Student Worksheet: Ratios, Proportions, and Cross-multiplication

Introduction

During space shuttle missions astronauts sometimes have to perform **extravehicular activities** (EVAs), also called spacewalks. They do EVAs to develop techniques, test procedures, and capture satellites for repair. You have to closely monitor the vital signs of astronauts during an EVA to make sure the astronauts don't use up their oxygen supplies too quickly.

In this activity you use cross-multiplication to find the unknown respiration rate per minute of an astronaut during several EVA tasks. You use this same mathematical process to find missing values in proportions during the mission.

Vocabulary

cross-multiplication: the process of multiplying the numerator of one ratio with the denominator of the other ratio in a proportion; the cross-products of two equal ratios are always equal.

proportion: a pair of equal ratios.

rate: a comparison of two quantities with different units of measure.

ratio: a comparison of two quantities, often written as a fraction.

You can use cross-multiplication to find a missing value in a proportion.

Procedure

1. Review the vocabulary section. Make sure you understand each term before going to the example problem.

2. Read the example problem. Work through it step by step. Make sure your answers match the answers given.

3. Complete the remaining proportions in the example to find the missing values in the data. Then answer the analysis questions that follow.

Example Problem

Astronaut Rick Warner completed five tasks on an EVA. The table below shows data his respiration monitor collected.

Table 1.1

Respiration Rates for Rick Warner			
Task	Liters (L) of Oxygen	Time Measured (sec)	Respiration Rate in L/min
Task 1	6.5	8	
Task 2	5	5	
Task 3	5.5	5	
Task 4	8.3	10	
Task 5	4	7	

To find Rick's respiration rate in liters per minute for each task, you can use a proportion.

If you know how much oxygen Rick has used in a given amount of time, you can find an equal ratio for a 60-second amount of time, using cross-multiplication.

Step 1: *Use the data in Table 1.1 to create the first ratio in the proportion for task 1.*

$$\frac{6.5 \text{ liters}}{8 \text{ seconds}} = \frac{\mathbf{X} \text{ liters}}{60 \text{ seconds}}$$

Step 2: *Cross-multiply to find the cross-products of the proportion.*

$$\frac{6.5 \text{ liters}}{8 \text{ seconds}} = \frac{\mathbf{X} \text{ liters}}{60 \text{ seconds}}$$

$$\mathbf{X} \text{ liters} \times 8 \text{ seconds} = 6.5 \text{ liters} \times 60 \text{ seconds}$$

Step 3: *To get the variable* **X** *liters by itself, you must divide both sides of the equation by 8 seconds.*

$$\frac{\mathbf{X} \text{ liters} \times 8 \text{ seconds}}{8 \text{ seconds}} = \frac{6.5 \text{ liters} \times 60 \text{ seconds}}{8 \text{ seconds}}$$

You can cancel out any numbers or units that are the same.

$$\frac{X \text{ liters} \times \cancel{8 \text{ seconds}}}{\cancel{8 \text{ seconds}}} = \frac{6.5 \text{ liters} \times 60 \cancel{\text{ seconds}}}{8 \cancel{\text{ seconds}}}$$

Step 4: *After canceling, you are left with the following equation:*

$$X \text{ liters} = \frac{6.5 \text{ liters} \times 60}{8}$$

Multiply 6.5 liters × 60. Then divide the answer by 8.

$$X \text{ liters} = \frac{390 \text{ liters}}{8}$$

$$X \text{ liters} = 48.75 \text{ liters}$$

Step 5: *In the last step of the problem, substitute your answer for the variable* **X** *in the original proportion.*

$$\frac{6.5 \text{ liters}}{8 \text{ seconds}} = \frac{48.75 \text{ liters}}{60 \text{ seconds}}$$

You now have the respiration rate for Rick Warner in liters/60 seconds. Since 60 seconds is equal to a minute, you can write the respiration rate for Rick Warner in liters/minute for task 1.

Rick Warner's respiration rate for task 1 is 48.75 liters/minute. Write Rick's respiration rate for task 1 in Table 1.1.

Proportions Practice

Now use the data in Table 1.1 to find Rick's respiration rates for tasks 2-5 in liters per minute. Use the proportion format below to set up the problems. Follow the steps in the example to cross-multiply and solve for **X**. Fill the respiration rates into Table 1.1. Round your answers to the nearest hundredth.

$$\frac{\square \text{ liters}}{\square \text{ seconds}} = \frac{X \text{ liters}}{60 \text{ seconds}}$$

You can use the back of this paper to solve each problem.

Analysis Questions

Use the data in Table 1.1 to answer the questions below.

1. During which task was Rick's respiration rate the highest?

2. During which task was Rick's respiration rate the lowest?

3. What can you infer about the level of physical effort needed for each task based on Rick's respiration rates?

4. To conserve oxygen during an EVA, an astronaut's respiration rate is monitored so that it does not reach the rate of 60 liters per minute or more. Does Rick's respiration rate reach this critical threshold during any of the tasks? If so, in which of the tasks did his respiration rate reach 60 liters per minute or more?

5. What recommendations would you give to Rick if you were monitoring his respiration rate during this EVA?

6. What types of activities on Earth increase your respiration rate?