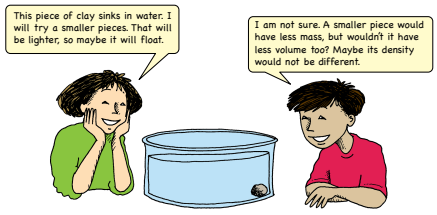
Mass vs. Volume: Proportions and Density

Mr. Moreno's class is experimenting with things that sink and float.



The students do an experiment to find out whether a different amount of the same material has a different density, $\frac{\text{Mass}}{\text{Volume}}$. They measure the mass and volume of 3 different amounts of clay, record their data in a data table, and graph their data. Then they do the same thing for different amounts of steel to see whether they get similar results for different materials. You will do the same in the lab that follows. You will find the mass and volume of 3 steel balls and 3 lumps of clay that are about the same size as the steel balls.

Draw

1. Discuss with your group how you will do the experiment. Then draw a picture that shows what you will do. Be sure to label the variables and include all the equipment you will use.

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Collect

2. Find and record the mass and volume of 3 different-sized steel balls to the nearest tenth. To get accurate measurements for the small steel ball, measure the mass and volume of 5 identical small steel balls and divide by 5.

Material 1: Steel

Size of Object	*V* Volume (in cc)	*M* Mass (in g)
small ($\frac{1}{2}$-inch diameter)		
medium (1-inch diameter)		
large ($1\frac{1}{4}$-inch diameter)		

3. Find and record the mass and volume of 3 different-sized clay balls to the nearest tenth. Make your lumps of clay about the same size as each of the steel balls. Use the same lumps of clay to measure mass and volume. Measure the mass first to avoid soggy clay.

Material 2: Clay

Size of Object	*V* Volume (in cc)	*M* Mass (in g)
small		
medium		
large		

Graph

4. Plot the data for each material on the same graph. Put Mass (*M*) on the vertical axis and Volume (*V*) on the horizontal axis. Scale your axes so that *M* goes up to at least 180 g and *V* goes up to at least 24 cc.
5. What is the value of *M* when *V* is 0 cc? Put this point on your graph.
6. Draw a best-fit line or curve to show the pattern of your points. Draw one for steel and a separate one for clay. Label each line or curve with the name of the material it represents.

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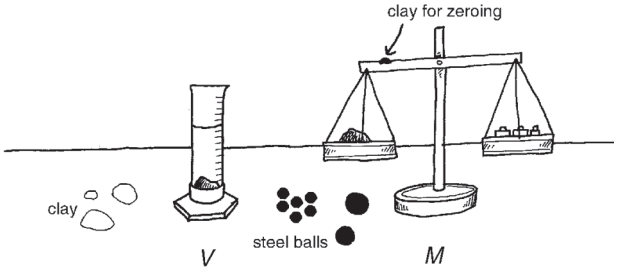
Mass vs. Volume: Proportions and Density (SG pp. 543–547) Questions 1–23

1.* A sample picture:



2–3.* Sample data tables:

Material 1: Steel

Size of Object	*V* Volume (in cc)	*M* Mass (in g)
small ($\frac{1}{2}$-inch diameter)	1.1	8.4
medium (1-inch diameter)	8.5	66
large ($1\frac{1}{4}$-inch diameter)	16.5	130

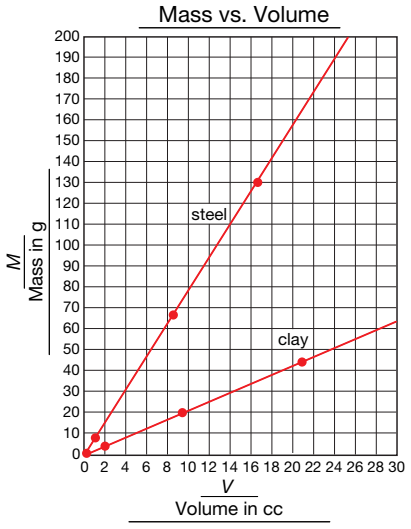
Material 2: Clay

Size of Object	*V* Volume (in cc)	*M* Mass (in g)
small	2	4
medium	9.5	19
large	21	45

4. See graph below.

5.* $M = 0$ g

6.*



***Answers and/or discussion are included in the lesson.**

7. A.* Both graphs are straight lines that pass through the point (0, 0).

B.* The graph for steel is a steeper line than the graph of clay.

