

Rolling like Rutherford Lab

Background:

The purpose of this activity is to discover the size and shape of an unknown object hidden underneath the middle of a large board (“Gold Foil Device”). This activity simulates Rutherford’s gold foil experiment wherein he directed positively charged alpha particles at a thin gold foil. Most of the alpha particles penetrated the gold foil and were detected on the other side. However; a few of the alpha particles actually reflected back toward the source or “scattered” due to the encounters with the metal atoms in the foil target. The number of alpha particles that were reflected back to the source depended on the atomic mass of the metal. Gold atoms, having the highest atom mass of the metals that were studied, gave the largest amount of reflections.

Pre-Lab Questions:

1. The key skill in this activity is the ability to make careful observations and to draw reasonable hypotheses. Assume that the marble strikes the following sides illustrated in the figures below. Sketch the path the marble might be expected to take in each scenario.

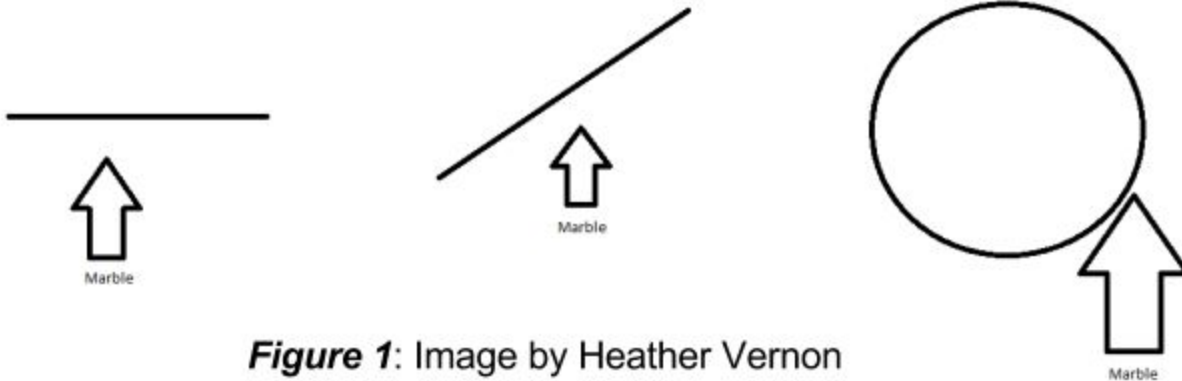


Figure 1: Image by Heather Vernon

Materials: • Marbles • Gold Foil Device • Large piece of construction paper

You may NOT look inside the wooden pieces.

Objective: To determine the shape in the center of the apparatus.

Hypothesis: As a group, determine the number of trials you think it will take to accurately determine the shape in the apparatus.

If _____ trials are taken, then the shape inside the device can be determined.

Procedure:

1. Write the number of trials next to your group number on the board.
2. Place large piece of paper on top of Gold Foil device. This is where you will collect your data. Carefully write the model number in the corner (Model A, B, C, D, E, or F.)
3. Be strategic when you decide where to shoot your marbles. To collect data draw lines that show where the marble enters and where it exits. Remember: You cannot look under the gold foil device, so the lines represent inferred paths of travel.
4. If, as a group you decide to change the number or trials you need, feel free to do so. Please update the board.
5. You are finished when your group has agreed upon the shape and are confident in your conclusion.

Conclusion: Please complete the sentence starters below to write your formal conclusion. Make sure that your conclusion is in the *past tense* and *third person*.

The objective for this lab was to _____
_____. The hypothesis was if _____ trials
are taken that the shape inside the device could be determined. After _____ trials and
analyzing the data, it was determined that shape inside of the device was _____.
Evidence collected during the lab that supportst this claim was _____
_____.

This evidence supports that the shape is _____ because _____
_____.

Error Analysis: Your teacher will write the 9 possible shapes on the board.

1. In looking over the classes results, how confident are you in your process of determining your shape? Give a percentage confidence and use details from the data to support your thinking.

2. If you could go back, how would you change steps in the procedure to increase your confidence in your results and claim? Why would the proposed changes help?

