WELCOME TO 1103 PERIOD 1

The correct 1103 web site url is:
www.physics.ohio-state.edu/phys1103/
(The syllabus address is incorrect.)
How can ratios be used to solve problems?
How efficient is energy use?
How can scientific notation simplify solutions?
What is the energy content of common fuels?
How are ratios used to solve problems?

Ratios are fractions: \[
\frac{60 \text{ miles}}{1 \text{ hour}} \text{ (MPH)} \quad \text{or} \quad \frac{26 \text{ gal}}{1 \text{ mile}} \text{ (MPG)}
\]

Example: A truck requires 3 liters of gasoline to travel 15 kilometers. How many kilometers can the truck go on 1 liter of gas?

Solution: Write the information as a ratio. Simplify the ratio by dividing the numerator by the denominator.

\[
\frac{15 \text{ km}}{3 \text{ liters}} = \frac{5 \text{ km}}{1 \text{ liter}}
\]
Ratios are used for comparisons

By looking at the first two rows of data in the table, you cannot easily tell which vehicle gets the best gas mileage.

When you use a ratio to calculate the miles per gallon, the comparison is easier.

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Pick up truck</th>
<th>School bus</th>
<th>Race car</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miles driven</td>
<td>43 miles</td>
<td>138 miles</td>
<td>500 miles</td>
</tr>
<tr>
<td>Gas used</td>
<td>4 gal</td>
<td>14 gal</td>
<td>57 gal</td>
</tr>
<tr>
<td>Miles per gal</td>
<td>?</td>
<td>?</td>
<td>?</td>
</tr>
</tbody>
</table>
Using ratios to convert units

On a balance, 10 jelly beans balance 15 M & Ms and 2 mini Snickers balance 12 M & Ms. How many jelly beans balance one mini Snickers?

Solution: Write the equalities as ratios. Cancel units of M&MS. The answer has units of jelly beans per Snickers.

\[
\frac{10 \text{ J beans}}{15 \text{ M&Ms}} \times \frac{12 \text{ M&Ms}}{2 \text{ Snickers}} = \frac{4 \text{ J beans}}{1 \text{ Snickers}}
\]

Use ratios to find the number of nuts per washer!
Using ratios to convert units

The equality 1 hour = 60 min can be written in 2 ways:

\[
\frac{1 \text{ hour}}{60 \text{ min}} \quad \text{or} \quad \frac{60 \text{ min}}{1 \text{ hour}}
\]

1,609 meters = 1 mile can be written:

\[
\frac{1,609 \text{ meters}}{1 \text{ mile}} \quad \text{or} \quad \frac{1 \text{ mile}}{1,609 \text{ meters}}
\]

Example: Convert 60 miles per hour into meters per second. Choose ratios that cancel the unwanted units (hours and miles).

\[
\frac{60 \text{ miles}}{1 \text{ hour}} \times \frac{1,609 \text{ meters}}{1 \text{ mile}} \times \frac{1 \text{ hour}}{3,600 \text{ sec}} = \frac{27 \text{ meters}}{1 \text{ sec}}
\]
How are ratios used to find efficiency?

Efficiency is the ratio of the useful energy out of the system per total energy put into the system.

What is the efficiency of an energy conversion that requires 600 joules of energy in to produce 450 joules of useful energy?

Efficiency = \( \frac{\text{Useful energy out}}{\text{Total energy in}} = \frac{450 \text{ joules}}{600 \text{ joules}} = 0.75 \)
Using exponents and powers of 10

\[ 2^3 = 2 \times 2 \times 2 = 8 \]

\[ 10^4 = 10 \times 10 \times 10 \times 10 = 10,000 \]
Rules for using exponents

1. When multiplying numbers with exponents, add the exponents

\[ 10^A \times 10^B = 10^{(A + B)} \]

\[ 10^2 \times 10^{-3} = 10^{(2 + (-3))} = 10^{-1} = \frac{1}{10} = 0.1 \]

2. When dividing numbers with exponents, subtract the exponents

\[ 10^A \div 10^B = 10^{(A - B)} \]

\[ 10^2 \div 10^{-3} = 10^{(2 - (-3))} = 10^5 = 100,000 \]
3. When raising numbers with an exponent to a power, **multiply** the exponents.

\[(10^A)^B = 10^{(A \times B)}\]

\[(10^3)^2 = 10^{(2 \times 3)} = 10^6 = 1,000,000\]

4. Any number to the zero power = 1:

\[10^0 = 1 \quad 237^0 = 1\]
SCIENTIFIC NOTATION

Scientific notation uses base 10 raised to an exponent (power of 10). The exponent shows the number of times that 10 is multiplied by itself.

