



What is Inquiry? Inquiring Minds Want to Know

Dr. Arthur Eisenkraft

Thursday, May 12, 2011

6:30 p.m. to 8:00 p.m. Eastern time



The Guillotine Story



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The Kaila Factor

$$\text{Kaila Factor} = \frac{\text{atomic number}}{\text{phase of matter (1,2,3)}}$$

1 = solid
2 = liquid
3 = gas

$$\kappa = \frac{A}{\phi}$$

- Helium
- Carbon
- Mercury
- Zirconium



Warm Feedback

- *What did you like about the lesson?*

1)

2)

3)

4)

Please raise your hand to volunteer!



Cool Feedback

- *What didn't you like about the lesson?*



1)

2)

3)

4)

Please raise your hand to volunteer!



Movies and books

- Why was there interest?
- What did you want to find out?
- What was the puzzle?
- Where was the tension?





Interest

- *What kept your interest in the Wizard of Oz or ET?*

Type your responses in the chat!



The Puzzle

- *What was a puzzle in the Wizard of Oz or ET?*

Type your responses in the chat!



TheTension

- *When was there tension in the Wizard of Oz or ET?*

Type your responses in the chat!



Movies and books

How do you maintain

- Interest
- Tension
- Puzzle

when the ending is
known to all?

- Titanic





Movies and books

How do you maintain

- Interest
- Tension
- Puzzle

when the ending is
known to all?

- Titanic
- Gravity





Textbook stories

- “We got it right”
- If mystery books were written in the way that science texts were written
- Where is
 - The mystery?
 - The puzzle?
 - The desire to find out?



