Section 1: The Nature of Science

Preview

Key Ideas

- How do scientists explore the world?
- How are the many types of science organized?
- What are scientific theories, and how are they different from scientific laws?

How Science Takes Place

- How do scientists explore the world?
- A scientist may perform experiments to find a new aspect of the natural world, to explain a known phenomenon, to check the results of other experiments, or to test the predictions of current theories.

How Science Take Place, *continued*

- Scientists investigate.
- Scientists plan experiments.
- Scientists observe.
- Scientists always test the results.

The Branches of Science

- How are the many types of science organized?

- Most of the time, natural science is divided into biological science, physical science and Earth science.

- **science:** the knowledge obtained by observing natural events and conditions in order to discover facts and formulate laws or principles that can be verified or tested

The Branches of Science, *continued*

- The branches of science work together.
  - *biological science:* the science of living things
    - botany, ecology
  - *physical science:* the science of matter and energy
    - *chemistry:* the science of matter and its changes
    - *physics:* the science of forces and energy
  - *earth science:* the science of the Earth, the atmosphere, and weather
    - geology, meteorology

Visual Concept: Natural Science

Click the button below to watch the Visual Concept.

Visual Concept

Visual Concept: Biology

Click the button below to watch the Visual Concept.

Visual Concept

Visual Concept: Physics

Click the button below to watch the Visual Concept.

Visual Concept

Visual Concept: Earth Sciences

Click the button below to watch the Visual Concept.

Visual Concept

The Branches of Science, *continued*

- Science and technology work together.
  - *pure science:* the continuing search for scientific knowledge
  - Advances in science and technology depend on each other.
- **technology:** the application of science for practical purposes

Scientific Laws and Theories

- What are scientific theories, and how are they different from scientific laws?
- Theories explain why something happens, laws explain how something works.

- **law:** a descriptive statement or equation that reliably predicts events under certain conditions
- **theory:** a system of ideas that explains many related observations and is supported by a large body of evidence acquired through scientific investigation

Scientific Laws and Theories, *continued*

- Experimental results support laws and theories.
  - Scientific theories are always being questioned and examined. To be valid, a theory must:
    - explain observations
    - be repeatable
    - be predictable

Visual Concept: Comparing Theories and Laws

Click the button below to watch the Visual Concept.

Visual Concept

Scientific Laws and Theories, *continued*

- Mathematics can describe physical events.
  - *qualitative statement:* describes something with words
  - *quantitative statement:* describes something with mathematical equations

Scientific Laws and Theories, *continued*

- Theories and laws are always being tested.

- Models can represent physical events.
  - *model:* a representation of an object or event that can be studied to understand the real object or event
  - Scientists use conceptual, physical, and computer models to study objects and events.

- We use models in our everyday lives.

Visual Concept: Models

Click the button below to watch the Visual Concept.

Visual Concept

Visual Concept: Physical, Mathematical, and Conceptual Models

Click the button below to watch the Visual Concept.

Visual Concept

Section 2: The Way Science Works

Preview

Key Ideas

- How can I think and act like a scientist?
- How do scientists measure things?

Science Skills

- How can I think and act like a scientist?

- Identifying problems, planning experiments, recording observations, and correctly reporting data are some of the most important science skills.

    - Scientists approach a problem by thinking logically.

Science Skills, *continued*

- Critical thinking helps solve problems logically.
- **critical thinking:** the ability and willingness to assess claims critically and to make judgments on the basis of objective and supported reasons
- Scientists use scientific methods to solve problems.
- **scientific method:** a series of steps followed to solve problems including collecting data, formulating a hypothesis, testing the hypothesis, and stating conclusions
  - The scientific methods are general description of scientific thinking rather than an exact path for scientists to follow.

Science Skills, *continued*

- Scientists test hypotheses.
- *hypothesis:* a possible explanation or answer that can be tested
  - Scientists test a hypothesis by doing a controlled experiment.
  - *controlled experiment:* an experiment in which the variables that could affect the experiment are kept constant (controlled) except for the one that you want to measure
  - *variable:* a factor that changes in an experiment in order to test a hypothesis

Science Skills, *continued*

- Experiments test ideas.
  - No experiment is a failure.
  - The results of every experiment can be used to revise the hypothesis or plan tests of a different variable.
  - *Peer-reviewed research:* research that has been reviewed by other scientists

Science Skills, *continued*

- Scientists use special tools.
- There are many tools used by scientists for making observations, including
  - *telescopes*
  - *spectroscopes*
  - *particle accelerators*

Units of Measurement

- How do scientists measure things?
- Scientists use standard units of measure that together form the International System of Units, or SI.

