

## **Aerodynamic Investigation**

What is aerodynamic drag?

Aerodynamic drag or “wind resistance” is the resisting force that a moving object feels as it moves through the air. You probably know that air consists of oxygen, nitrogen, carbon dioxide, and other gases, so it is clear that air does have mass and is not “nothing”. As an object moves through air it will experience a resisting force proportional to the object’s speed and geometry. Since we want our cars to go as fast as possible, let’s look into how to reduce the drag due to the physical dimensions of the car.

There are two primary physical characteristics responsible for aerodynamic drag on a moving vehicle. The first is the “frontal area” of the car, or the cross-sectional size of the car as viewed head-on. The second is the shape of the car, or how “streamlined” it is.

## Aerodynamics Investigation #1: Nose cone

Aerodynamic drag can be demonstrated with an ordinary soda can. Since the soda can is lightweight and will slide easily on many hard surfaces, the friction forces on it will be low enough that we look at variations in the resistance from aerodynamic drag. If an object is relatively large and heavy, the friction forces are likely to far outweigh the aerodynamic forces unless the “wind” gets very strong. Most of us are not worried about our family’s cars blowing away when sitting in the driveway, but drag is a major factor in fuel efficiency when driving at highway speeds.

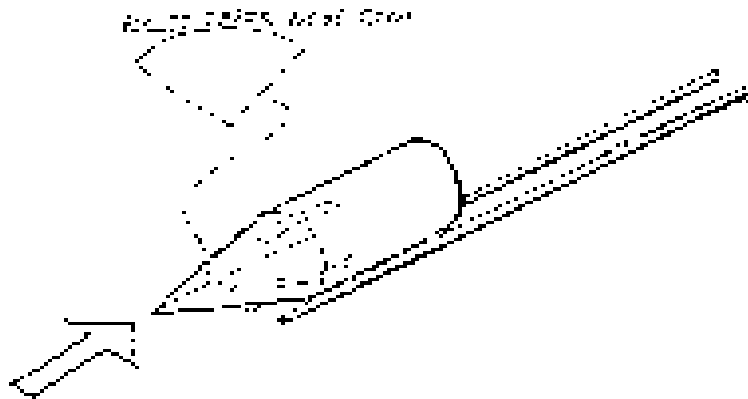
We can vary the car’s shape while maintaining it’s frontal area by using different lightweight shapes in the front of the can.

### Materials

- Soda can
- Sheet of ordinary paper
- Scotch Tape
- 2 half inch diameter wooden dowel rods three feet long

Set up the dowels as shown in the diagram and place the soda can on them at one end. Blow on the end of the can and see if it moves.

Now make a cone out of the paper, and tape it to the front of the can, so it looks like a rocket with a pointed nose cone.. Blow on the can with the nose cone again and see if it moves. What kind of resistance forces would this can feel if it were on a moving vehicle? As compared to the flat face can?



## Aerodynamics Investigation #2: Roll down test

Roll-down tests are used by some automobile manufacturers, race car builders, and car testing organizations (among others) to test the aerodynamic drag of a car. The idea is to roll a car (with the engine turned off and out of gear) down a hill, and see how far it rolls. A car with more drag (for example, a car with a parachute behind it) will roll to a stop faster (or after a shorter distance) than a streamlined, low drag car.

### Materials

Ramp

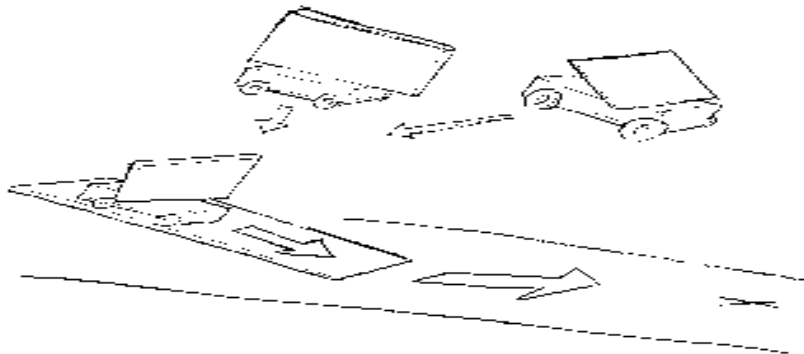
One miniature car

(a small toy car and track may also work)

Different car profile shapes to put on the car

(blocks, streamlined shapes of paper, sheets of foamcore, etc.)

- Set up the ramp and release the car from the top until it repeatably rolls to the same place.
- Repeat with different frontal areas, keeping the car weight constant. Use one which has a very large frontal area.
- Try out different streamlined shapes as you did with the nose cone on the soda can. Be careful to keep the other variables constant.
- Why is it invalid to use different test cars? What other physical properties can affect the amount of distance traveled?



How can you reduce aerodynamic drag in your car?

- What effect would a streamlined body or nose cone have on the car's top speed and its acceleration? How can you build an aerodynamic shape?
- The roll-down test is a good tool that can be used to fine tune the aerodynamics of the final solar car design. Leave enough time to work on the aerodynamics.

Everyday examples of aerodynamic drag:

Aerodynamic drag is considered in many facets of modern life where high speeds are demanded relative to the power source provided.

- Semi tractor-trailer trucks now have a "fairing" above the cab to streamline the trailer. Truckers find that the added cost of the fairing is easily offset by the savings in fuel.
- When coasting down a hill on a bicycle, crouching down reduces the frontal area, and prevents the rider's body from acting like a sail (or parachute).
- Birds and fish have streamlined bodies to slip through air or water with minimal effort. Water drag is very similar to aerodynamic drag; the same rules apply, but the effects are seen much sooner in water. (Is it easier to swim through the water headfirst presenting a small frontal area or to walk in chest deep with a large frontal area?)
- Airplane and ship profiles are designed to minimize drag as much as is reasonably possible, to increase fuel economy.
- Ships have barnacles (clam-like crustaceans which attach themselves to anything solid in the water, including whales and ships) periodically removed from their bottom surface to make them smoother and reduce their drag when moving through the water.