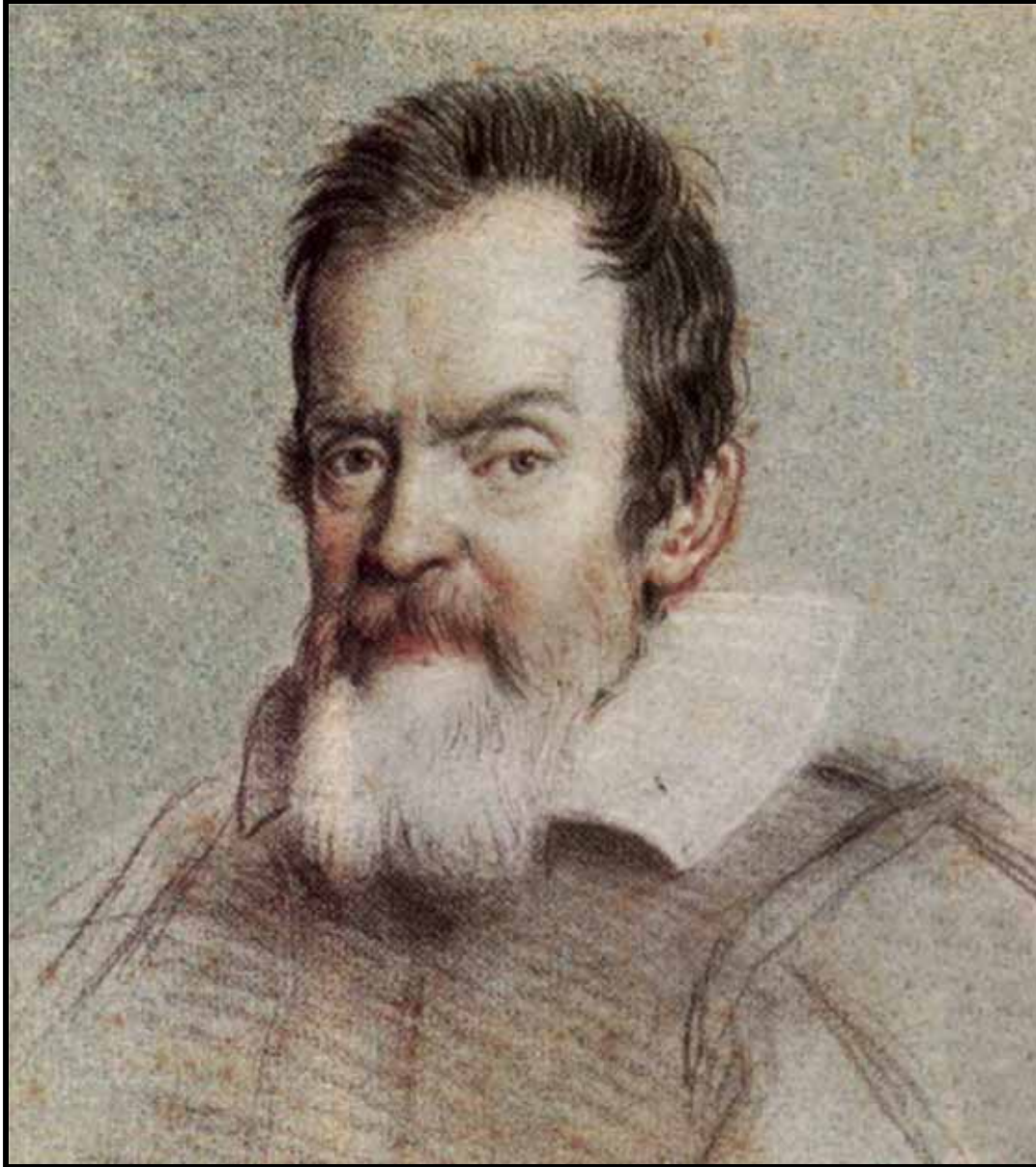
The Pendulum Lab





Have you ever had students complete a pendulum lab?

- A. I have very little familiarity with a pendulum.
- B. I know something about pendulum but have never completed a lab.
- C. My students have completed this lab.
- D. My students complete this lab every year.
- E. I know EVERYTHING there is to know about pendulum labs.



The chandelier in
church

Observations

The chandelier
becomes a
pendulum

The pendulum
becomes a clock



The Pendulum Lab

- Without inquiry
 - The long pendulum has a longer period
 - The mass doesn't matter
 - Complete the data chart and make a graph

Length	period



The Pendulum Lab

- With some inquiry

Type on the chat ways you could change the pendulum lab to create 'some inquiry'.



The Pendulum Lab

- With some inquiry
 - Every team gets a different length of cord with a different mass attached.
 - Measure the time it takes for your pendulum to swing back and forth 10 times.
 - Compare results
 - Why aren't they all the same?
 - Can you find a way to **predict** the time for a pendulum of a given length and some mass?

The Pendulum Lab

- With inquiry
 - The story of Longitude (Dava Sobel)
 - The thorniest scientific problem of the eighteenth century was how to determine longitude. Many thousands of lives had been lost at sea over the centuries due to the inability to determine an east-west position. This is the engrossing story of the clockmaker, John "Longitude" Harrison, who solved the problem that Newton and Galileo had failed to conquer, yet claimed only half the promised rich reward.