Units of Measurement, continued

- SI units are used for consistency.
  - SI has seven base units.

Quantity	Unit	Abbreviation
Length	meter	m
Mass	kilogram	kg
Time	second	s
Temperature	kelvin	K
Electric current	ampere	A
Amount of substance	mole	mol
Luminous intensity	candela	cd

  - *derived units:* combinations of the base units

Units of Measurement, *continued*

- SI prefixes are for very large and very small measurements.
  - The prefixes are multiples of 10.
  - SI prefixes for large measurements

Prefix	Symbol	Meaning	Multiple of base unit
kilo-	k	thousand	1,000
mega-	M	million	1,000,000
giga-	G	billion	1,000,000,000

Units of Measurement, *continued*

- SI prefixes for small measurements

Prefix	Symbol	Meaning	Multiple of base unit
deci-	d	tenth	0.1
centi-	c	hundredth	0.01
milli-	m	thousandth	0.001
micro-	µ	millionth	0.000001
nano-	n	billionth	0.000000001

Units of Measurement, *continued*

- You can convert between small and large numbers.
  - To convert to a smaller unit, multiply the measurement by the ratio of units so that you get a larger number.
  - To convert to a larger unit, divide the measurement by the ratio of units so that you get a smaller number.

Math Skills

Conversions within SI

The width of a soccer goal is 7 m. What is the width of the goal in centimeters?

1. List the given and unknown values.

Given: *length in meters, l* = 7 m

Unknown: *length in centimeters* = *?* cm

Math Skills, *continued*

2. Determine the relationship between units.

1 cm = 0.01 m

1 m = 100 cm

Multiply by 100 because you are converting from meters, a larger unit, to centimeters, a smaller unit.

3. Write the equation for the conversion.

$$\textit{length in cm} = \text{m} \times \frac{100\ \text{cm}}{1\ \text{m}}$$

Math Skills, *continued*

4. Insert the known values into the equation, and solve.

$$\textit{length in cm} = 7\ \cancel{\text{m}} \times \frac{100\ \text{cm}}{1\ \cancel{\text{m}}}$$

$$\boxed{\textit{length in cm} = 700\ \text{cm}}$$

Units of Measurement, *continued*

- Measurements quantify your observations.
- **length:** a measure of the straight-line distance between two points
- **mass:** a measure of the amount of matter in an object
- **volume:** a measure of the size of a body or region in three-dimensional space
- **weight:** a measure of the gravitational force exerted on an object

Section 3: Organizing Data

Preview

Key Ideas

- Why is organizing data an important science skill?
- How do scientists handle very large and very small numbers?
- How can you tell the precision of a measurement?

Bellringer

Imagine your teacher asked you to study how the addition of different amounts of fertilizer affects plant heights. In your experiment, you collect the data shown in

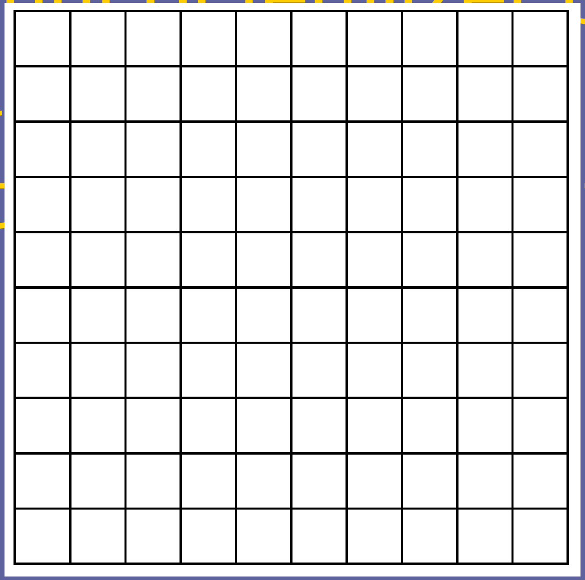
Plant number	Fertilizer (g)	Height (cm)	Plant number	Fertilizer (g)	Height (cm)
1	10	15	5	5	14
2	25	21	6	30	19
3	20	18	7	15	17
4	0	12	8	35	16

Bellringer, *continued*

1. Which amount of fertilizer produced the tallest plants?

2. Which amount of fertilizer produced the smallest pla

3. Plot the dat the one below.



Presenting Scientific Data

- Why is organizing data an important science skill?