8. The answers are based on the sample graph in Question 6.

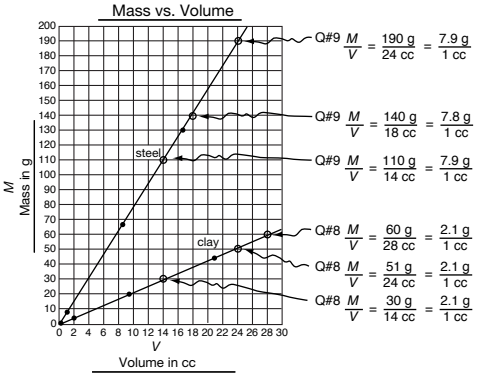
A. About 94 g; interpolate

B. About 23 cc; extrapolate

C. 10 g; interpolate

D. About 28 cc; extrapolate

9. The answers are based on the sample graph.



A. $\frac{M}{V} = \frac{60\text{ g}}{28\text{ cc}} = \frac{2.1\text{ g}}{1\text{ cc}}$

B. $\frac{M}{V} = \frac{51\text{ g}}{24\text{ cc}} = \frac{2.1\text{ g}}{1\text{ cc}}$

$\frac{M}{V} = \frac{30\text{ g}}{14\text{ cc}} = \frac{2.1\text{ g}}{1\text{ cc}}$

All 3 ratios are equal.

10. The answers are based on the sample graph in Question 9.

A. $\frac{M}{V} = \frac{190\text{ g}}{24\text{ cc}} = \frac{7.9\text{ g}}{1\text{ cc}}$

B. $\frac{M}{V} = \frac{140\text{ g}}{18\text{ cc}} = \frac{7.8\text{ g}}{1\text{ cc}}$

$\frac{M}{V} = \frac{110\text{ g}}{14\text{ cc}} = \frac{7.9\text{ g}}{1\text{ cc}}$

All 3 ratios are approximately equal.

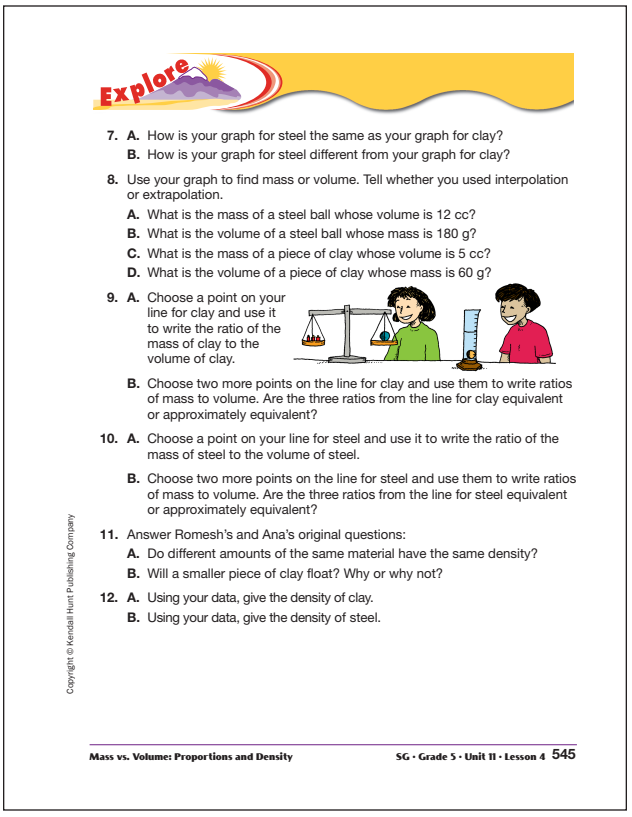
11. A. Yes; The density is the ratio $\frac{M}{V}$ and since this ratio is constant for different amounts of the same material, they have the same density.

B.* No; Since the smaller piece of the clay has the same density as the larger piece that sinks, the smaller piece will sink also.

