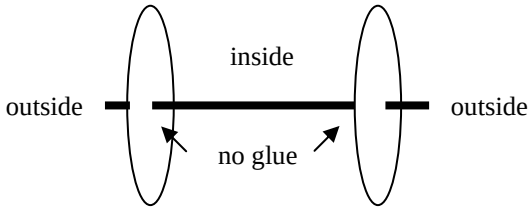
shifts up & down

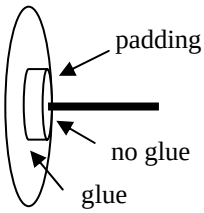
The wheels must be perpendicular to the axle. Else, the wheels would wobble as the racer moves. Padding helps to provide extra stability and less wobbling.





When gluing the wheels to the axle, **DO NOT** put any glue on the inner side where the inner axle will come in contact with the *Wheel Axle Cylinder*. For example, if you added padding to you wheels on the inner portion, you would glue the padding to the wheel but not where the padding comes in contact with the inner axle.

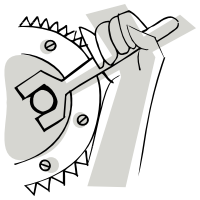




KEY!!!

Only glue ONE wheel on each axle (front and back one). If you glue both wheels on at this point, you will end up having to disassemble things to recreate new ones.

Assembling the Parts

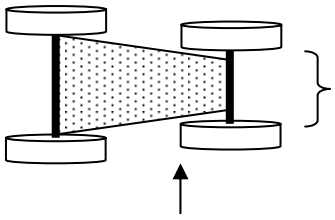


This portion is one of the most important concepts towards building a successful racer.
** This is only a design phase; so, **DO NOT** construct anything just yet. **

Structural Frame and Wheel Axles

Before continuing with the racer assembly, you must shift back into design mode.

- Where should the *Wheel Axles* be placed? How far up and down the *Structural Frame*?
  Things to consider
  Will the racer tip backwards?
  Does the front wheels hit the back wheels?
  Will the *Structural Frame* collapse in the middle? Is extra support needed?
- How wide should the *Wheel Axle Cylinders* be?
  You must be certain of the Wheel Axles' positioning, especially if you are using a Triangular/ Trapezoidal frame (see below). It is recommended that you pencil in exactly where your axles will be placed.
  Things to consider
  The cylinder should be at least wider than the width of the *Structural Frame*.
  It must be wide enough such that the wheels do not hit the *Structural Frame* when spinning.
  Do not make it too wide because the cylinder will lose some of its structural support and collapse or bend into the inner axle.



The ***Wheel Axle Cylinder*** is wide enough such that the back part of the front wheels and the ***Structural Frame*** do not collide.

possible contact between
Wheels and ***Structural Frame***

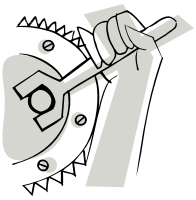
When you get to mounting the *Wheel Axles* onto the *Structural Frame*, the *Cylinders* **MUST** be parallel. Else, the Propelleracer will **NOT** go in a straight line but curve to one side.

The Physics behind the following considerations is concerned with the racer's distribution of weight.
A racer with its center of gravity:

- biased forward will result in less acceleration and harder steering
- biased backward will risk losing traction and/ or toppling backwards*
- biased to one side (left or right) will risk toppling over/ leaning towards one side and losing traction. This is true even if the front and back *Wheel Axles* are parallel.
- "just right" will have the best results

* Drag Racers best compensate for this by having smaller front wheels and a portion of the force pushing downwards.

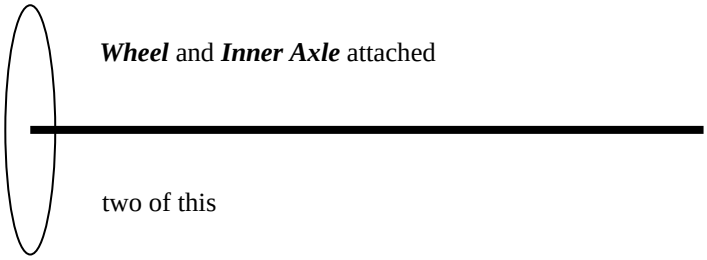
Assembling the Parts



You MUST complete the design portion for the "*Structural Frame and Wheel Axles***"** before continuing.