- Because scientists use written reports and oral presentations to share their results, organizing and presenting data are important science skills.

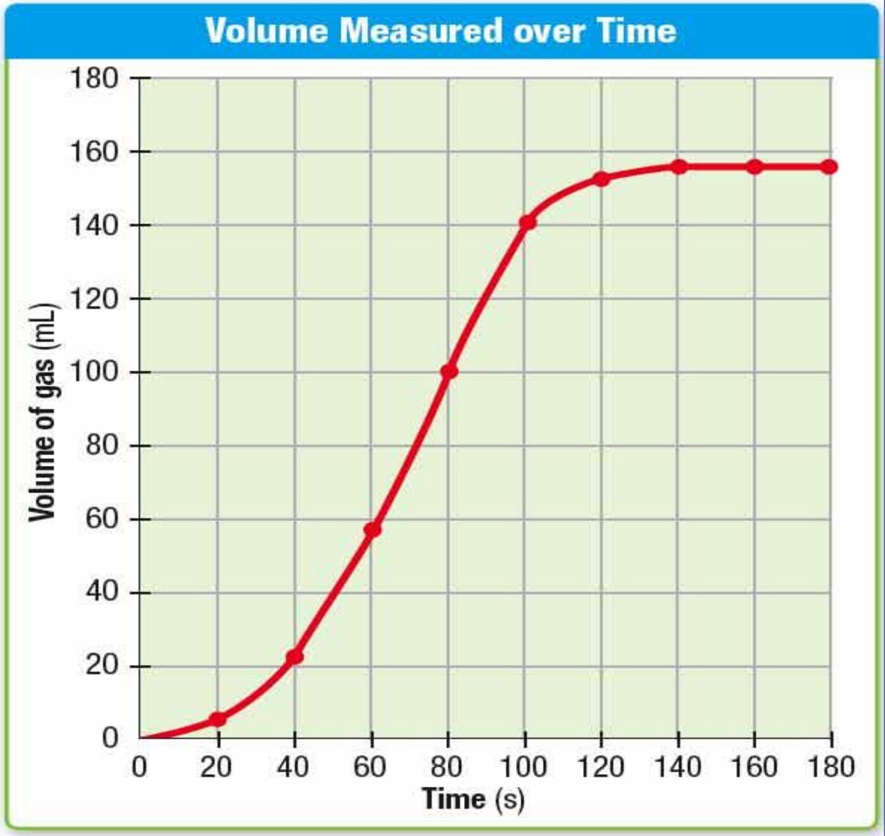
Presenting Scientific Data, *continued*

- *Line graphs* are best for continuous change.
  - *dependent variable:* values depend on what happens in the experiment
    - Plotted on the x-axis
  - *independent variable:* values are set before the experiment takes place
    - Plotted on the y-axis

Line Graph

Experimental Data

Time (s)	Volume of gas (mL)
0	0
20	6
40	25
60	58
80	100
100	140
120	152
140	156
160	156
180	156

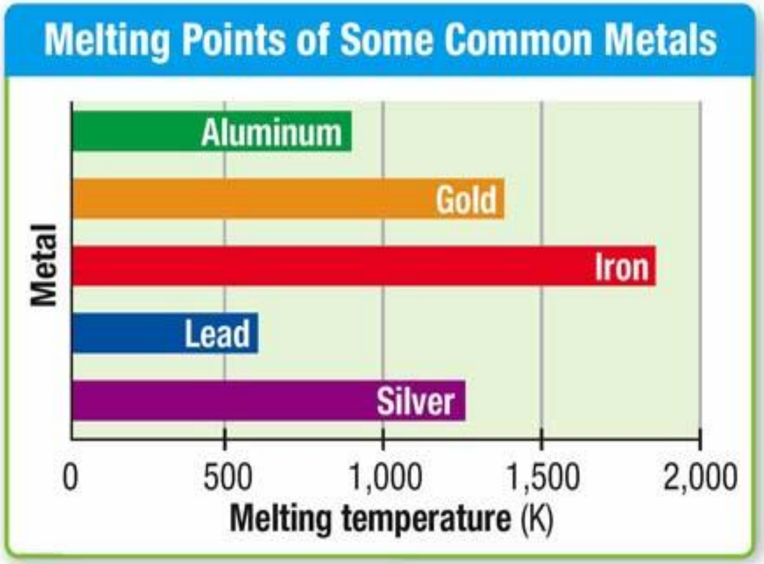


Back Next Preview Main

Presenting Scientific Data, *continued*

- *Bar graphs* compare items.
  - A bar graph is useful for comparing similar data for several individual items or events.
  - A bar graph can make clearer how large or small the differences in individual values are.