12. A. Answers will vary. Using points from the sample graph as in Questions 9 and 10, the density of clay is $\frac{M}{V} = \frac{30\text{ g}}{14\text{ cc}} = \frac{2.1\text{ g}}{1\text{ cc}}$.

B. Answers will vary. Using points from the sample graph, the density of steel is $\frac{M}{V} = \frac{110\text{ g}}{14\text{ cc}}$

***Answers and/or discussion are included in the lesson.**


Explore

7. **A.** How is your graph for steel the same as your graph for clay?
   B. How is your graph for steel different from your graph for clay?
8. Use your graph to find mass or volume. Tell whether you used interpolation or extrapolation.
   A. What is the mass of a steel ball whose volume is 12 cc?
   B. What is the volume of a steel ball whose mass is 180 g?
   C. What is the mass of a piece of clay whose volume is 5 cc?
   D. What is the volume of a piece of clay whose mass is 60 g?
9. **A.** Choose a point on your line for clay and use it to write the ratio of the mass of clay to the volume of clay.
   B. Choose two more points on the line for clay and use them to write ratios of mass to volume. Are the three ratios from the line for clay equivalent or approximately equivalent?
10. **A.** Choose a point on your line for steel and use it to write the ratio of the mass of steel to the volume of steel.
    B. Choose two more points on the line for steel and use them to write ratios of mass to volume. Are the three ratios from the line for steel equivalent or approximately equivalent?
11. Answer Romesh's and Ana's original questions:
    A. Do different amounts of the same material have the same density?
    B. Will a smaller piece of clay float? Why or why not?
12. **A.** Using your data, give the density of clay.
    B. Using your data, give the density of steel.

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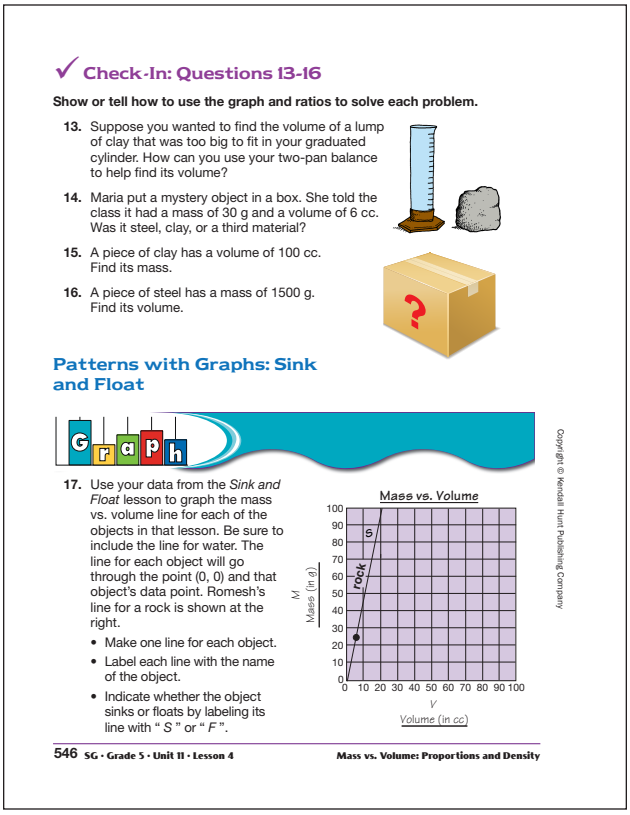

✓ Check-In: Questions 13-16

Show or tell how to use the graph and ratios to solve each problem.

13. Suppose you wanted to find the volume of a lump of clay that was too big to fit in your graduated cylinder. How can you use your two-pan balance to help find its volume?

14. Maria put a mystery object in a box. She told the class it had a mass of 30 g and a volume of 6 cc. Was it steel, clay, or a third material?

15. A piece of clay has a volume of 100 cc. Find its mass.

16. A piece of steel has a mass of 1500 g. Find its volume.

Patterns with Graphs: Sink and Float

Graph

17. Use your data from the *Sink and Float* lesson to graph the mass vs. volume line for each of the objects in that lesson. Be sure to include the line for water. The line for each object will go through the point (0, 0) and that object's data point. Romesh's line for a rock is shown at the right.

