Dimensional Analysis Converts The Skeptical Mind

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Students should perform effectively and confidently when presented with issues that have a quantitative basis. Numerous activities related to dimensional analysis are provided throughout the semester in order to give students ample experience with quantitative reasoning. All activities are presented in context and related to content discussed in class. Examples include a variety of map scale exercises, numerous speed and distance conversions, and others that routinely use mental estimates. Repeated application allows students to become confident with the technique. All problems are setup in a similar fashion – students must note the initial units, final units, and conversion factors. Organizing the equation and cancelling units play a key role in comprehension, confidence, and success.

Topographic Maps and Map Scale

Objective:
Create a topographic map, calculate map scale, and draw two topographic cross-sections with different vertical exaggerations.

Activity:
Use a 3-d landform in a clear plastic box (Figure 1), fill with water at 300 m increments – the contour interval (Figure 2), trace contact between the water and the landform (Figure 3); repeat until landform is completely submerged.


Figure 1. Landform.

Figure 2. Vertical scale; water level at 1800 m.

Figure 3. Contour lines drawn; line of cross-section defined; scale bar present.

Use the bar scale of the topographic map and calculate the ratio scale. Ratio scales require i) similar units on both sides of the equation, and ii) the ratio is one to something (1:x). Students measure the bar scale (3.5 cm on the map) and observe that it is equivalent to 3 km in real space (Figure 3). To convert from km to cm, one needs to know that 1 m = 100 cm, and 1 km = 1000 m, so:

$3.5\ cm_{map} = 3\ km_{real}$
$3.5\ cm_{map} = 3\ km_{real} \cdot 1000\ m/km \cdot 100\ cm/m$
$3.5\ cm_{map} = 300{,}000\ cm_{real}$
$1\ cm_{map} = 85{,}714\ cm_{real}$
1:85,714

Draw two cross-sections (one for a VE=0 and the other for a VE=3) (Figure 4). The most difficult part is labeling the vertical axis.

Additional, related questions:
1) Given that a 6 cm line is equivalent to 1 km in real space, calculate the ratio scale for the map.
2) Given a map ratio scale of 1:800, draw two bar scales (one in feet and the other in meters).

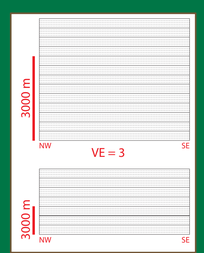

Figure 4. Graph paper for cross sections.

Glacial Striations and Map Scale

Objective:
Determine glacial transport direction and calculate map scale.

Activity:
Students calculate their average pace on a 100 m slope (Figure 5) and use their pace factor to determine the distance between the eastern and western limits of their map of oriented glacial striae and glacial gouges (Figure 6). Students are asked to describe the glacial history of the area, calculate a ratio scale, and draw two bar scales (one in meters and one in feet).


Figure 5. Pace calculations.

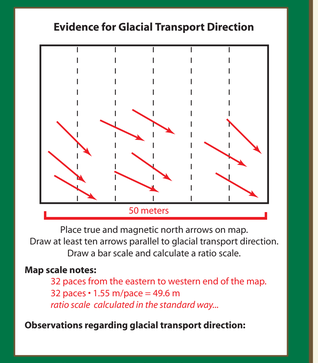

Figure 6. Glacial striae .

Scaled Solar System

Objective:
Plot relative planetary distances, calculate a ratio scale, draw a bar scale, and label distance scale.

Activity:
Students create a scaled model of the solar system (Figure 7). Distance scale must be properly labeled, planets placed at appropriate distances from the sun, and a bar scale developed. This activity incorporates very large numbers.

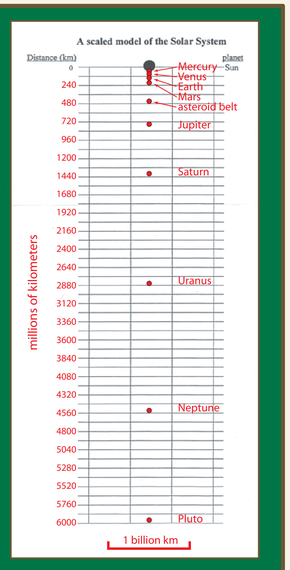

Figure 7. Scaled Solar System.

Watershed and Map Scale

Objective:
Define the watershed drained by Joe Brook, and calculate a bar scale and ratio scale.


Figure 8. Joe Brook Watershed.

Activity:
Students circumscribe the watershed drained by Joe Brook and are told that the distance between the 'J' in Joe and the 'k' in Brook is equivalent to 1 km in order to calculate the ratio scale (Figure 8).

Other Questions To Comfort the Skeptical Mind

How far does light travel in one year? *Convert from m/s to mi/y.*
1 ly = 299,792,458 m/s • 1 km/1000 m • 1 m/1.609 mi • 60 s/min • 60 min/h • 24 h/d • 365.25 d/y = 5.9 x 10^{12} miles

Gasoline costs $C 1.14 per liter in Canada, and $C 1.10935 Canadian dollars is equal to $US 1.00. What is the equivalent $US cost per gallon? *Convert from $C to $US and from liters to gallons.*
1.14 $C/liter • 1 $US/1.10935 $C • 3.7854 liter/1 gallon = 3.89 $US/gallon

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