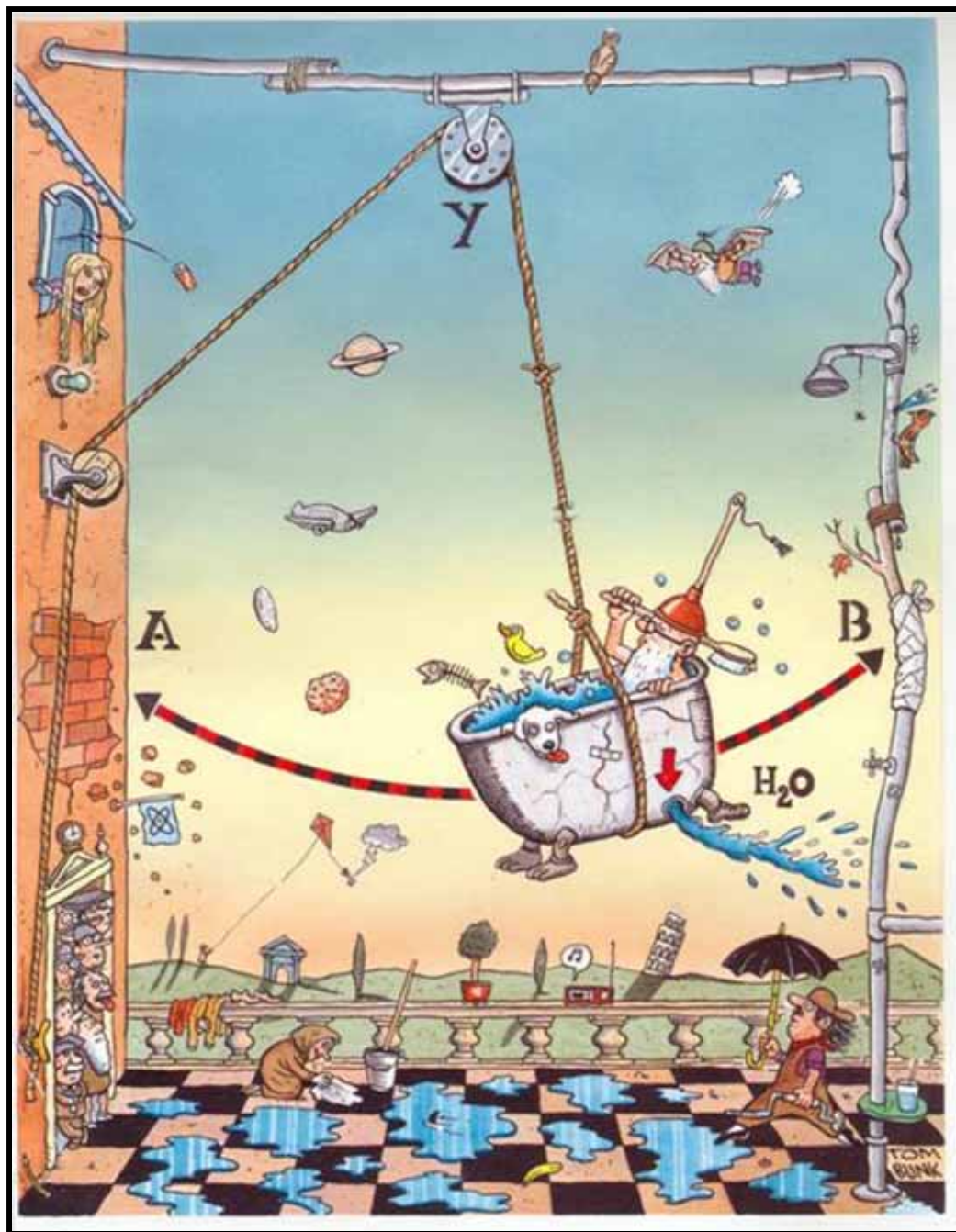




The Pendulum Lab

- With inquiry
 - How does it work?
 - Can you get a pendulum to swing at the rate of 1 second per swing? 1 second every half swing?
 - Here is some string and some masses.
 - Good luck.



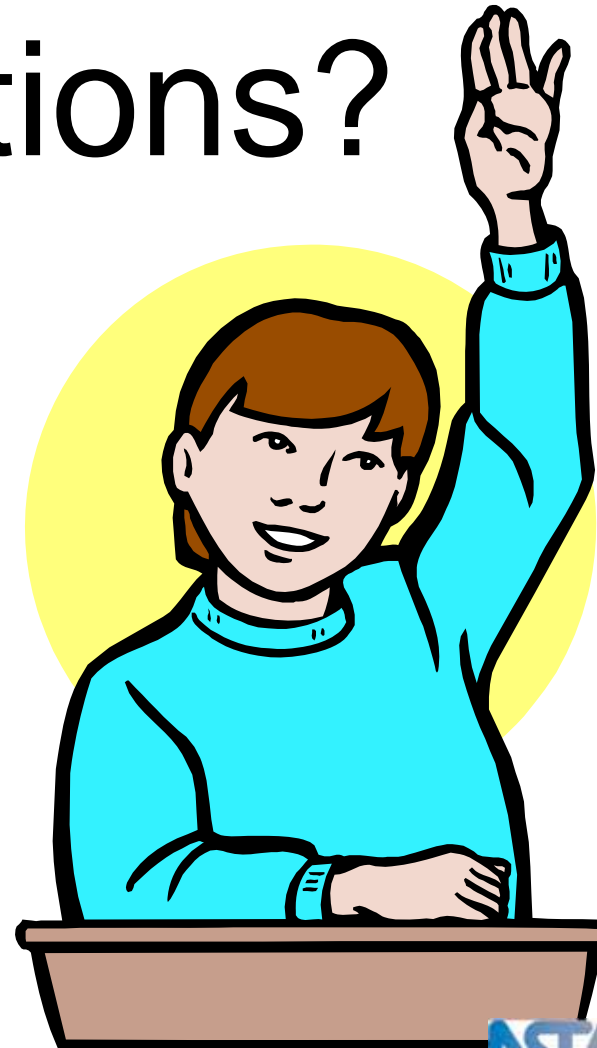


The Pendulum Lab

(illustration from
Quantoons)
www.nsta.org



Questions?





