

## Rutherford Roller

What's underneath?

### Introduction:

A hidden object is located under a sheet of cardboard. Students roll marbles under the cardboard to find the location and the shape of this object. This lesson is meant to be an analogy to Rutherford's famous experiment in which he deduced the existence of the

atomic nucleus. It can also be used as a "black box" activity.

### Materials:

Film cans - 4 or 5 per set up

Glue - hot glues seems to work well for this

Cardboard - at least 16" by 16" (40cm by 40cm)

(Masonite can substitute for the cardboard to make a sturdier device.)

Rulers

Marbles

Various shaped pieces of wood or other material -

See assembly to get ideas (Shapes shouldn't be smaller than the size of a film can.)

### Optional:

Velcro

PVC pipe

Butcher Paper

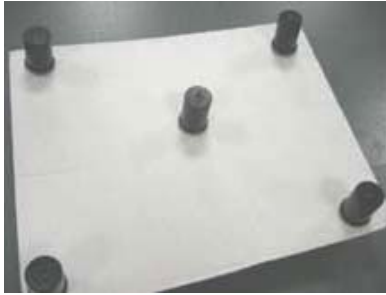
### Assembly:

1. Glue the caps of the film cans in each corner of your cardboard. Insert the body of the cans into the caps. These will be the legs of your device (The legs of your device are also detachable for easy storage).

2. Pick a shape to be the unknown object. Plain shapes work best. This object can be made of any material, but needs to be cut to the appropriate dimensions.



This shape should be the same height as the film cans.  
This unknown shape should be located close to the center of the device so that it will not be visible when the device is flipped-over.  
Glue or Velcro the shape into place (velcro-ing allows for changing the unknown shape and for easier storage of your device).



Optional - You may also use a film can as your unknown object. This allows your device to be totally collapsible for storage. You can also place several film can caps in different locations so that you can move the unknown.

Flip the device over and you're ready to start.



#### Optional- Marble roller:

Since you will be rolling marbles under this device, it is recommended that the balls roll straight. Rolling by hand often causes the balls to roll in unexpected directions.

Here are suggestions for rolling marbles straight:

A) Place the marble in the groove of an elevated 1-foot ruler. Use the ruler's groove to guide the marble as it rolls.

B) Place the marble in a short piece of PVC pipe. Elevate the pipe and let the ball roll down.



#### To do and notice:

Students should roll marbles under the cardboard to find out what's under it.

The two basic questions are:

**What's the shape of the object?**

**Where's the object located?**

There are two rules for this activity:

**-They may not look under the cardboard until instructed.**

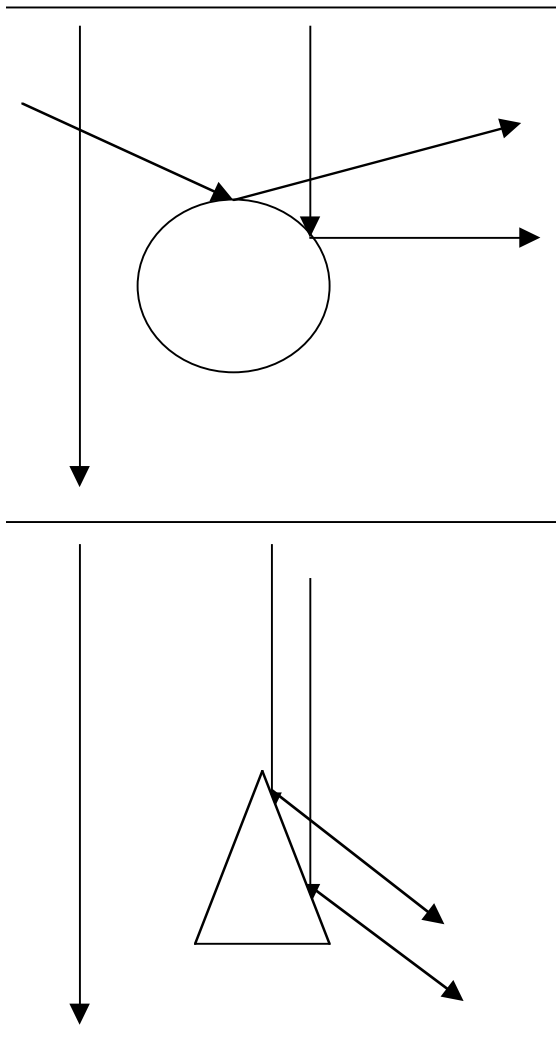
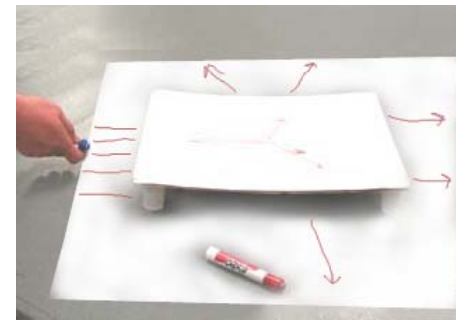
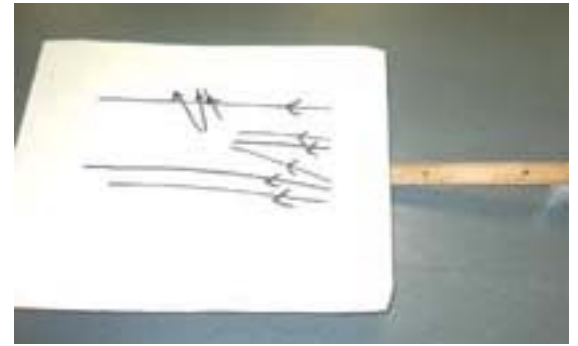
**-They can only roll marbles under the cardboard to figure out what's there.**

Students can be introduced to ways of collecting data. A recommend method for collecting is data is to draw lines that show where the marble enters its journey under the cardboard and where it exits from under the cardboard. Since you can not look under the cardboard, the lines represent inferred paths of travel.

Two common techniques are used to draw the inferred travel vectors of the marbles.

One method is to place a piece of paper on top of the device and draw the line on this sheet (see upper drawing to the right).

Another method is to place the device on top of a sheet of butcher paper and draw the lines here (see lower drawing to right). When finished, the device can be lifted and the lines can



be extended to show where the shape might be located.

#### Optional Pre- activity:

Students may not be familiar as to how marbles roll and bounce off of other objects. It is a good idea to have students practice rolling marbles at various shaped objects and observe their directions of travel. If you have a class set of devices, one way to do this is to flip the devices over so that the shapes are exposed. Have students roll marbles and note how the balls move. Discuss with them angles of reflection and incidence. When ready for the main lesson, flip the devices over and redistribute them around the room.

#### What's going on:

The marbles can tell you about what's under the cardboard by the way they scatter. You can make a really good guess about an unknown even if you can't see it.

Ernest Rutherford conducted a similar experiment with his colleagues in Cambridge. Instead of marbles, he used alpha particles and instead of a piece of cardboard, his objects were hidden inside of gold foil. In his famous gold foil scattering experiment, Rutherford shot alpha particles at the atoms in the foil. What he found was many of the alpha particles were scattered by something small and heavy inside the gold atoms. He concluded that atoms have nuclei. \*

\* The Latin definition of nucleus is kernel or little nut.

Credits: This activity was first presented to me by Mike Shulist at the 2002 Summer Teacher Institute