Ghost Particles
Task Card - Lesson 1

Materials: *Plastic beaker or clear cup, 5 mL scoop, salt, water, stir stick or plastic spoon.*

WORK WITH A PARTNER

1. Person 1, get a beaker or plastic cup from the materials table and fill it with water to the 180 cc line.
2. Person 2, get a scoop and plastic spoon (or stir stick) from the materials table, and use the scoop to measure out 5 milliliters (mL) of salt (1 scoop).
3. Person 1 observe as Person 2 carefully adds the scoop of salt to the water and stirs. What happens?
4. Dump the water into a sink, trade jobs and repeat the experiment. This time Person 1 will stir in the salt while Person 2 observes.
5. Discuss what you noticed with your partner.


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Ghost Particles
Exit Card - Lesson 2

On the front of your index card, show the following:
(you can use your Notebook for reference)

- Draw a picture of one object you and your partner found during your exploration.
- Under the object, write its size in meters and one other unit (decimeter, centimeter, or millimeter)
- Write 3 properties of the object under its size.

Don't forget to write your name on your index card.

Ghost Particles
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Ghost Particles
Exit Card - Lesson 2

On the back of your index card, reflect on today's lesson by writing four statements using the following sentence frames. (you can use some more than once and skip some)

- Today I noticed __________________________ .
- Today I learned __________________________ .
- I wonder ________________________________ .
- I think __________________ because _________ .

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Task Card - Lesson 3
Now You See It…
(Exploration A)

DRIVING QUESTION. Do the properties of salt change with size?

MATERIALS

- Scale Plate
- One materials bag containing
  - Spoon
  - Toothpick
  - Hand lens

Your teacher will put a small amount of salt on your scale plate.

1) Use your toothpick to move 10 random grains of salt to the middle of your plate. Use the scale plate to measure the size of each grain, to the nearest power of 10 (1 mm, 0.1 mm) and record in your Notebook. Draw the shapes you see.
2) Move all but one grain of salt to the side of the plate. Using the back of your spoon, carefully crush that grain. Using your hand lens, observe:
   a) Approximately how many grains do you have?
   b) Pick 10 of the new grains, and push the rest to the side. Measure and record the sizes of the new grains. Draw the shapes you see.

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Task Card - Lesson 3
Now You See It…
(Exploration B)

DRIVING QUESTION. Does the weight of salt change when it is crushed into smaller pieces?

WORK WITH TWO OTHER PEOPLE FOR THIS INVESTIGATION.

MATERIALS

Supplies from Investigation A, plus

- Weigh boat (one per group)
- Salt
- Digital scales (shared)

GROUP ROLES

MATERIALS MANAGER – collects the materials and crushes the salt

DATA TAKER – weighs the empty boat and the boat with salt (before and after crushing)

DATA RECORDER – fills out the data table

PROCEDURE

- Weigh the empty boat. Don't forget to write units.
- Collect a small scoop full of salt from the teacher.
- Weigh the boat and uncrushed salt.
- Crush the salt, carefully.
- Weigh the crushed salt.
- Fill out the data table and calculate the difference.

Task Card - Lesson 3
Now You See It…
(Exploration B)

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Task Card - Lesson 3
Science Seminar

STEP 1. The data recorder for each group will report out: Did the weight decrease, increase or stay the same after the salt was crushed?

STEP 2. Anyone can use their talking chip to add to the discussion of one of the following questions (your teacher will tell you when to move from one question to the next:

- Did the results of your investigation match with what the other teams found? Why or why not? Defend your team's result or note possible reasons it might be inaccurate.
- Did the results of your investigation match with your prediction of what would happen? Why do you think it did or didn't?
- What would you have done differently if your group were able to repeat the investigation?

STEP 3. With your experimental group, talk over the results of your experiment and the discussion during the Science Seminar. Do you think your result is accurate? Why or why not? The materials manager for each group will report out.

STEP 4. Your teacher will poll the class. Is there now class consensus as to whether the weight of the salt decreases, increases or stays the same after the salt is crushed?

Task Card - Lesson 3
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Task Card - Lesson 4
...Now You Don't!

DRIVING QUESTION. How will we do an investigation to give more evidence about happens to salt when it is added to water and is no longer visible?

MATERIALS

- Students can use any items used in previous investigations, plus will have available one 100 milliliter graduated cylinder per group.