Bar Graph

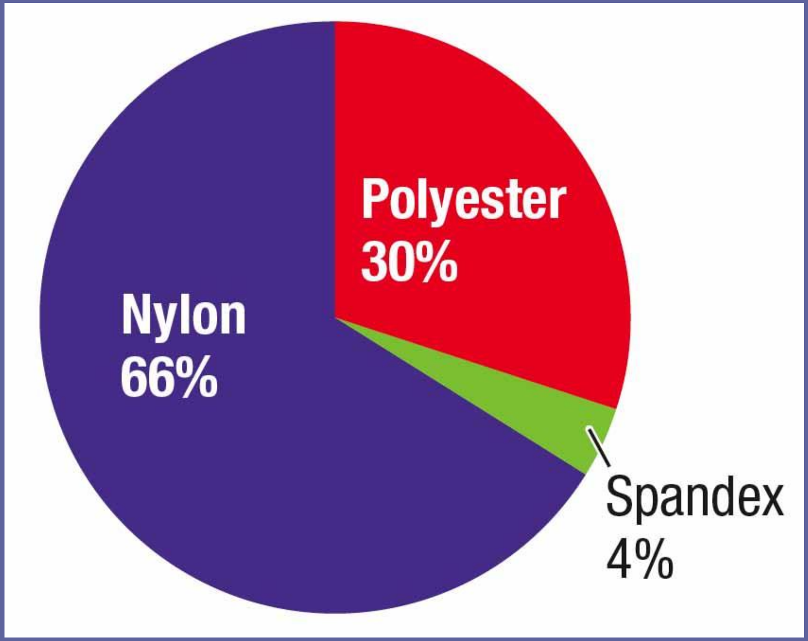


Melting Points of Some Common Metals

Element	Melting temperature (K)
Aluminum	933
Gold	1,337
Iron	1,808
Lead	601
Silver	1,235

Presenting Scientific Data, *continued*

Composition of a Winter Jacket



- *Pie graphs* show the parts of a whole.
  - A pie graph is ideal for displaying data that are parts of a whole.
  - Data in a pie chart is presented as a

Writing Numbers in Scientific Notation

- How do scientists handle very large and very small numbers?

- To reduce the number of zeros in very big and very small numbers, you can express the values as simple numbers multiplied by a power of 10, a method called scientific notation.

- **scientific notation:** a method of expressing a quantity as a number

Writing Numbers in Scientific Notation, *continued*

- Some powers of 10 and their decimal equivalents are shown below.

  - $10^3 = 1,000$
  - $10^2 = 100$
  - $10^1 = 10$
  - $10^0 = 1$
  - $10^{-1} = 0.1$
  - $10^{-2} = 0.01$
  - $10^{-3} = 0.001$

Writing Numbers in Scientific Notation, *continued*

- Use scientific notation to make calculations.
- When you use scientific notation in calculations, you follow the math rules for powers of 10.
- When you multiply two values in scientific notation, you add the powers of 10.
- When you divide, you subtract the

Math Skills

Writing Scientific Notation

The adult human heart pumps about 18,000 L of blood each day. Write this value in scientific notation.

1. List the given and unknown values.

Given: *volume, V* = 18,000 L

Unknown: *volume, V* = ? × 10$^{?}$ L

Math Skills, *continued*

2. Write the form for scientific notation.

$V = ? \times 10^{?}$ L

3. Insert the known values into the form, and solve.

Find the largest power of 10 that will divide into the known value and leave one digit before the decimal point.

You get 1.8 if you divide 10,000 into 18,000 L.

18,000 L can be written as (1.8 × 10,000) L

Math Skills, *continued*

Then, write 10,000 as a power of 10.

$10{,}000 = 10^{10}$

18,000 L can be written as 1.8×10^{10} L

$V = 1.8 \times 10^{10}$ L

Math Skills

Using Scientific Notation

Your county plans to buy a rectangular tract of land measuring 5.36 x 10^3 m by 1.38 x 10^4 m to establish a nature preserve. What is the area of this tract in square meters?