What do you know about density?



- A. I have never studied density.
- B. I know something about density but have never completed a lab.
- C. I can determine the density of a material in the lab.
- D. My students complete this lab every year.
- E. I'm a "density" expert.



Density



What is the crucial understanding of density that you want students to have?

1)

2)

3)

4)

Please raise your hand to volunteer!



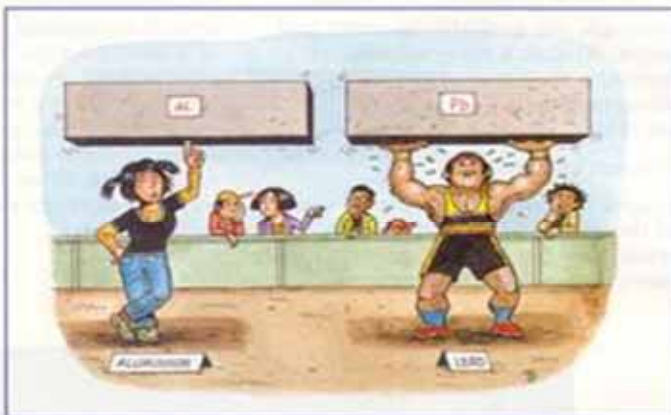
Textbook stories

- Density in many textbooks.
- What's wrong?



Activity 5

Mass and Volume



GOALS

In this activity you will:

- Determine the densities of various liquid and solid materials.
- Make measurements in the laboratory to the precision of the instruments used.
- Learn the difference between accuracy and precision in experimental measurements.
- Retain significant figures in calculations involving experimental measurements.
- Use density measurements to determine the identity of a material.
- Locate sources of the variation in the class's experimental results.

What Do You Think?

A piece of steel sinks in water, but a steel boat floats. A tiny rock sinks in water, but a large log floats.

- Since a kilogram of feathers and a kilogram of lead have the same mass, how do they appear different and why?

Record your ideas about this question in your *Active Chemistry* log. Be prepared to discuss your responses with your small group and the class.

Investigate

Part A: Mass and Volume of Liquids

1. In your *Active Chemistry* log create a table to record your data for this part of the activity. You may wish to use a table similar to the one on the opposite page.

Density study in most textbooks

Density as an inquiry activity

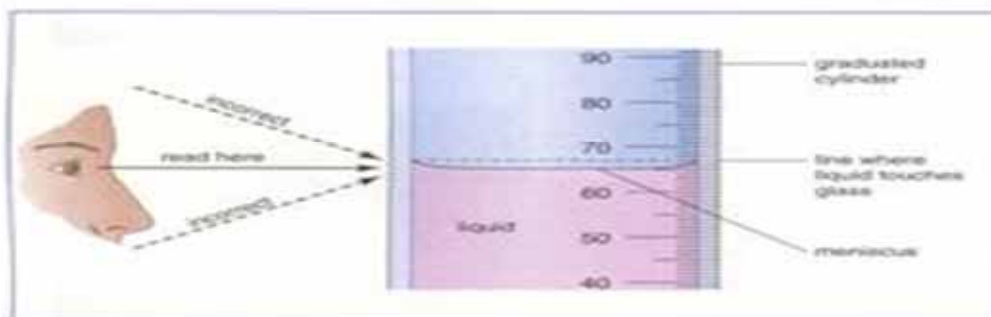
3.

Volume and Mass of Water				
Mass of graduated cylinder (g)	Volume of water (mL)	Mass of graduated cylinder and water (g)	Mass of water (g)	Mass/Volume (g/mL)

2. Measure the mass of an empty, dry, graduated cylinder.

a) Record the mass of the cylinder in your *Active Chemistry* log.

3. Add 10 mL of water to the graduated cylinder. Remember when reading the volume, take the reading at the lowest part of the meniscus, as shown in the diagram.



a) Record the volume of water in your table. Remember to consider the precision of your measurement when recording your data.

