A rate is a ratio that compares two quantities with different units of measure. Some examples of rates are shown below:

- Miles per gallon: \(\frac{540 \text{ miles}}{18 \text{ gallons}}\) or \(\frac{540 \text{ miles}}{18 \text{ gallons}}\)
- Cost: \(\frac{$3.60}{4 \text{ pounds}}\) or \(\frac{$3.60}{4 \text{ pounds}}\)
- Pay rate: \(\frac{$285}{30 \text{ hours}}\) or \(\frac{$285}{30 \text{ hours}}\)

Rates are often given as a unit rate, which is a rate in which the second measure is 1 unit. Each of the rates listed above can be simplified as unit rates.

- Miles per gallon: \(\frac{540 \text{ miles}}{18 \text{ gallons}} = \frac{30 \text{ miles}}{1 \text{ gallon}}\)
- Cost: \(\frac{$3.60}{4 \text{ pounds}} = \frac{$0.90}{1 \text{ pound}}\)
- Pay rate: \(\frac{$285}{30 \text{ hours}} = \frac{$9.50}{1 \text{ hour}}\)

In general, for every ratio \(a:b\), the corresponding unit rate is \(\frac{a}{b}\), where \(b \neq 0\).

For example, if there are 4 cups of cranberry juice to every 5 cups of orange juice in a punch recipe, the ratio of cranberry juice to orange juice is 4:5, or \(\frac{4}{5}\). That means that there is \(\frac{4}{5}\) cup of cranberry juice for every 1 cup of orange juice. You can see this mathematically by multiplying each quantity by 5:

\[
\frac{4}{5} \times 5 = \frac{20}{5} = 4
\]

Example 1

A recipe for trail mix uses 5 ounces of mixed nuts, 6 ounces of dried fruit, and 4 ounces of granola. How many ounces of granola are there for every ounce of dried fruit?

Strategy

Write a ratio. Then find the unit rate.

Step 1

Write the ratio of granola to dried fruit.

For every 4 ounces of granola, there are 6 ounces of dried fruit.

The ratio of granola to dried fruit is 4:6, or \(\frac{4}{6}\).

In simplest form, \(\frac{4}{6} = \frac{2}{3}\).

Step 2

Interpret the ratio as a unit rate.

The ratio 2:3 means that there is \(\frac{2}{3}\) ounce of granola for every ounce of dried fruit.
Lesson 14: Unit Rates

Step 3

Check your work.

Multiply by 6.

\[
\frac{2}{3} = \frac{2 \times 6}{3 \times 6} = \frac{4}{6}
\]

For every 4 ounces of granola, there are 6 ounces of dried fruit.

Solution

There is \( \frac{2}{3} \) ounce of granola for each ounce of dried fruit.

To find a unit price, identify the quantities you want to compare and write a rate. Then simplify the rate to find the unit price.

Example 2

Mr. Wilson spent $252 to stay 3 nights at Pavia Pavilions. At that rate, how much will he spend to stay 7 nights?

Strategy

Find the unit price. Then multiply by 7 nights.

Step 1

Find the rate.

The rate is $252 for 3 nights, or \( \frac{252}{3} \).

Step 2

Find the unit rate, or unit price.

Divide 252 by 3 to find the price for one night.

\[
\begin{align*}
252 & \div 3 \\
3)252 & \\
-24 & \\
12 & \\
-12 & \\
0 & \\
\end{align*}
\]

The unit price is $84 per night.

Step 3

Multiply the unit price by 7.

\( 7 \times 84 = 588 \)

Solution

Mr. Wilson will spend $588 to stay 7 nights at Pavia Pavilions.

In Example 2, you could also have set up equivalent ratios to solve the problem. Let \( x \) represent the cost of staying 7 nights.

\[
\frac{252}{3} = \frac{x}{7}
\]

\( 3 \times x = 252 \times 7 \) \hspace{1cm} \text{Cross multiply.}

\( 3x = 1,764 \) \hspace{1cm} \text{Divide both sides by 3.}

\( x = 588 \)
A common use of rate is the speed formula $r = \frac{d}{t}$, or rate $= \frac{\text{distance}}{\text{time}}$.

**Example 3**

A train is traveling at a constant speed of 45 miles per hour. How far will the train travel in 2.5 hours?

**Strategy**  Use the speed formula.

**Step 1**  Substitute the known values in the speed formula.

$$r = \frac{d}{t}$$

$$45 = \frac{d}{2.5} \text{ or } \frac{45}{\frac{1}{2.5}} = \frac{d}{2.5}$$

**Step 2**  Find an equivalent fraction for $\frac{45}{\frac{1}{2.5}}$ with a denominator of 2.5.

$$\frac{45}{\frac{1}{2.5}} = \frac{45 \times 2.5}{1 \times 2.5} = \frac{112.5}{2.5}$$

$$\frac{45 \text{ miles}}{1 \text{ hour}} = \frac{112.5 \text{ miles}}{2.5 \text{ hours}}$$

**Solution**  The train will travel 112.5 miles in 2.5 hours.

You can rewrite the speed formula $r = \frac{d}{t}$ to solve for either distance, $d$, or time, $t$.

If $r = \frac{d}{t}$, then $d = r \times t$.

If $r = \frac{d}{t}$, then $t = \frac{d}{r}$.

In Example 3, you could have used the formula $d = r \times t$ to solve the problem.

$$d = r \times t$$

$$d = 45 \times 2.5$$

$$d = 112.5$$

---

**Coached Example**

Tanya walked 15 laps on an indoor track in 30 minutes. What was Tanya’s average speed in laps per minute?

The speed formula is $r = \text{____}$.

The distance is ______ laps.

The time is ______ minutes.

Substitute the known values into the speed formula.

$r = \text{____}$.

Simplify the fraction.

$r = \text{____}$

Tanya’s average speed was ______ laps per minute.