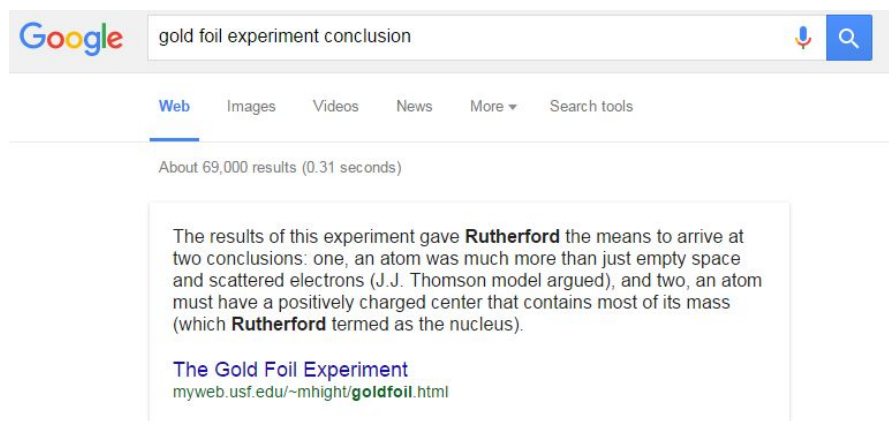
Post-lab Reflection:

1. Suppose two groups determined that they both had the rectangle shape. Clearly, both models could not have had the same shape. What could the groups do to resolve this?

2. The following is a Google search about the conclusions Rutherford made from the Gold Foil Experiment. Support each claim with evidence from the experiment.

Claim 1: The atom is mostly empty space.

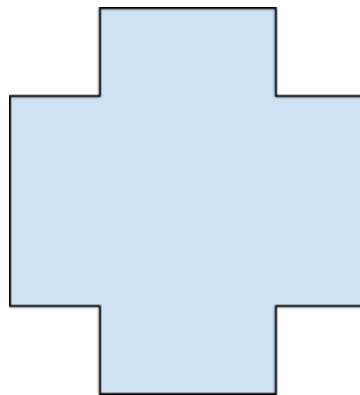
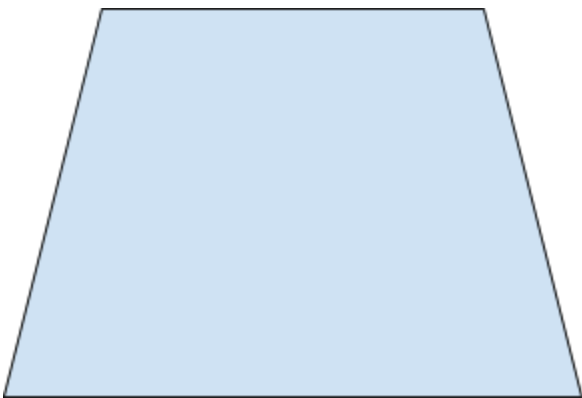
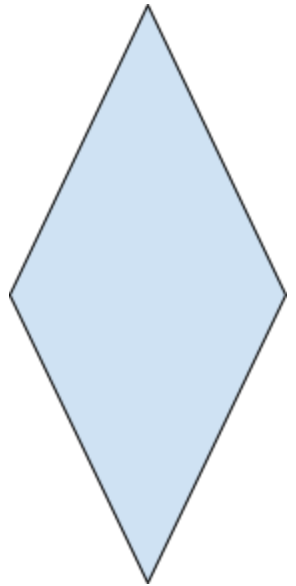
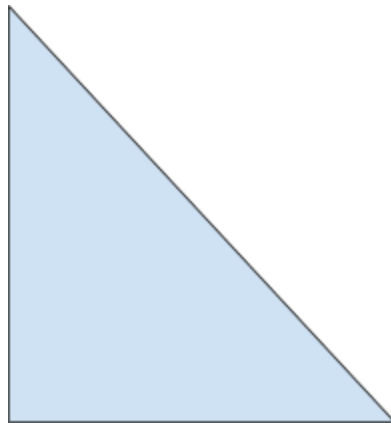
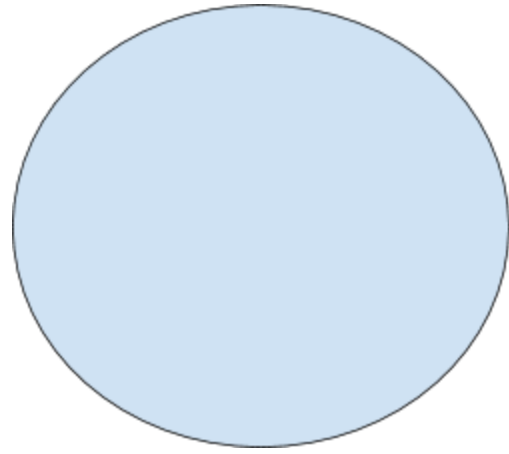
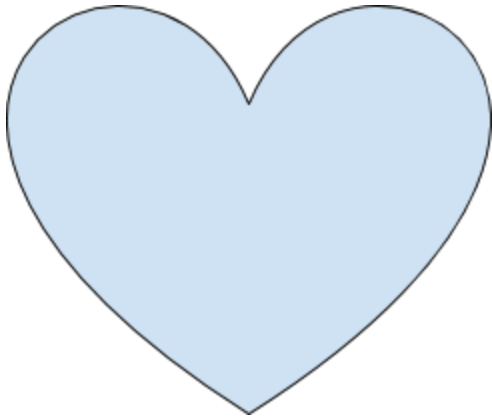
Claim 2: The atom must have a positively charged center that contains most of the mass.



