Friction Investigation #1: Friction Between Axles and Bearings of Various Materials

Objective

To determine what materials to use for axles and bearings that will minimize friction in a model solar car

Materials

Plank of wood that can be lifted at one end

Small objects and sheets of various materials

Ruler

Lubricants: oil, graphite, soap, etc.

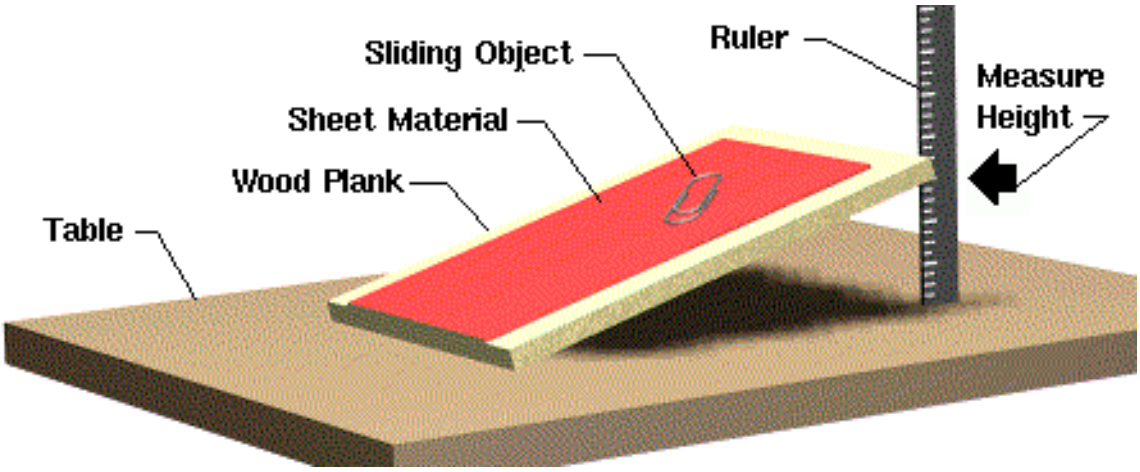
Procedure

1. Introduce the lesson by explaining that friction is a resisting force between two materials that are in contact and moving past each other, in other words, the sticking force between two objects being rubbed together. In a solar car, the wheels and axles have friction when they turn with respect to the chassis. Minimizing this friction will let the wheels spin more freely, resulting in a faster car.

The interface between the axle and the chassis is called the “bearing.” A plain bearing can be as simple as an axle in a hole, or it could be a bushing. A bushing is a smooth sleeve in the hole that gives the axle a low friction surface to run on. A “ball bearing” is a set of balls in the hole that are arranged so the axle rolls on the balls instead of sliding in a sleeve. Ball bearings are found in many familiar devices such as bicycles, rollerblades and skateboard wheels. Ball bearings have the least friction, but they are expensive, and more difficult to use than plain bearings and bushings. For these reasons, most Junior Solar Sprint cars use plain bearings.

2. To choose the best materials for axles and bearings (e.g. metal axle in a wood bearing) instruct students to obtain samples of the different materials and test the friction between them. To test, put an object made of the first material on a sheet of the second material, then tilt the sheet until the object starts to slide and note the angle of the sheet. For example, to test metal on wood, put a piece of metal

on a plank of wood and tip up the wood until the metal piece moves. Measure the height of the end of the plank so you can compare it to the next sample and record the results. (See figure below.)



This test will help determine at what angle a sample piece of material starts to slide. The steeper the hill, the more friction there is between the test piece and the material covering the slope. The more friction, the worse those materials are for bearings. The lower the friction, the sooner the object will start to slide and the smaller the angle will be.

One interesting feature of this test is that the weight of the object is not important. A steel paper clip will start sliding at the same angle as a heavy steel object.

3. Try different materials and record the results.

4. Try different lubricants such as soap, oil, graphite, or pencil lead and see what happens. Which work best on which materials? Keep in mind that it can be difficult to un-lubricate something if it doesn't work, so test a scrap piece of material using this friction test before lubricating your car if you are not sure.

5. Conclude with a discussion based on the idea that selecting two materials that "run" well together for the axles and bearing in the model solar car will mean that less power will be used to overcome the friction and more will go towards driving the car faster.

Sources: Adapted from *Junior Solar Sprint: Classroom Investigations*, by Andrew Heafitz for NREL, 2001; and materials created by Rick Butchart for the Chimacum School District in Washington; used with permission.