Scaling the Layers of the Earth's Atmosphere

Subject Area: Earth Sciences, Mathematics

Grade Level: 5-8

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Overview

Most maps have scales that relate actual distances in miles or kilometers to distances in inches or centimeters on the paper. How are such scales created? How does one choose a scaling ratio, and how is the ratio used to make and interpret the map? In this activity students will make a simple one-dimensional map of the layers of the earth's atmosphere by establishing a scaling ratio and using the ratio to mark the thicknesses of the layers. They will do some quick research about the composition of the layers along the way. The activity presumes that the students have had some experience with fractions, decimals and rounding.

Objectives

- Students will describe the importance of the concept of scale
- Students will divide the dimension of a system by the dimension of a model to obtain a value for a scaling ratio
- Students will use their scaling ratio to make a scaled model of a system
- Students will name the layers of the earth's atmosphere and describe the approximate thickness of each layer
- Students will describe the important features of the different layers of the earth's atmosphere

Connections to Standards

- Math: Ratio and proportion, computation, measurement, representations, mathematical ideas in other disciplines.
- Science: Composition and properties, models, Earth's atmosphere

Materials

- The student handout for this activity (below) will give the students the names and rough thicknesses of the layers of the atmosphere, but you will need to provide a source of information that describes features of the layers. This could come from a textbook or from Web sites such as http://csep10.phys.utk.edu/astr161/lect/earth/atmosphere.html or http://www.windows.ucar.edu/tour/link=/earth/Atmosphere/overview.html
- Students could do the activity individually or in pairs. All who do the activity will need a 1.75 m strip of adding machine tape (available at most office supply or variety stores). Students will also need a meter stick and colored pens/pencils.

Procedure

Students might benefit from an introductory discussion of scaling in which you discuss scale-type calculations, perhaps in the context of a map. The text of a sample discussion is given below.

Note: The data on the handout gives a total thickness for the atmosphere of 350 kilometers. Our procedure calls for a strip of adding machine tape that is 175 cm in length. 175 cm will give the students a scaling ratio of 2 km per cm, avoiding the need for fractional calculations.

The driving distance between Portland, OR and San Francisco, CA is about 1,000 km. When you look at a typical map (such as a map in an atlas), you will notice that the map distance will be some number of centimeters. Let's assume that on a certain map the distance would be about 12 cm. Every 12 cm of distance on the map would correspond to 1,000 km of actual driving distance. If you measured about 12 cm of distance between Miami, FL and Pensacola, FL on the map, you know that the driving distance between those cities will also be about 1,000 km. The connection between actual distances and the distances on a map is called the **scale** of a map.

You may have seen the term **scale** in other places. Model cars usually have a scale number printed on the box, such as "Scale 1/64". This means that the actual car is 64 times bigger than the model. Scales are used to help us know the size relationship between a model and the 'real thing'. Maps are a type of model.

On our U.S. map from above, the scale is 1,000 km for every 6 cm. We usually divide the number of kilometers by the number of centimeters to get the number of kilometers *for every centimeter*. Here is what this looks like:

$$\frac{1000 \text{ km}}{12 \text{ cm}} = 83 \text{ kilometers per centimeter}$$

We had a little remainder when we divided, but we rounded it off. So, every time we move by 1 centimeter on the map, we would be traveling 83 kilometers in the car. 83 km per cm is the **scaling ratio** for the map.

When you are making a map, you first need to calculate the scaling ratio by dividing the real distance you are mapping by the length of the map. This will look like the calculation shown above. Once you figure out the scaling ratio you can use it to mark your map.