Wheels and Wheel Axles Revisited

You should have **TWO** *Wheels* with *Inner Axles* attached.

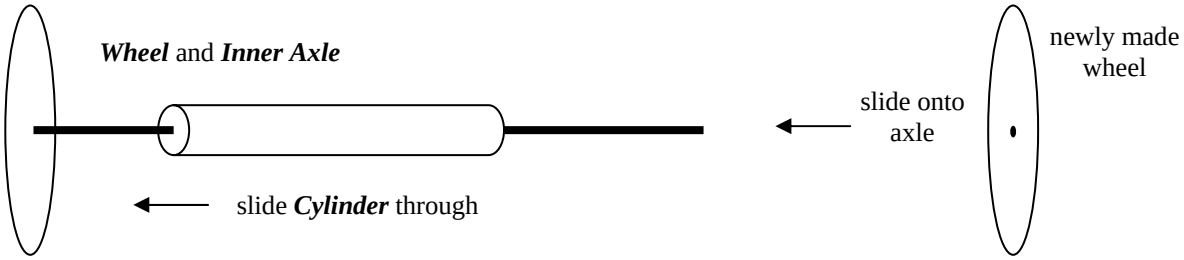


In the previous design phase, you decided on the placement of the *Wheel Axle Cylinder* and how wide it should be. You should now cut the cylinders to the length(s) desired.

If you have followed these instructions correctly, you should have two working wheels. Now, you will need to refer back to the "*Wheels and Inner Wheel Axles*" section **BUT** with a slight change to the instructions. **DO NOT** disregard this change.

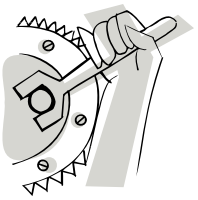
Reuse or find another Inner Axle to make the remaining wheels.
** Here is the change. **
Previously, you glued the wheels to the axle.
Now, **DO NOT** glue the wheels to the axle yet.
You are simply using the axle to make adjustments to the new wheels, such as centering them or making them perpendicular to the axle.

Now that you have your remaining wheels, you can assemble the *Wheels* and *Wheel Axles*.
Begin by sliding the *Cylinder* onto the *Wheel and Inner Axle*.
Next, slide the other wheel onto the axle.



DO NOT push the wheels together so tightly that the *Cylinder* cannot spin freely inside. Allow some room for the *Cylinder* to move back and forth.

Assembling the Parts

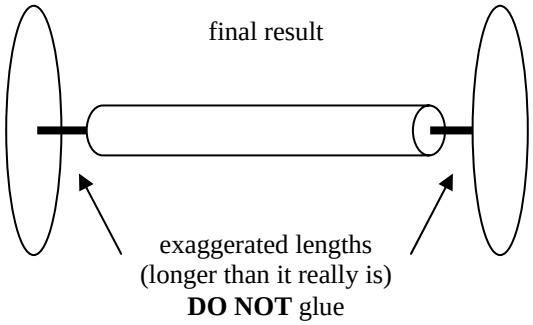


Wheels and Wheel Axles (Continued)

Glue the new wheel onto the axle. Remember **NOT** to glue on the inner side where the wheel touches the axle. Else, the wheels will not spin.

Trim/ cut off the excess length of the Inner Axle on the outside of the wheels.

Repeat for the other axle.



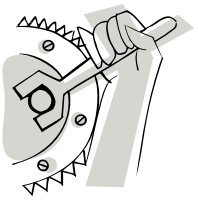
Structural Frame and Wheel Axles Revisited

Now, you simply mount the *Wheel Axle Cylinder* onto the *Structural Frame*. You can mount the *Cylinder* using glue, tape, or anything you can think of. The only true hassle that you may encounter is the wheels getting in the way.

If you had penciled in where you wanted the axles like recommended, this task is much easier. Simply refer back to the previous design section and review what the considerations were. Everything else is self-explanatory.

