In the Lab

A Mystery Liquid

Reg, Bea and Gabe were doing an experiment in science class. They had an unknown liquid whose volume they measured in a graduated cylinder. A graduated cylinder is a tall, narrow container that is used for accurately measuring liquid volume. They used one that weighed 50 grams, and measured volume in milliliters. They used a balance to find the weight of the liquid to the nearest gram.

Reg's data

volume	weight
10 ml	16 g
20 ml	32 g
50 ml	80 g
80 ml	128 g

1. Plot Reg's data, with *weight* on the vertical axis and *volume* on the horizontal axis.

2. Does it make sense to connect the points on your graph? Explain.

3. Find an equation relating weight to volume.

4. Estimate the weight of
   a. 60 ml of liquid
   b. 1 ml of liquid

5. If you add 30 ml to the volume, how much are you adding to the weight? See if you get the same answer in two different cases.

6. If you double the volume, do you double the weight?

Bea's data

weight	volume
16 g	10 ml
32 g	20 ml
48 g	30 ml
64 g	40 ml

7. Plot Bea's data with *volume* on the vertical axis and *weight* on the horizontal axis.

8. Connect the points on your graph with a line and write an equation for the line.

9. Estimate the volume of:
   a. 100 g of liquid   b. 1 g of liquid

10. Compare Bea's graph with Reg's graph. Explain the similarities and differences.

We say that Reg graphed weight vs. volume, while Bea graphed volume vs. weight.

11. If you add 10 ml to the volume, how much are you adding to the weight? See if you get the same answer in three different cases. Is the answer consistent with what you found in Reg's data?

Definition: *Density* equals weight per unit of volume. This means that to find the density of the mystery liquid, you would find the weight of 1 ml of the liquid. (Actually, scientists use *mass* rather than weight, but we will use weight, which is equivalent for our purposes.)

12. Find the density of the mystery liquid, using three different pairs of weight / volume values from Reg's and Bea's data. Do all your answers agree? Explain.

13. In previous problems, you have found the weight in grams of one ml of liquid, and the volume in ml of one gram. Multiply the two numbers. Explain the result.

The Mystery Grows

Gabe's data:

volume	weight
10 ml	66 g
20 ml	82 g
40 ml	114 g
60 ml	146 g

14. Draw a pair of axes and label the vertical axis "weight" and the horizontal axis "volume". Plot Gabe's data.

15. If you double the volume, does the weight double? Check this in two cases.

16. If you add 20 ml, how much weight are you adding? Is this consistent with what you learned from Reg's and Bea's data?

17. *According to Gabe's graph*, what is the weight of 0 ml of the liquid? Does this make sense?

18. What might be the real meaning of the y-intercept on Gabe's graph? Did Gabe make a mistake? Explain.

19. Find the density of the mystery liquid, by dividing weight by volume for three different pairs of values from Gabe's data. Do all your answers agree? Explain.

20. * Write an equation that expresses weight as a function of volume for Gabe's data.

Direct Variation

Definition: If the relationship between two variables x and y can be expressed in the form y = mx, we call this a *direct variation,* or say that *y varies directly with x*.

21. Which of Reg's, Bea's, and Gabe's data are examples of direct variation? Explain.

22. Compare Gabe's graph to Reg's. How are they the same, and how are they different?

23. € There are number patterns in all the data.
    a. What pattern is there in all of Reg's, Bea's, and Gabe's data?
    b. What patterns are only true of Reg's and Bea's data?

24. **Summary.** What do you know about direct variation? Be sure to discuss equation, graph, and number patterns.

"Real" Numbers and Measurement Error

The three tables above contained data that were invented. You can tell because all the points lie exactly on a line. In real experiments, measurements can never be exact. This table contains more realistic data, for another substance.

volume	**weight**
10 ml	32 g
20 ml	63 g
50 ml	146 g
80 ml	245 g

25. Draw and label a pair of axes and plot these points.

26. You cannot draw a straight line through all the points, but draw one that passes as close as possible to all of them. Be sure your line goes through the origin. (Explain why it must.)

27. What is the equation of the line you drew? (Choose a point on the line to help you figure this out.)

28. Based on your answer to Exercise 27, what would you estimate the density of the substance to be?

29. Find the ratio of weight to volume for each data point in the table.

30. Based on your calculations in Exercise 29, what do you estimate the density of the substance to be?

31. **Summary**. You estimated the density of this substance in two different ways. If you did not get the same answer using both methods, explain any differences. Which method do you like better, and why?

32. **Research.** What do you think this substance could be?