4. Measure the mass of the graduated cylinder and 10 mL of water.

a) Record the measurement in your log.

b) Calculate the mass of the water and record this in your table.

5. Add another 10 mL to the graduated cylinder and measure the mass. Calculate the mass of 20 mL of water.

Repeat this step for 30 mL, 40 mL, 50 mL, and so on up to 100 mL.

a) Record all your measurements and calculations in the table in your log.



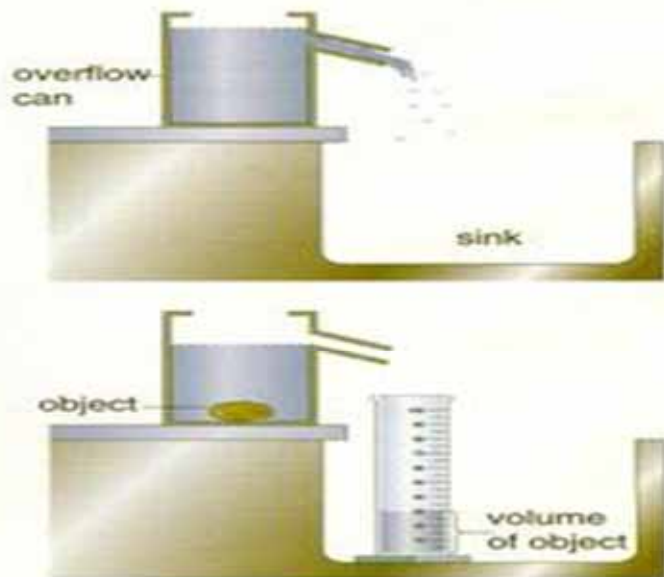
6. Use the data you obtained.
 - a) Plot a graph of the mass versus the volume of water. Plot volume on the *x*-axis (horizontal axis) and mass on the *y*-axis (vertical axis).
 - b) As the volume of the water increases, what happens to the mass?
Since the graph you created is a straight line (or close to a straight line), you should draw the best fit line through the data points. Do not connect the points with small segments but draw one line that comes closest to all of the individual points.
 - c) From your graph predict the mass of 55 mL of water. What would be the volume of 75 g of water? Predicting data from within a graph is called interpolation.
 - d) An important attribute of a straight line graph is its slope. How steep is the graph? Calculate the slope of the graph you plotted. Remember to calculate slope you divide the "rise" by the "run." What does the "rise" of the graph represent? What does the "run" represent?
 - e) Divide the mass of each sample of water by the volume. What do you notice about the relationship between the mass and the volume?
How does the slope of the graph compare to the values you calculated in this step?
7. Your teacher will provide you with a sample of a liquid.

Use the procedure you used to find the mass and corresponding volumes of water to determine the slope of this liquid's mass/volume graph.

- a) Record all your data and calculations in your *Active Chemistry* log.
8. Dispose of your liquid sample as directed by your teacher. Clean up your work station.

Part B: Mass and Volume of Solids

1. Your teacher will provide you with three samples of two different solid materials.
2. As a group, decide on a procedure to calculate the mass/volume ratio and slopes of the graph of each material.



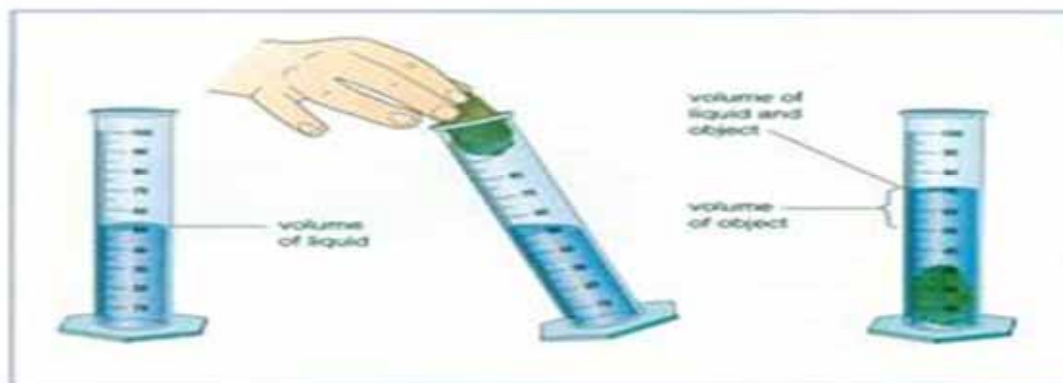
You can consider using either method shown in the diagrams on the preceding page and at right for measuring the volume of each solid. Volume of solids is usually expressed in cubic centimeters. One milliliter is equivalent to one cubic centimeter ($1 \text{ mL} = 1 \text{ cm}^3$)

- Record your procedure in your *Active Chemistry* log. Be sure to include what measurements you need to make, what equipment you will need, what safety precautions you must use, and what calculations you have to do.