GROUP ROLES (Switch them around from Lesson 3)

MATERIALS MANAGER – collects the salt and the water for the investigation

DATA TAKER – measures the samples (weight and/or volume)

DATA RECORDER – creates and fills out the data table

PROCEDURE

- With your whole group, plan your investigation:
    - How are you going to determine whether or not the salt is taking up space after mixing?
    - How are you going to determine whether or not the salt has weight after mixing?
- Develop a procedure as a group and write it in your notebook before starting.
- Decide what data to record and everyone make a table before starting.

Task Card - Lesson 4
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Task Card - Lesson 5
What's Up with Air?

DRIVING QUESTION. Is air matter? Does it take up space and have weight?

MATERIALS AVAILABLE: Balloons (limited to one per person + one control), plastic hanger (limited to one per group), balloon pump (share with another group), string (precut in two lengths), rubber bands, paper clips, rulers, scissors^, masking tape, scotch tape

PLAN YOUR INVESTIGATION

✓ What variable are we going to change (our independent variable) *? How will we change it?

✓ What dependent variable will show us whether air takes up space?* What dependent variable will show us whether air has weight?* How will we measure them?

✓ What is our procedure? Write it in your notebook and get it approved by your teacher before gathering materials.

✓ What data will we record? Do we have a control? Will we have at least three data points?

GROUP ROLES

SCIENTIST 1 – will change the independent variable

SCIENTIST 2 – will measure the volume variable

SCIENTIST 3 – will measure the weight variable

The whole team will record, analyze and graph data.

* See the back of the card for some ideas.

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Task Card - Lesson 5
What's Up with Air?

THINGS TO THINK ABOUT WHEN PLANNING YOUR INVESTIGATION:

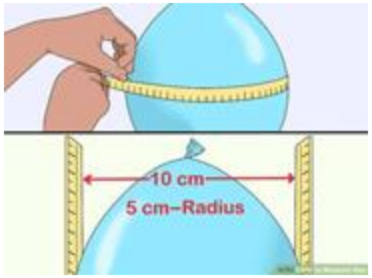
- The independent variable will be on the x-axis when you graph your results. It should be something that you can consistently change. An example could be the number of pumps of air you add to a balloon.
- The dependent variables are what you choose to measure as an equivalent for volume and weight.
- You may need a control variable, for example a balloon with no air.

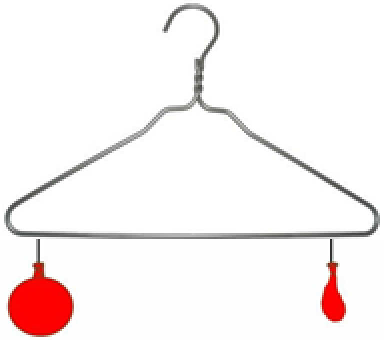
IDEAS FOR VOLUME

- You can use a string, measuring tape or rulers to measure how the circumference or radius of a balloon grows as you add air.

IDEAS FOR WEIGHT

- You can use a clothes hanger or a ruler as a balance. Measure how far the balance tips down towards the floor as you add air.





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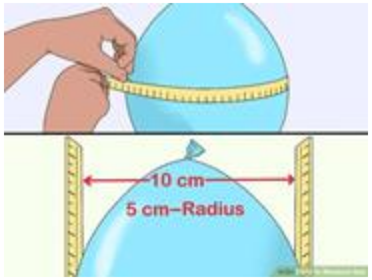

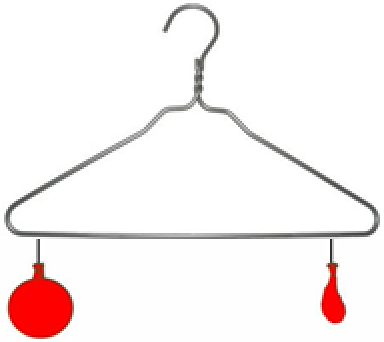

Ghost Particles - Lesson 5
Resource Limits

INVESTIGATION B

- One balloon per person plus one for a control
- One balloon pump per group (may need to share with another group)
- One clothes hanger per group

Ghost Particles - Lesson 5
Resource Limits

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- One balloon per person plus one for a control
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Task Card – Lesson 6
Making Atoms 'Visible'

DRIVING QUESTION. Can we use indirect evidence to infer the presence of atoms even if we can't see them?

PART A: Build an electroscope

Pierre and Marie Curie used electroscopes to detect invisible particles that were emitted from ore samples.

MATERIALS: large paper clip, aluminum foil, plastic cup (with holes on top)

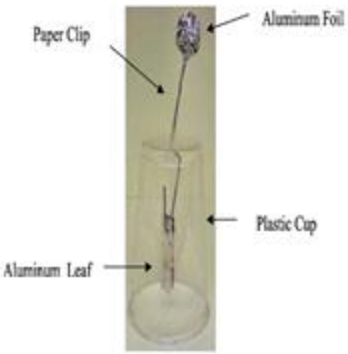
A. Cut two strips of aluminum foil that measure roughly ¼ inch by 1 ½ inch. Use the end of the paper clip to punch one small hole in each aluminum foil strip.

