Chapter 1: Introduction, Measurement, Estimating

Outline

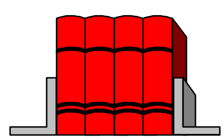
1.1 The Nature of Science
1.2 Physics and its Relation to Other Fields
1.3 Models, Theories, and Laws
1.4 Measurement and Uncertainty; Significant Figures
1.5 Units, Standards, and the SI System
1.6 Converting Units

Major Concepts

By the end of the chapter, students should understand each of the following and be able to demonstrate their understanding in problem applications as well as in conceptual situations.

- General definitions of science and physics
- Significant figures
    - Addition and multiplication
    - Scientific notation
- Systems of units
    - Length
    - Mass
    - Time
- Unit conversions

Book References:



Physics: Principles with Applications, Giancoli, Sixth Edition Chapter 1 pages 1-18.

Week 1: Lesson 1

1.1 The Nature of Science

Observation: important first step toward scientific theory; requires imagination to tell what is important.
Theories: created to explain observations; will make predictions.
Observations will tell if the prediction is accurate, and the cycle goes on.

How does a new theory get accepted?
- Predictions agree better with data
- Explains a greater range of phenomena

1.2 Physics and Its Relation to Other Fields

Physics is needed in both architecture and engineering.
Other fields that use physics, and make contributions to it: physiology, zoology, life sciences, …

1.3 Models, Theories, and Laws

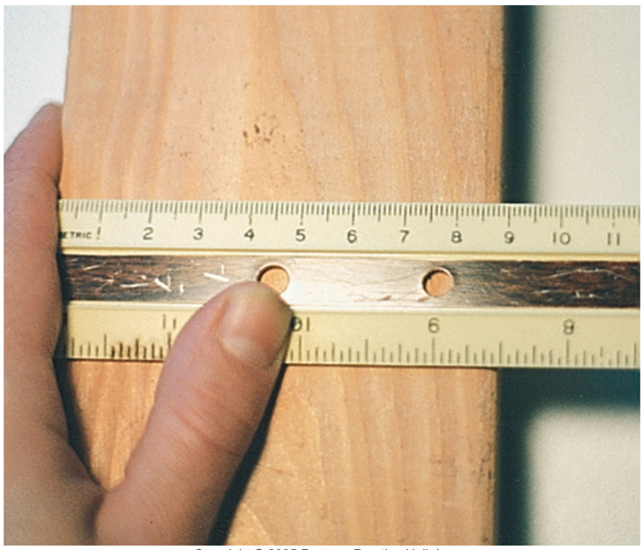
Science uses **experiments**, and explains the results with **laws** and **hypotheses**. Sometimes the theories and hypotheses have to be changed because they no longer fit the data shown by new experiments. When the facts are more clear a hypothesis becomes a theory. An example would be the atomic theory.

Good scientists are always logical and looking for new ways of explaining things and they always try to follow up on any new information shown by new experiments. The scientific method is a way of adding new observations and testing hypotheses. The logical methods used by scientists are also useful in doing things in our everyday lives.

Models are very useful during the process of understanding phenomena. A model creates mental pictures; care must be taken to understand the limits of the model and not take it too seriously.
A **theory** is detailed and can give testable predictions.
A **law** is a brief description of how nature behaves in a broad set of circumstances.
A **principle** is similar to a law, but applies to a narrower range of phenomena.

1.4 Measurement and Uncertainty; Significant Figures

No measurement is exact; there is always some **uncertainty** due to limited instrument accuracy and difficulty reading results.



The above photograph illustrates this. It would be difficult to measure the width of this board to better than a millimeter (the smallest division on the ruler).

Estimated uncertainty is written with a ± sign; for example:

$$8.8 \pm 0.1 \text{ cm}$$

Percent uncertainty is the ratio of the uncertainty to the measured value, multiplied by 100:

$$\frac{0.1}{8.8} \times 100\% \approx 1\%$$

Example:

What is the percent uncertainty in the measurement 3.76 ± 0.25 m ?