When your teacher has approved your procedure, carry out your activity.

- Carefully record all your data. Use the data you collected.
- Plot a mass versus volume graph for each solid. Plot both solids on the same graph.
- How do the slopes for the two solids compare? Which solid is more dense?
- Use the table in the *Chem Talk* reading section to identify the two samples of materials.

The mass of a unit volume of a material is called its density. You found the density of water by calculating the slope of the mass versus volume graph. You can also



calculate density by dividing the mass of a sample of a material by the volume.

$$\text{Density } (D) = \frac{\text{Mass } (M)}{\text{Volume } (V)}$$

- Find the densities of water, the other liquid, and the two solid materials.
- Compare your answers with another lab group.

Part C: Density and Special Effects

- Your teacher will display a set of four colored liquids that float on one another. The densities of each of the liquids were measured. The top layer has a density of 0.8 g/mL . The next layer has a density of 0.9 g/mL . The following layer has a density of 1.1 g/mL . The bottom layer has a density of 1.3 g/mL .
 - What do you notice about the densities of the liquids and their position in the display?



2. Your teacher will drop a pen barrel of a density of about 1.2 g/cm^3 into the liquids.
 - a) What would you predict will happen to the pen cap? Write your prediction in your *Active Chemistry* log.
 - b) Observe the movement of the pen cap as your teacher places it in the liquid. Record your observation in your log.
3. You will now make a pen cap float in liquid.

Place the pen barrel in a beaker of ethanol.

Next place the pen barrel in a beaker of distilled water.

Return the pen cap to the beaker of ethanol. Slowly add distilled water to the ethanol until the pen barrel floats.

- a) Before you begin, predict what you think will happen in each part of this step. Give a reason for your prediction.

ChemTalk

DENSITY

Density as a Property of Matter

If you were to compare a 1 cm^3 cube of iron to a 1 cm^3 cube of wood, you would probably say that the iron is "heavier." However, if you compared a tree trunk to iron shavings, the tree trunk is obviously heavier. As you discovered in this activity, a "fair" comparison of the "heaviness" of two materials is a comparison of their densities.

Density is the mass per unit volume of a material. In this activity you measured the density of water and other liquids. You found that each sample of the same liquid had the same density and each different liquid had its own characteristic density. You also found that each solid material you investigated had its own characteristic density. Density can be expressed in grams per milliliter (g/mL) or grams per cubic centimeter (g/cm^3). The table on the next page shows the densities of some common liquids and solids.

You used the slope of the mass versus volume graph of a material to calculate density. You also calculated density using the equation:

$$\text{Density (D)} = \frac{\text{Mass (M)}}{\text{Volume (V)}}$$

Chem Words

density: the mass per unit volume of a material.

Density and Flotation

In this activity you further observed that materials with a greater density than a given liquid will sink, and materials with less density than a given liquid will float. In the column of colored liquids, the liquid with the highest density was on the bottom, and the liquid with the lowest density was on the top. The pen barrel sank in ethanol and floated in water. When you added ethanol to the water you created just the right density to have the pen barrel float within the liquid. This position of floating is where the density of the pen barrel is equal to the density of the ethanol/water. The pen barrel "found" the place where the density of the liquid was identical to the density of the pen barrel.