1. List the given and unknown values.

Given: *length* (*l*) = 1.38 × 10^4 m

Math Skills, *continued*

2. Write the equation for area.

$A = l \times w$

3. Insert the known values into the equation, and solve.

$A = (1.38 \times 10^4 \text{ m})\ (5.36 \times 10^3 \text{ m})$

Regroup the values and units as follows.

$A = (1.38 \times 5.36)\ (10^4 \times 10^3)\ (\text{m} \times \text{m})$

When multiplying, add the powers of 10.

$A = (1.38 \times 5.35)\ (10^{4+3})\ (\text{m} \times \text{m})$

$A = 7.3968 \times 10^7 \text{ m}^2$

$\mathbf{A = 7.40 \times 10^7\ m^2}$

Using Significant Figures

- How can you tell the precision of a measurement?
- Scientists use significant figures to show the precision of a measured quantity.

- **precision:** the exactness of a measurement
- **significant figure:** a prescribed decimal place that determines the amount of rounding off to be done based on the precision of the measurement

Using Significant Figures, *continued*

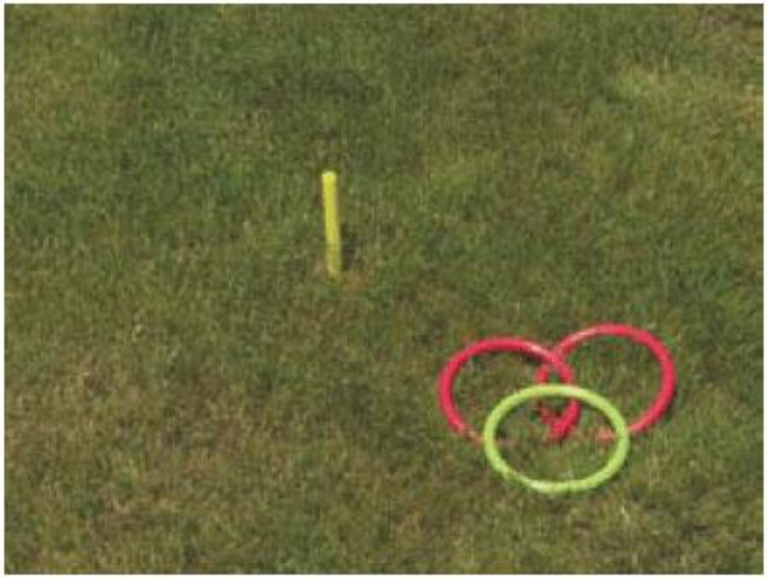
- Precision differs from accuracy.
- **accuracy:** a description of how close a measurement is to the true value of the quantity measured

Accuracy and Precision, Part 1

A Good accuracy (near post) and good precision (close together)

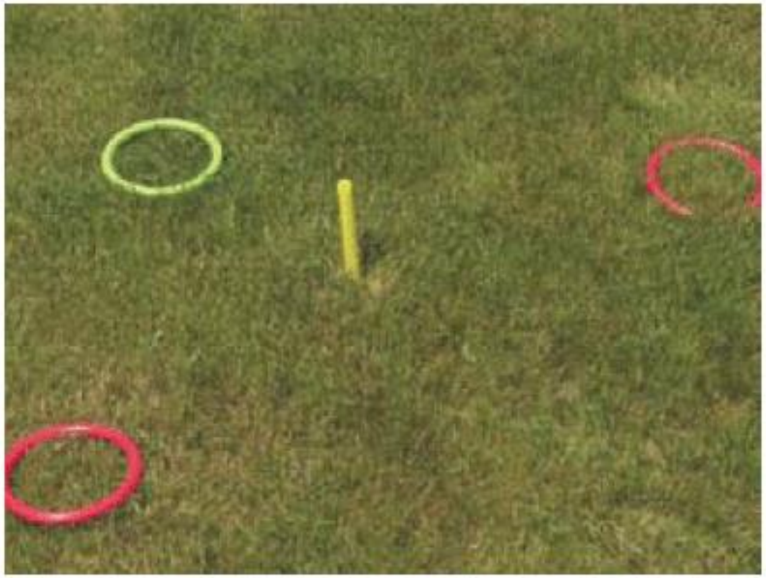
B Good accuracy (near post) and poor precision (spread apart)