- Make one line for each object.
- Label each line with the name of the object.
- Indicate whether the object sinks or floats by labeling its line with "*S*" or "*F*".

Mass vs. Volume

M Mass (in g)

V Volume (in cc)

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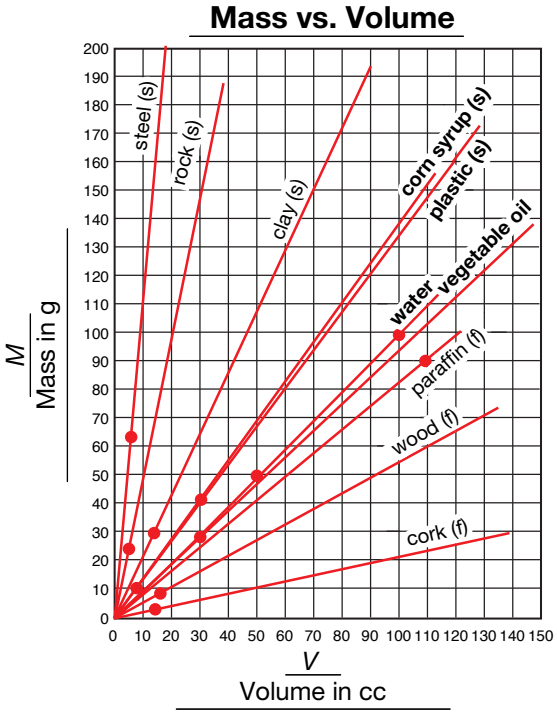
13. Possible response: We can use the balance together with our graph of Mass vs. Volume for clay to find the answer. We can use the two-pan balance to find the mass of the clay. Then, using the graph, we can interpolate or extrapolate to find the volume. Another method we can use is to represent density as the ratio of $\frac{M}{V}$ and to compare ratios to find the volume.

14.* It is a third material. The mystery object has a density of $\frac{30\text{ g}}{6\text{ cc}} = 5$ g/cc. This is less than the density of steel and more than that of clay.

15.* $M \approx 214$ g or 210 g

16.* $V \approx 190$ cc

17.*



*Answers and/or discussion are included in the lesson.

18. The lines of objects that sink lie above the line for water, and the lines of objects that float lie below the line for water.

19. A.* Since the line for the object lies below the line for water, the object will float.

B.* Density $= \frac{50\text{ g}}{80\text{ cc}} = 0.625$ g/cc. Since this density is less than 1 g/cc, the object will float in water.

20. A.* Using a calculator we can compute the densities for the mass and volume given in the data table using the ratio $\frac{M}{V}$.

B.* Graphically, a steeper line represents more mass per volume than a line that is not as steep. Therefore, a steeper line represents a material that is denser.

21. A.* 320 g; $\frac{M}{80\text{ cc}} = \frac{4\text{ g}}{1\text{ cc}}$; $M = 320$ g

B. 25 cc; $\frac{100\text{ g}}{V} = \frac{4\text{ g}}{1\text{ cc}}$; $V = 25$ cc

22. Methods may vary. We can represent density as a ratio of $\frac{M}{V}$ and compare the ratios to solve the problem.

23. We can find the density of each of the rocks, and if they are the same, then we can conclude that the rocks are probably made of the same material.