Approximate Densities of Some Common Liquids and Solids

Material	Density (g/cm ³)
wood (balsa)	0.12
wood (birch)	0.66
gasoline	0.69
isopropanol	0.79
vegetable oil	0.92
distilled water	1.00
glycerol	1.26
magnesium	1.70
aluminum	2.70
iron	7.90
copper	8.90
nickel	8.90
silver	10.50
mercury	13.50
gold	19.30





Chemistry to Go

1. Look at the table in the Chem Talk reading section. Use density to identify the liquid and solid samples you investigated in this activity.
2. Calculate the density of a solid from the following data:

Volume of water	48.4 mL (or cm^3)
Volume of water and solid	62.7 mL (or cm^3)
Mass of solid	123.4 g
3. Determine the density of a liquid from the following data:

Mass of the graduated cylinder	33.79 g
Mass of the cylinder and liquid	40.14 g
Volume of liquid	13.3 mL
4. Methanol has a density of 0.79 g/mL . How much would be the mass of 589 mL of methanol?
5. Copper has a density 8.90 g/cm^3 . What would be the volume of a 746 g sample of copper?
6. In a well-known movie, there is a famous scene in which the hero tries to outwit the designers of a trap by replacing a gold statue with a bag of sand of about the same volume.
 - a) Given the density of gold is 19.3 g/mL and sand is 3.1 g/mL , does this seem like a scientifically reasonable plan?
 - b) In the movie, the hero grabs the gold statue with one hand and appears to handle it quite easily. Given that the volume of the statue appears to be about one liter, what would be the mass of the statue?
 - c) A mass of 454 g has a gravitational weight of about 4.45 N (newtons) which is about 1 lb. How many pounds would the statue weigh?
 - d) One gallon of milk has a mass of 3.7 kg and a weight equivalent of approximately 8 pounds. How many gallons of milk would be equivalent to the gold statue?
7. In each of the following pairs, which has the greater mass?
 - a) 1 kg lead or 1 kg feathers?
 - b) 1 L gold or 1 L water?
 - c) 1 L copper or 1 L silver?

8. Which of the following has the greater volume:
 - a) 1 kg lead or 1 kg feathers?
 - b) 1 kg gold or 1 kg water?
 - c) 1 kg copper or 1 kg silver?
9. Review the measurements you made for mass and volume. How certain were your measurements? If you were to make the measurements again, could you be more certain? Explain your answer.
10. In calculating density you divided the mass of the material by the volume. Review the calculations you made. Adjust the accuracy of your answers using the rule for division given in the Chem Talk reading section.

Preparing for the Chapter Challenge

Design a special effect in which an object is suspended in a liquid. Consider the density of the material you will suspend, and the density of the liquid

you will use. Show the calculations that you used to make your choice of materials.

Inquiring Further

1. Is it real gold?

The new United States dollar coin has a golden color. Could it be made of real gold? Devise a method to determine if the new golden coin is any of the metals in the list on page 39.

2. Density of gas

Devise an investigation that you could do to determine the density of air.





Poll Question

- A) I have heard of the 5 E instructional model.
- B) I use the 5 E instructional model in class.
- C) I have heard of the 7 E instructional model.
- D) I use the 7 E instructional model in class.
- E) I haven't heard of either model.



A recipe for inquiry

7E instructional model

- Engage
- Elicit
- Explore
- Explain
- Elaborate
- Extend

Evaluate

Enhancing the 5E model:
The Science Teacher (9/03)
Available at
www.cosmic.umb.edu



The Pendulum Lab as 7E

- Engage – the longitude story
- Elicit – how does the grandfather clock work
- Explore – investigate pendulum
- Explain
 - students compare data, graphs, predictions
 - Teacher helps with equation