Here is an example of a map-making problem. We are going to make a map of the U.S., and we know that the map can be 75 centimeters at the widest point (based on the size of our paper). We also know that the widest span from the west coast to the east coast is about 5,000 kilometers. We draw the outline of the U.S. on our 75 cm paper, and then we calculate the **scaling ratio:**

$$\frac{5000 \text{ km}}{75 \text{ cm}} = 67 \text{ kilometers per centimeter}$$

Now we can use the scaling ratio to mark off other distances on the map. The driving distance from the top of Washington (Blaine) to the bottom of Washington (Vancouver) is about 440 km. Use the scaling ratio to mark the number of centimeters:

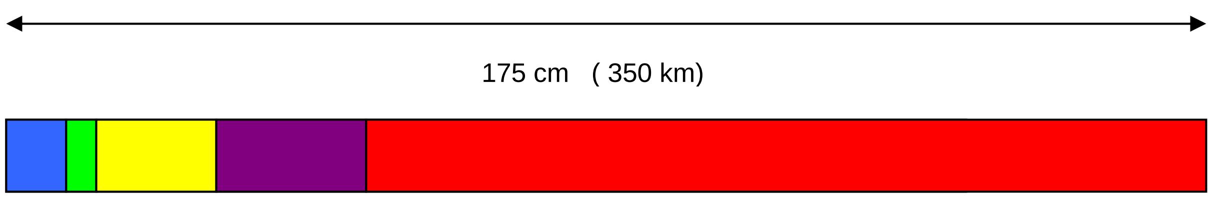
$$\frac{440 \text{ km}}{67 \text{ km/cm}} = 6.5 \text{ (or } 6\tfrac{1}{2}\text{) centimeters}$$

You **divide** the actual distance (in kilometers) by the scaling ratio (in km/cm). The height of western Washington on your map will be about 6½ centimeters.

Warning: As you might guess, map making isn't really this simple! We're looking at only one aspect of the process.

Today you will use the scaling methods we have discussed to make a simple map of the layers of the earth's atmosphere. You will learn the names of the layers and some important facts about each one. You will compare the thicknesses of the layers on your map.

Once the students have processed this introductory material, they will need to read whatever information you will provide for the layers of the atmosphere. As they read they should fill in the 'important facts' column on the handout.



The map will resemble this strip. Students can color or otherwise mark the layers to distinguish them from each other. Students should write the names and thicknesses of the layers on the map as they work.

A Handout for Students

Scaling the Layers of the Earth's Atmosphere

Procedure

- Read about the layers of the earth's atmosphere using the information that your teacher has provided. As you read, fill in the 'Important Facts' column on your worksheet with some comments about each layer of the atmosphere. What gases are in each layer? How does the layer influence the earth?
- Obtain a 175-centimeter strip of adding machine tape from your teacher. You will make a map of the atmosphere layers on this strip by showing the thickness of each layer.
- Calculate the total thickness of the earth's atmosphere by adding all of the thicknesses from column two of the data table. Write the total thickness in the bottom box in column two.
- Calculate the **scaling ratio** for your map in the space above the data table. You should write a number on each of the dotted blanks. Divide the thickness of the atmosphere (kilometers) by the length of your paper strip (cm) to find the scaling ratio in kilometers per centimeter.
- Fill in the last column of your data table with the **scaled** thicknesses of each layer. You will find the scaled values by dividing the actual thickness (kilometers) by the scale ratio (kilometers per cm).
- Now you are ready to make your map! Start from one end of the strip, and measure with your meter stick the number of centimeters for each layer. Make marks across the strip to show the boundaries between the layers. Make each layer a different color. Write each layer name on the various colored map layers, and write the thickness of the layer in kilometers. Be sure to write your name on your map. When you finish the map, answer the questions below.

Questions

1. What is the value of the scaling ratio that you used for your map?

2. When you are making a map, what are the two pieces of information that you must know to come up with a scaling ratio?

3. In what atmospheric layer does most of our weather occur?

4. Perhaps you have heard of the *Aurora Borealis* – the Northern Lights. What layer is responsible for the appearance of the Aurora?

Bonus: What is the *Ozone Layer*, and within what atmospheric layer is it located?

Data Table for Layers of the Earth's Atmosphere

Calculate your scaling ratio here: $\dfrac{\text{...... km}}{\text{...... cm}} = \text{......}$ **km per cm**

Name of Layer	Average Thickness of Layer (kilometers)	Important Facts About the Layer	Scaled Thickness of the Layer in Your Model (centimeters)
Troposphere	**15**		
Tropopause	**5**		
Stratosphere	**30**		
Mesosphere	**40**		
Ionosphere	**260**		
Total Thickness of the Atmosphere			