Homework (SG pp. 549–550) Questions 1–7

1. A. Density $= \frac{48\text{ g}}{8\text{ cc}} = \frac{6\text{ g}}{1\text{ cc}}$

B. 96 g; $\frac{M}{16\text{ cc}} = \frac{6\text{ g}}{1\text{ cc}}$; $M = 96$ g

C. 50 cc; $\frac{300\text{ g}}{V} = \frac{6\text{ g}}{1\text{ cc}}$; $V = 50$ cc

2. These problems can be solved using the proportion $\frac{M}{V} = \frac{4\text{ g}}{3\text{ cc}}$.

A. 15 cc **B.** 27 cc

C. 6 cc **D.** 1.5 cc

E. 75 cc **F.** 45 cc

3. A. About 105 g, extrapolate

B. About 10.5 cc, interpolate

4. Using the point (13 cc, 50 g):

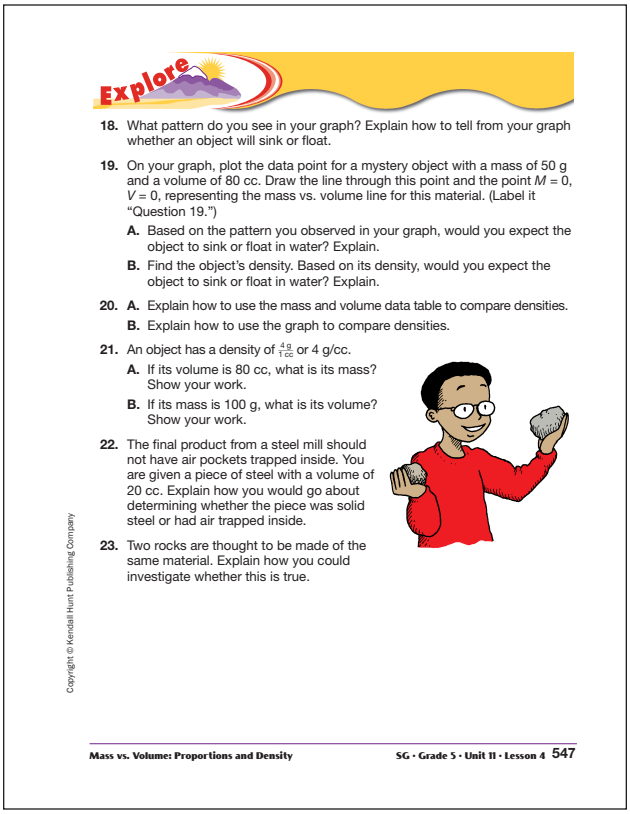
$$\frac{200\text{ g}}{V} \overset{\times 4}{=} \frac{50\text{ g}}{13\text{ cc}} \quad (\times 4)$$

$V = 52$ cc

Using the point (16 cc, 60 g):

$$\times 3.75\ \frac{200\text{ g}}{V} = \frac{60\text{ g}}{16\text{ cc}} \times 3.75$$

$V = 53.3$ cc


Explore

18. What pattern do you see in your graph? Explain how to tell from your graph whether an object will sink or float.

19. On your graph, plot the data point for a mystery object with a mass of 50 g and a volume of 80 cc. Draw the line through this point and the point $M = 0$, $V = 0$, representing the mass vs. volume line for this material. (Label it "Question 19.")
   A. Based on the pattern you observed in your graph, would you expect the object to sink or float in water? Explain.
   B. Find the object's density. Based on its density, would you expect the object to sink or float in water? Explain.

20. A. Explain how to use the mass and volume data table to compare densities.
   B. Explain how to use the graph to compare densities.

21. An object has a density of $\frac{4\text{ g}}{1\text{ cc}}$ or 4 g/cc.
   A. If its volume is 80 cc, what is its mass? Show your work.
   B. If its mass is 100 g, what is its volume? Show your work.

22. The final product from a steel mill should not have air pockets trapped inside. You are given a piece of steel with a volume of 20 cc. Explain how you would go about determining whether the piece was solid steel or had air trapped inside.