Accuracy and Precision, Part 2



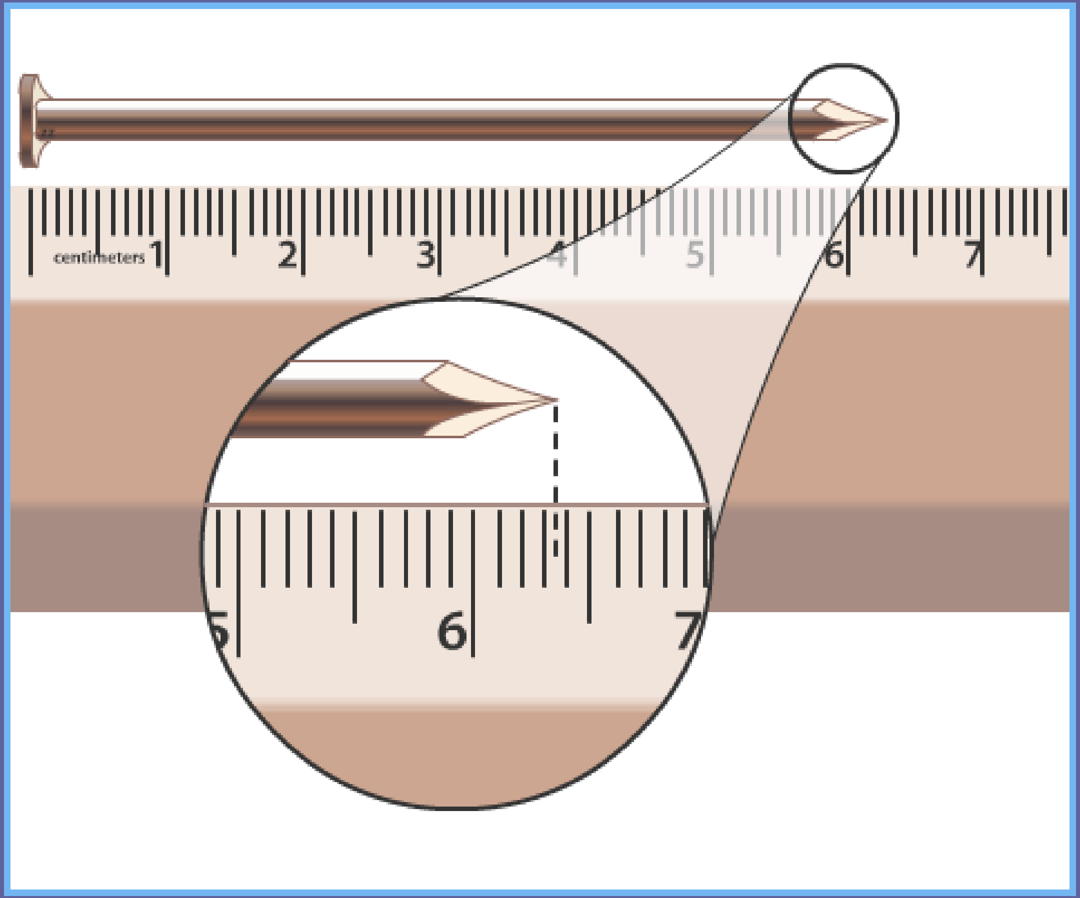
Sam Dudgeon/HRW

C Poor accuracy (far from post) and good precision (close together)



D Poor accuracy (far from post) and poor precision (spread apart)

Visual Concept: Significant Figures



Using Significant Figures, *continued*

- Round your answers to the correct significant figures.
- When you use measurements in calculations, the answer is only as precise as the least precise measurement used in the calculation.
- The measurement with the fewest significant figures determines the number of significant figures that can be used in the answer.

Math Skills

Significant Figures

Calculate the volume of a room that is 3.125 m high, 4.25 m wide, and 5.75 m long. Write the answer with the correct number of significant figures.

1. List the given and unknown values.

Given: *length, l* = 5.75 m

width, w = 4.25 m

height, h = 3.125 m

Unknown: *volume, V* = ? m^3

Math Skills, continued

2. Write the equation for volume.

$V = l \times w \times h$

3. Insert the known values into the equation, and solve.

$V = 5.75\ \text{m} \times 4.25\ \text{m} \times 3.125\ \text{m}$

$V = 76.3671875\ \text{m}^3$

The answer should have three significant figures, because the value with the smallest number of significant figures has three significant figures.

$V = 76.4\ \text{m}^3$