\[
\begin{align*}
10^1 &= 10 \\
10^2 &= 10 \times 10 = 100 \\
10^3 &= 10 \times 10 \times 10 = 1,000 \\
10^{-1} &= 1/10 = 0.1 \\
10^{-2} &= 1/(10 \times 10) = 0.01 \\
10^{-3} &= 1/(10 \times 10 \times 10) = 0.001
\end{align*}
\]
Converting numbers into scientific notation

1) For numbers equal to or greater than one (positive exponents), count the places the decimal point is shifted to the left.

\[2,600.0 = 2.6 \times 10^3\]

2) For numbers less than one (negative exponents), count the number of places the decimal point is shifted to the right.

\[0.035 = 3.5 \times 10^{-2}\]
# Prefixes for multiples of ten

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Symbol</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>quad</td>
<td>quadrillion</td>
<td>$10^{15}$</td>
</tr>
<tr>
<td>tera</td>
<td>trillion</td>
<td>$10^{12}$</td>
</tr>
<tr>
<td>giga</td>
<td>G billion</td>
<td>$10^{9}$</td>
</tr>
<tr>
<td>mega</td>
<td>M million</td>
<td>$10^{6}$</td>
</tr>
<tr>
<td>kilo</td>
<td>k</td>
<td>$10^{3}$</td>
</tr>
<tr>
<td>hecto</td>
<td>h</td>
<td>$10^{2}$</td>
</tr>
<tr>
<td>deca</td>
<td>da</td>
<td>$10^{1}$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Symbol</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>deci</td>
<td>d</td>
<td>$10^{-1}$</td>
</tr>
<tr>
<td>centi</td>
<td>c</td>
<td>$10^{-2}$</td>
</tr>
<tr>
<td>milli</td>
<td>m</td>
<td>$10^{-3}$</td>
</tr>
<tr>
<td>micro</td>
<td>μ</td>
<td>$10^{-6}$</td>
</tr>
<tr>
<td>nano</td>
<td>n</td>
<td>$10^{-9}$</td>
</tr>
<tr>
<td>pico</td>
<td>p</td>
<td>$10^{-12}$</td>
</tr>
<tr>
<td>femto</td>
<td>f</td>
<td>$10^{-15}$</td>
</tr>
</tbody>
</table>

**Examples:**

3 kilograms = $3 \times 10^3$ kg = 3,000 kg

6 nanoseconds = $6 \times 10^{-9}$ seconds = 0.000000006 sec
Powers of ten on a calculator

• To enter $8 \times 10^7$: press 8, x, the $10^x$ key, and enter the exponent (7).

• If the $10^x$ symbol is above another key, press 2$^{nd}$ F before the $10^x$ key.

• For a negative exponent, press the +/- key before entering the exponent:

• If your calculator has an EE or EXP key, press that key and then enter the exponent.

• A calculator’s $y^x$ key does NOT give powers of 10. For example, $3.4^8$ is NOT the same as $3.4 \times 10^8$. 
Energy content of common fuels

<table>
<thead>
<tr>
<th>Type of Fuel</th>
<th>Energy Content (joules/kilogram)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen gas (fuel cells)</td>
<td>$14.2 \times 10^7$</td>
</tr>
<tr>
<td>Natural gas</td>
<td>$5.5 \times 10^7$</td>
</tr>
<tr>
<td>Crude oil / Gasoline</td>
<td>$4.6 \times 10^7$</td>
</tr>
<tr>
<td>Ethanol</td>
<td>$3.0 \times 10^7$</td>
</tr>
<tr>
<td>Coal (bituminous)</td>
<td>$2.4 \times 10^7$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type of Fuel</th>
<th>Energy Content (joules/kilogram)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood</td>
<td>$1.8 \times 10^7$</td>
</tr>
<tr>
<td>Metabolism of food</td>
<td>$1.7 \times 10^7$</td>
</tr>
<tr>
<td>Household waste</td>
<td>$0.8 \times 10^7$</td>
</tr>
<tr>
<td>Nuclear fission with U-235</td>
<td>$8 \times 10^{13} = 8,000,000 \times 10^7$</td>
</tr>
</tbody>
</table>
Comparisons of energy content

To make a comparison, use a ratio!

Example: How many kilograms of natural gas equal the energy content of 1 kilogram of hydrogen gas?

\[
\frac{1 \text{ kg natural gas}}{5.5 \times 10^7 \text{ J}} \times \frac{14.2 \times 10^7 \text{ J}}{1 \text{ kg hydrogen}} = 2.6 \text{ kg gas}
\]

Arrange the ratios to cancel the unwanted units (joules) and give an answer in the desired units (kg natural gas/kg hydrogen)
BEFORE THE NEXT CLASS…

✓ Read textbook chapter 2
✓ Watch Video 1: Ring of Truth: Change
✓ Complete Homework Exercise 1

(Exercise 1 is found at the end of Activity Sheet 1.)

For hints/help answering the Exercise questions, refer to the sample problems in the textbook Chapter 1.