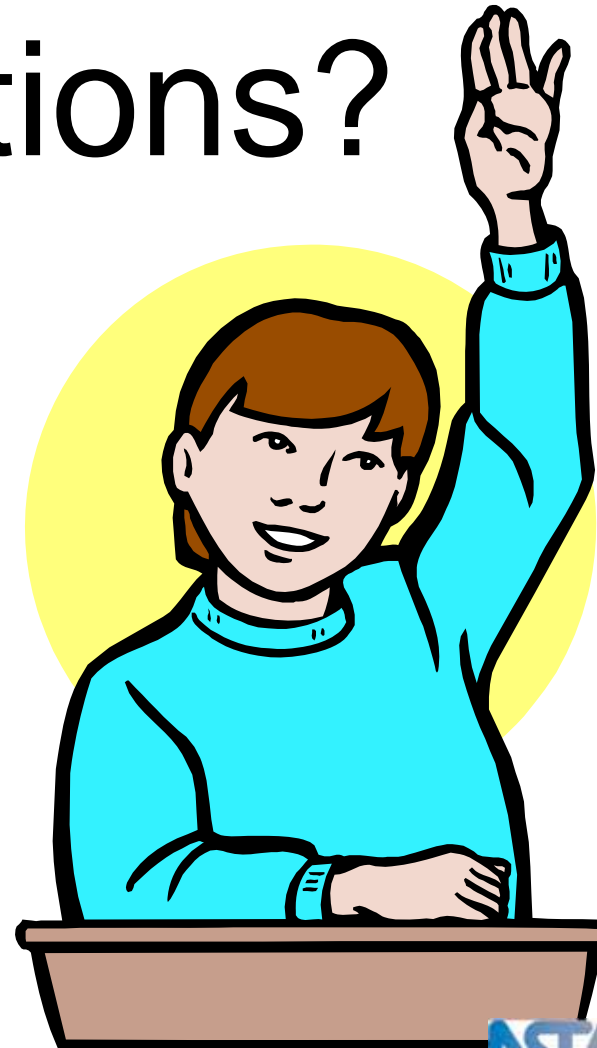
The Pendulum Lab as 7E

- Elaborate
 - How do you measure the length?
- Extend
 - The leaky pendulum
- Evaluate
 - Elicit, engage, explore, explain, elaborate, extend
 - AND a report, test, quiz





Questions?



Why ABC (Activity Before Concept)

Experience

- Experience is required – science is experiments
 - Learn baseball without ever seeing the game
 - Learn baseball without ever having equipment
 - Knitting without instruction
- Why do we think students can learn science by watching?

Why ABC (Activity Before Concept)

Common Experience

- Television viewing habits of Black and White Americans
- 10 top programs
 - Only 2 programs in common
- What are the common programs?
- What is the lesson?
 - Every time I made a reference to television, I was disenfranchising some group of students.

Why ABC (Activity Before Concept)

Common Experience

- There is no common experience
 - TV, music, food, vacation, movies, travel, home
 - Can someone imagine what a mango tastes like?
 - TRADITIONAL BOOKS ARE FILLED WITH “You know; Imagine”
 - ... like waves at the ocean
 - ...like a recipe for making brownie
 - Examples from your teaching
 - Examples from literature or movies



Examples from your teaching?



When have you mentioned something in class only to find out somebody had no idea what you were talking about?

1)

2)

3)

4)

Please raise your hand to volunteer!



A lab with inquiry

- *Modify a lab to make it more consistent with inquiry*
 - *Describe lab as it is traditionally done.*
 - *Describe lab as it's done with inquiry.*



Goals for today

- Help us all to have a better sense
 - Of what is inquiry
 - Why we value inquiry
 - How the 7E model and ABC can be recipes to help guide your lessons to inquiry

How did we do it today?

- Engage



- Elicit

The Kaila Factor



How did we do it today?

- Explore



- Explain
 - 7E instructional model





How did we do it today?

- Elaborate
 - 7E and Classroom Instructional Framework
- Extend
 - State Performance Standards – Inquiry
 - Habits of mind
 - Modify a lab for more inquiry
 - And for additional “extend” ...

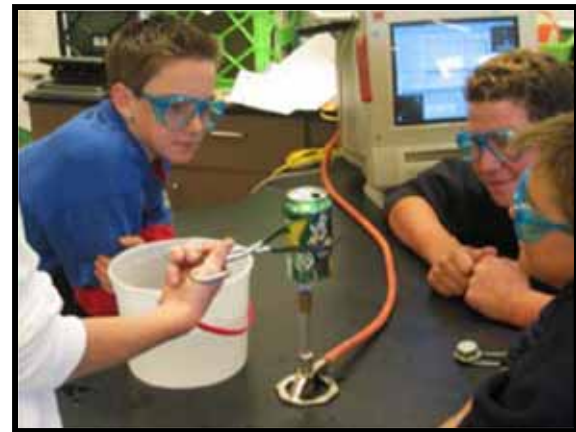
I wish you “the courage for inquiry”

- Inquiry requires patience
- Patience requires courage
- Have the courage to pursue inquiry!



We shall not cease from
exploration
And the end of all our
exploring
Will be to arrive where
we started
And know the place for
the first time.

– *T. S. Eliot (Little
Gidding V)*



What is Inquiry?



What is Inquiry?

You figure it out!

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COSMIC

- Please check out our website:
www.cosmic.umb.edu



Or email with questions:
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