23. Two rocks are thought to be made of the same material. Explain how you could investigate whether this is true.

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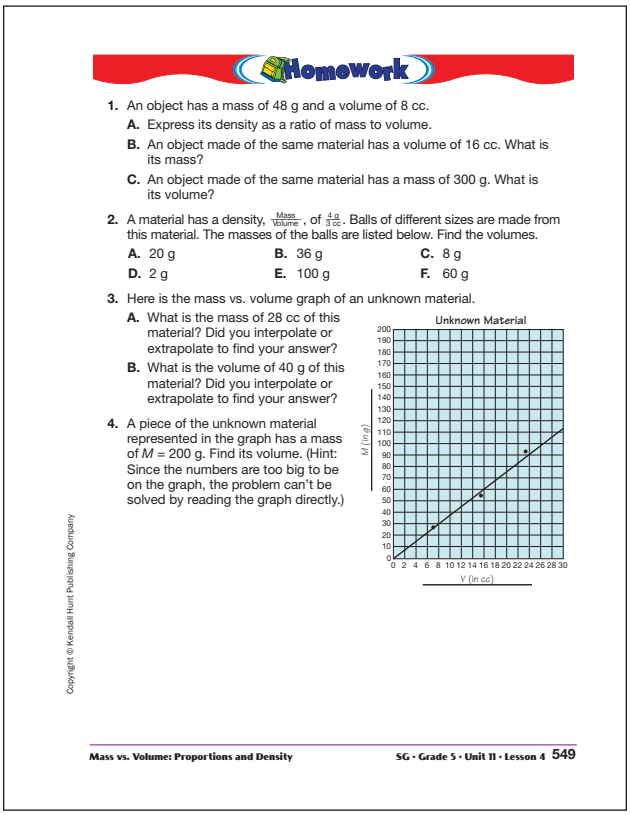
Homework

1. An object has a mass of 48 g and a volume of 8 cc.
   A. Express its density as a ratio of mass to volume.
   B. An object made of the same material has a volume of 16 cc. What is its mass?
   C. An object made of the same material has a mass of 300 g. What is its volume?

2. A material has a density, $\frac{\text{Mass}}{\text{Volume}}$, of $\frac{4\text{ g}}{3\text{ cc}}$. Balls of different sizes are made from this material. The masses of the balls are listed below. Find the volumes.
   A. 20 g B. 36 g C. 8 g
   D. 2 g E. 100 g F. 60 g

3. Here is the mass vs. volume graph of an unknown material.
   A. What is the mass of 28 cc of this material? Did you interpolate or extrapolate to find your answer?
   B. What is the volume of 40 g of this material? Did you interpolate or extrapolate to find your answer?

4. A piece of the unknown material represented in the graph has a mass of $M = 200$ g. Find its volume. (Hint: Since the numbers are too big to be on the graph, the problem can't be solved by reading the graph directly.)

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***Answers and/or discussion are included in the lesson.**

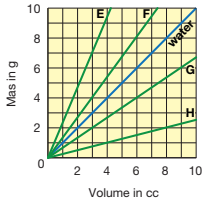
5. Find the density of the objects in the table. Which object has the greatest density?

Mass vs. Volume of Objects A–D

Object	Volume of Object (in cc)	Mass of Object (in g)	Density in g/cc
A	24	11.0	
B	9	11.0	
C	4	5.5	
D	11	5.5	

6. Here is a graph of the mass vs. volume of several materials. Using the graph, tell which of the materials will sink and which will float in water. Explain why.

Mass vs. Volume of Objects E–F



7. **A.** Find the densities of the materials in the graph.
   B. Based on their densities, tell which materials will sink and which will float in water. Explain why.

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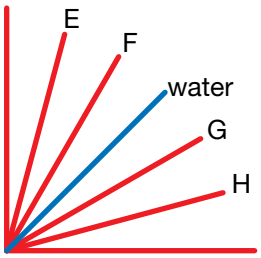
5. Object C has the greatest density.

Object	Volume of Object (in cc)	Mass of Object (in g)	Density in g/cc
A	24	11.0	11 g/24 cc
B	9	11.0	11 g/9 cc
C	4	5.5	5.5 g/4 cc
D	11	5.5	5.5 g/11 cc

6. The M vs. V line for water falls between the lines for material F and G.



The lines above the line for water (materials E and F) will sink; materials G and H will float. Alternatively, students can use the graph to find $\frac{M}{V}$ ratios for the four materials. Materials E and F have a $\frac{M}{V}$ ratio that is greater than 1. The ratio of $\frac{M}{V}$ for materials G and H is less than 1. Thus, materials E and F sink and materials G and H float.

7. A. Density of Material E $= \frac{7\text{ g}}{3\text{ cc}}$

Density of Material F $= \frac{4\text{ g}}{3\text{ cc}}$

Density of Material G $= \frac{2\text{ g}}{3\text{ cc}}$

Density of Material H $= \frac{1\text{ g}}{4\text{ cc}}$

B. Since the densities of Materials E and F are greater than 1, these materials will sink in water. Since the densities of Materials G and H are less than 1, these materials will float in water.