B. Unfold the paperclip so that it looks like a long J. Insert the two strips of aluminum foil, called leaves, on the curved end of the J. Make sure that the foil sheets are smooth, hang straight, and are not stuck together.

C. Place the plastic cup upside down and insert the straight part of the J paper clip through the small punched in hole on the bottom of the cup.

D. The leaves should hang inside the upside down cup as shown in the image. Be sure that the leaves are not touching.

E. Roll some aluminum foil into a ball the size of a marble. Place the ball on the top of the paperclip that is sticking outside of the cup.



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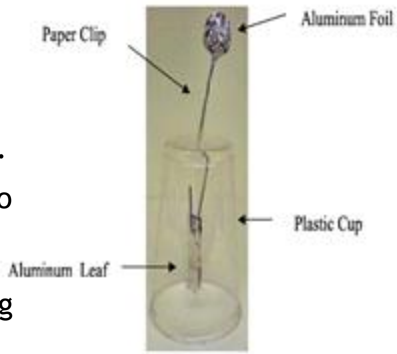

Task Card – Lesson 6
Making Atoms 'Visible'

PART B: Test your electroscope

The electroscope responds to static electricity. Try the following and record your observations in your notebook:

- Blow up a balloon and charge the balloon by rubbing it vigorously against your hair. Then, move the charged balloon close to the foil ball, but do not touch the ball with the balloon. What happens?
- Now take the comb and rub it with the wool cloth. Hold it near the foil ball. What happens? Touch it carefully onto the ball. What happens?

PART C: Investigate

Your teacher will bring around a special rod. What makes it special? Let's find out.

- Charge up your electroscope so that the leaves inside are being repelled from one another. With a partner, have one person carefully hold the cup in the air. Insert the rod into the space between the two leaves. What do you see?
- With your partner, plan an investigation to explore the effect of the rod further. You might think about things like:
    - How close do you need to get the rod to have an effect?
    - What happens if you "ground" the system by touching your finger to the ball?
- Fill in the Claims, Evidence, Reasoning Matrix in your notebook.

Task Card – Lesson 6
Making Atoms 'Visible'

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Task Card - Lesson 7 PART A -Modeling an Atom

DRIVING QUESTION. Why do they have to build very large detectors and put them deep underground in order to study neutrinos?

PART A: Let's model an atom at multiple scales

Can we model the size of an atom in the classroom?

MATERIALS: marble, screenshot of Vikings football field, ruler, post-it notes, 10-meter rope, string, salt

MODEL A. Working with a partner, analyze the atomic model that was featured in the video, *How Small is an Atom?*

a. The video described the nucleus as being the size of a marble. Write the size of a marble to the nearest power of 10 on a post-it note.

b. The video described the atom as being the size of a football stadium. Use the screenshot to determine the size of a stadium to the nearest power of 10 and write on a post-it note.

c. How many powers of 10 bigger is the atom than the nucleus? Since we know an atom is a nanometer, what size is a nucleus?

MODEL B. Let's scale our model down a power of 10. With the whole class, make a circle that is 10 meters in diameter. How small would the nucleus be? What could you use to model it? Decide as a class and add it to the middle.

MODEL C. (Optional) Let's scale down one more power of 10. Make an outline of an atom 1 meter in diameter using string. How small would the nucleus be? What could you use to model it?

Task Card - Lesson 7 PART A -Modeling an Atom

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Task Card - Lesson 7 PART B - A Ghost Particle

PART B: Let's model an atom with a visible neutrino. Use scientific notation.

MODEL D. A neutrino has an approximate diameter of 10^{-24} meters. Can we scale up our model of an atom to make the neutrino visible?

- The smallest object we can see with our eyes, the size of crushed salt, is approximately how many meters in size?
- How many powers of 10 do we have to scale up the neutrino to make it visible (the size of a crushed grain of salt)?
- The nucleus of an atom is 10^{-13} meters. What size would it be if we scale it up the same amount as the neutrino?
- The atom is 10^{-9} meters. What size would it be if we scale it up the same amount as the neutrino?
- Pick an object that would be approximately the size of the nucleus in this model.
- Pick an object that would be approximately the size of the atom in this model.

DO NOT WRITE ON THIS TASK CARD!

Task Card - Lesson 7 PART B - A Ghost Particle

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