** Note ** If you chose to have a Suspended Wheels design, such as the Hybrid Drag Racer or Monster Truck, you **MUST** look at the next page before assembly.

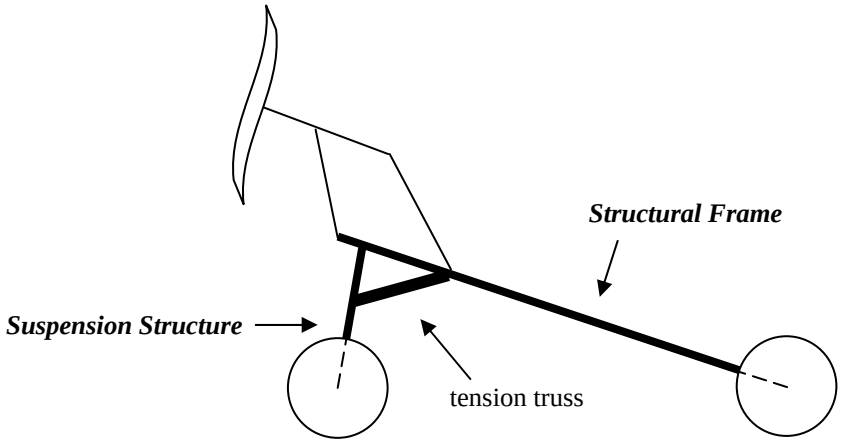
Assembling the Parts



Wheel Suspension (Skip this section if it does not apply.)

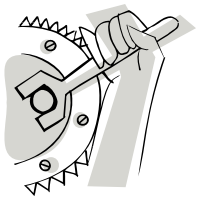
Wheel suspension simply means how high the wheels will be raised up.

- How high is too high?
  Higher suspensions mean less forward motion.
- How should the Suspension Support Structure be built?
  For a Monster Truck, the supports are straight down (perpendicular to the ground).
  For a Hybrid Drag Racer, the supports should be perpendicular to the *Structural Frame*
- How do you make the Suspension Support sturdier?
  Consider how a bridge is supported up.
  For a Drag Racer, the Suspension Support wants to shift backwards away from the center. Thus, a tension truss or bar holds the Suspension Support to the *Structural Frame*.
  For a Monster Truck, the Suspension Supports can shift either backwards or forwards and must be braced on both sides.



After building the Suspension Support Structure, you would attach the *Wheel Axles* to that structure **instead of** the *Structural Frame*. For a Hybrid Drag Racer, only the front axle is attached directly to the *Structural Frame*.

Assembling the Parts

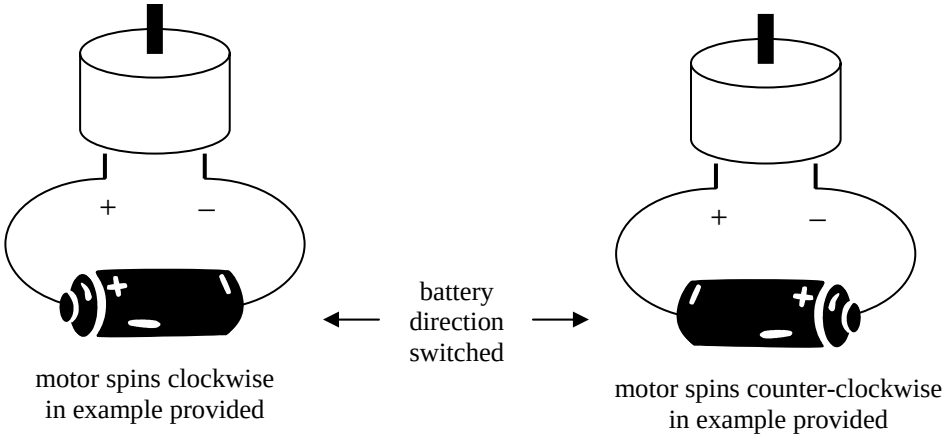


Getting the Propelleracer to Run!!!

Propeller and Motor

First, you must test the wind direction of the propeller. Is it designed to spin best in a certain way (clockwise or counter-clockwise), or is it the same in both directions?

