7.RP How Fast is Usain Bolt?

Alignments to Content Standards: 7.RP.A.3

Task

Jamaican sprinter Usain Bolt won the 100 meter sprint gold medal in the 2012 Summer Olympics. He ran the 100 meter race in 9.63 seconds. There are about 3.28 feet in a meter and 5280 feet in a mile. What was Usain Bolt's average speed for the 100 meter race in miles per hour?

IM Commentary

This task involves a multi-step conversion between two rates, going from meters per second to miles per hour. In this case, the units coming from the 100 meter race are meters per second and we do not have a good intuition for what this means in miles per hour. Most of us are used to thinking about speeds in terms of miles per hour since the speedometers in our automobiles use these units, so it is good for students to be able to convert between miles per hour and other units for speed that naturally come up.

The first solution shows all units in the calculations and does not make any calculations until the end. The second solution goes step by step and provides an excellent opportunity to discuss rounding error as it is important here to make all calculations (as in the first method) before rounding rather than using the rounded numbers for successive calculations.

In addition to the work on conversion of units, it might be interesting to compare the top speed of the fastest human being to some familiar animals:

Animal	Top Speed (in mph)

Hippopotamus	19
Kangaroo	45
Horse	47
Gazelle	50
Cheetah	70

Remarkably, of the animals in the table, the fastest human beings can only run faster than the hippopotamus. Note that the speed calculated in this problem is the *average* speed for 100 meters which is a little less than the top speed, but 23mph is significantly less than any of the other animals on the list. For a more creative implementation of this task, the teacher could provide the table of different animal speeds and ask the students how the fastest human beings would fair against them in a race.

The relevant practice standards for this problem are MP2, Reason abstractly and quantitatively, as students move between the context and the calculations, and MP6, Attend to precision, as students must focus on units and the accuracy with which they present their final answer. Note that both the time for the 100 meter race and the conversion from meters to feet are given with three digit, so only three digits should remain in the answer. Also, given the number of steps required to solve this problem, it is well aligned to MP1, Make sense of problems and persevere in solving them.

Given the complexity of the problem, it would not be appropriate for high-stakes summative assessment but would be very appropriate in an instructional setting.

Solutions

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Solution: 1 Table

We can make a table of distances and times and then find the corresponding rate at the end. In this solution, each successive line in the table represents a single unit conversion, either for distance or for time. The method used here first finds how many feet per second Usain Bolt is running and then moves from here to miles per hour.

- Usain Bolt traveled 100 meters in 9.63 seconds. 1 meter is 3.28 feet, so 100 meters is $100 \times 3.28 = 328$ feet.
- Usain Bolt traveled 328 feet in 9.63 seconds. This means he traveled 1 foot in $9.63 \div 328 = 0.02936$ seconds.
- Usain Bolt traveled 1 foot in 0.02936 seconds. 1 mile is 5280 feet, so at this speed, he would travel 1 mile in $5280 \times 0.02936 = 155$ seconds.
- At this speed, Usain Bolt would travel 1 mile in 155 seconds. 1 hour is $60 \times 60 = 3600$ seconds, so he traveled 1 mile in $155 \div 3600 = 0.043056$ hours.
- At this speed, Usain Bolt would travel 1 mile in 0.043056 hours. This means he would travel $1 \div 0.043056 \approx 23.2$ miles in 1 hour.
- At this speed, Usain Bolt would travel 23.2 miles in 1 hour.

We can summarize these steps in a table:

Distance Travelled	Time
100 meters	9.63 seconds
328 feet	9.63 seconds
1 foot	0.29 seconds
1 mile	155 seconds
1 mile	0.043 hours
23.2 miles	1 hour

The last line in the table tells shows that Usain Bolt is running a little over 23 miles per hour.

In this table the measurements of 9.63 seconds and 100 meters are not exact. The other measurement, in these calculations, which is not exact is the 3.28 feet per meters. In a situation like this, all further numbers need to be appropriately rounded. The rounding must come at the end, however, after making *all* calculations: for example, the 0.29 seconds to run a foot is a rounded number. So in the next step when this is used to find how long it would take Usain Bolt to run one mile, the calculation needs to be done not with 0.29 seconds but with 9.63 ÷ 328 seconds.

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Solution: 2 Unit conversions

We are given that Usain Bolt ran 100 meters in 9.63 seconds. We first determine how many meters per second this is:

$$100 \text{ meters} \div 9.63 \text{ seconds} = \frac{100}{9.63} \frac{\text{meters}}{\text{second}}$$

Next we use the fact that there are about 3.28 meters per foot to convert the speed to feet per second:

$$\begin{aligned} 100 \text{ meters} \div 9.63 \text{ seconds} &= \frac{100}{9.63} \frac{\text{meters}}{\text{second}} \\ &= \frac{100}{9.63} \times 3.28 \frac{\text{feet}}{\text{meter}} \times \frac{\text{meters}}{\text{second}} \\ &= \frac{100 \times 3.28}{9.63} \frac{\text{feet}}{\text{second}}. \end{aligned}$$

Next we convert feet to miles. There are 5280 feet in a mile so this gives:

$$\begin{aligned} 100 \text{ meters} \div 9.63 \text{ seconds} &= \frac{100 \times 3.28}{9.63} \frac{\text{mile}}{5280 \text{ feet}} \times \frac{\text{feet}}{\text{second}} \\ &= \frac{100 \times 3.28}{9.63 \times 5280} \frac{\text{miles}}{\text{second}}. \end{aligned}$$

Finally there are 60 seconds per minute and 60 minutes per hour so this is $60 \times 60 = 3600$ seconds per hour. Using this we can now convert our original information in terms of meters per second to miles per hour:

$$\begin{aligned} 100 \text{ meters} \div 9.63 \text{ seconds} &= \frac{100 \times 3.28}{9.63 \times 5280} \frac{\text{miles}}{\text{second}} \\ &= \frac{100 \times 3.28}{9.63 \times 5280} \frac{3600 \text{ seconds}}{\text{hour}} \times \frac{\text{miles}}{\text{second}} \\ &= \frac{100 \times 3.28 \times 3600}{9.63 \times 5280} \frac{\text{miles}}{\text{hour}}. \end{aligned}$$

Using a calculator, we find that Usain Bolt's average speed over the 100 meter race was about 23.2 miles per hour. Note that some of the numbers in this calculation, namely 100, 3600, and 5280 are exact while 3.28 and 9.63 are only approximate. Since the approximate numbers only have 3 significant digits we only report three digits in the final answer.