The screenshot shows a Google search interface. The search bar contains the text "gold foil experiment conclusion". Below the search bar, there are tabs for "Web", "Images", "Videos", "News", "More", and "Search tools". The search results show "About 69,000 results (0.31 seconds)". A featured snippet is displayed, stating: "The results of this experiment gave **Rutherford** the means to arrive at two conclusions: one, an atom was much more than just empty space and scattered electrons (J.J. Thomson model argued), and two, an atom must have a positively charged center that contains most of its mass (which **Rutherford** termed as the nucleus)." Below the snippet is a link titled "The Gold Foil Experiment" with the URL "myweb.usf.edu/~mhight/goldfoil.html".

Feedback

Possible Shapes



Instructor Notes:

There are 9 different apparatus and each one has a different shape. You can choose to make the lab more complex or simple by choosing which apparatus to use.

Set Up:

Have kids read the background and answer the pre-lab questions. Go over the answers for the questions emphasizing how the marble will reflect and how to document the data.

Demo how to collect the data by drawing the incoming and outgoing pathways (just like the pre-lab).

Then give one large piece of paper and ask them how many trials (shots) they think they will need to figure out the shape inside. (At this point I don't tell them anything about the shapes!) Have them fill in the table I have written on the board. Once they write it on the board, then give them the marble.

Students can always change the number of trials they take by updating the board. When students are confident in their shape, have them write their shape on the board (and/or draw it)

After most of the groups have all put their shapes up, I stop and have the kids present to the class what shape they visualize (or what information they feel strongly about), give their data, then their reasoning. I don't use claims, evidence, and reasoning vocabulary until after the 3rd group has shared. At this point, I expect that some groups have identified the same shape. Sometimes kids come up with alternative testing methods... AWESOME! As long as it does not involve looking at the shape or damaging my structures I am ok with it. Kids typically use pencil or ruler probes, great. I always get asked about taking pictures. I tend to let the kids after they have used the marbles. They still need to put the 4 images together, so I figure it is like an xray.

Apparatus #	# Trials	Shape
1		
2		
3		
4		
5		
6		
7		
8		
9		

Possible questions:

- *What are some shapes that could be easily confused for one another? How can you eliminate one?*
 - *triangle and a diamond*
 - *square, rectangle, and trapezoid?*
- *More than one group identified a circle. What can we do to clarify which is the circle and what the other shapes are?*
- *Is more trials always going to give you better data? Explain?*
- *What other tools/methods could we use to identify the shapes? (without looking!) Possible answers... probes like rulers/pipe cleaners, lasers, etc., taking a picture, using a flashlight for a shadow*

Apparatus #	Shape
1	(Right) Triangle
2	Square
3	Heart
4	Circle
5	Trapezoid
6	Diamond/Rhombus
7	U
8	Rectangle
9	Plus