After you have determined this, you should mount it **TEMPORARILY** to the motor to test the spin direction. If you reverse the wiring on the motor, it will spin in the opposite direction. For example, + to + and – to – causes the motor to spin clockwise. If you change this to be + to – and – to +, then the motor will spin counter-clockwise. Take note of the polarities (+ or –) in order to ensure that the Propelleracer moves forward rather than backwards.



motor spins clockwise
in example provided

motor spins counter-clockwise
in example provided

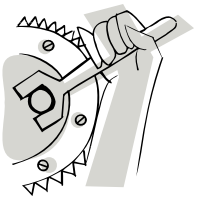
Now, attach the propeller permanently to the motor. Use hot glue or some other method to secure the two if they do not fit properly.

Propeller Support Structure

If the size of your propeller is smaller than your back wheels, you can mount the motor (next page) directly on the *Structural Frame* (no *Propeller Support Structure*). Else, consider the following:

- The *Propeller Support Structure* should be high enough such that the propeller does not hit the ground when spinning.
- The structure should extend back far enough so that the propeller does not hit the back of the *Structural Frame* or the back wheels.
- Use sturdy materials, such as cardboard, to make the *Propeller Support Structure.*
- The weight of the support structure **DOES** matter. If it is too heavy, your racer will tip backwards.

Assembling the Parts



Start Your Engines!!!

Motor and Batteries

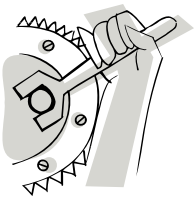
Refer to the diagram in the "*Propeller and Motor*" section on how to connect the motor and batteries. Be conscious about polarities (+ or –).

In general, more batteries mean more power. However, there is a limit on the number of batteries.

(Read this section only if you have time and are curious to why there is a limit.)

This explanation gets into the concepts of Electrical Engineering. When a battery, or voltage source, is connected to the motor in a complete circuit, something called *current* flows through the circuit. Current can be thought of as the power flowing out of the batteries and into the motor, but this is not the correct technical definition. Most motors can only handle a certain range of current before it "smokes." Similarly, circuit breakers found at home trip off when the current is too high, such as after a lightening strike. More advanced motors would have devices such as capacitors or diodes that automatically saturate the current or voltage levels. When something saturates, it has increased to a certain point and then remains constant or is steady. Thus, even if a hundred batteries were connected, the power produced would be the same as where the saturation level is, which may have been reached with five batteries. In other words, the ninety-five extra batteries do not add any extra power to the motor.

Assembling the Parts



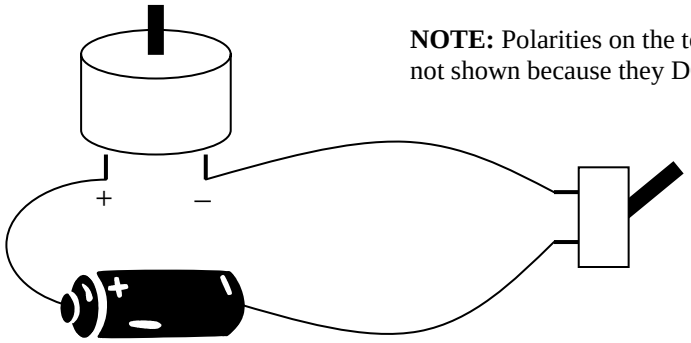
Toggle Switch (optional)

A toggle switch breaks the connection of a circuit, which essentially turns the system off. Once the switch is flipped on, the circuit is complete again and the system is turned on.

Read the CAUTION note below before you make any connections.

1. Connect the first wire directly between the BATTERY and the MOTOR. Be cautious of polarities (+ or –) and what the correct one is (refer to previous page).
2. Connect the second wire between the BATTERY and the toggle SWITCH.
3. Connect the third wire between the toggle SWITCH and the MOTOR.

CAUTION: Make sure the toggle switch is **OFF** when making the connections.



NOTE: Polarities on the toggle switch are not shown because they DO NOT matter.

NOTE: Polarity connections shown between the motor and batteries are only an example. Refer to the diagram in the "*Propeller and Motor*" section for the correct connections.