Solution:

$$\% \text{ uncertainty} = \frac{0.25 \text{ m}}{3.76 \text{ m}} \times 100\% = 6.6\%$$

Significant Figures

Even good students seem to have trouble remembering to use significant figures correctly. Proper use of significant figures is part of the "culture" of Science and engineering. It is important that you understand the reasons for significant figures and that you get in the habit of using them properly.

The result of a measurement has two parts: a number and a unit. One without the other is meaningless. **The number of reliably known digits in a number is called the number of significant figures.**

The number of signifant figures may not always be clear. When making measurements, or when doing calculations, you should not keep more digits in the final answer than is justified.

In laboratory work, the proper number of significant figures is determined by the experiment. The least precisely measured quantity sets the proper number.

NUMBERS:

Number can be exact or non-exact

Exact numbers

Exact numbers come from counting or from definitions. Examples:

There are 8 students in the classroom – 8 is an exact number

Na2SO4, the 2 and 4 in the formula are exact numbers

1 m = 1000 mm, 1000 is exact since it is a definition of mm

Average = (2.41 + 2.46 + 2.42) / 3 = 2.43, the number 3 in the denominator is exact as there were exactly three numbers to average

Non-exact numbers

These numbers come from measurements or estimates. Examples:

Mass of beaker = 22.38 g. This number is not exact. A better balance might give us 22.3792 g. The last digit (8 in the first number, 2 in the second) is significant (see below) but uncertain.

There are 4.5 million people in the UAE. This number is not exact, it is an estimate.

Rules for significant figures

1. All non-zeros are significant. Example: 22.4 has 3 significant figures (s.f.)

2. All leading zeros (zeros in front of nonzero digits) are not significant. Example: 0.0224 has 3 s.f., 0.00098 m has two significant figures.

3. All imbedded zeros (zeros between non-zero digits) are always significant. Example: 3104.2 has 5 s.f., 250.4 g has four significant figures.

4. Trailing zeros are significant if the number has a decimal point. Examples:

3.230 (4 s.f.)	1.00 (3 s.f.)	1.20 x 102 (3 s.f.)
3500 (2 s.f.)	3040 (3 s.f.)	0.02030 (4 s.f.)
120 km/h (2 s.f.)	120. km/h (3 s.f.)	100. (3 s.f.)
1000 (1 s.f.)	1000. (4 s.f.)	1.0 x 103 (2 s.f.)

N.B. The number of significant figures may not always be clear. Take for example the number 80: Are there one or two significant figures?
If we say it is about 80 km between two cities, there is only one significant figure. If it is exactly 80 km within an accuracy of 1 or 2 km then the 80 has two significant figures. If the 80 has two significant figures, some people prefer to write it 80., with a decimal point.
If it is precisely 80 km to within $\pm 0.1 km$, **then we write 80.0 km (3 s.f.).**

When zeros come after other nonzero digits, however, there is the possibility of misinterpretation. For example, suppose the length of an object is given as 1500 mm, it is difficult to know whether the last two zeros are being used to locate the decimal point or whether they represent significant figures. One way to solve such problem is to report all values using scientific notation.

http://science.widener.edu/svb/tutorial/sigfigures.html

Decimal Places

These refer to the number of figures which follow the decimal point (d.p.)
Thus: 35.1 has one d.p. and 2.402 has three d.p.

Rounding off

If a number needs to be rounded off to a particular number of significant figures, look at the next digit. If that digit is 0-4 drop it, if it is 5-9 increase the previous number by 1. Examples:

2.424 rounded to 3 s.f. is 2.42
2.388 rounded to 3 s.f. is 2.39
2.1455 rounded to 3 s.f. is 2.15
2.1455 rounded to 2 s.f. is 2.1
0.02496 rounded to 3 s.f. is 0.0250

Scientific notation

Very large numbers and very small numbers are best presented in scientific notation. Examples:

1.204×10^6 5.34×10^{-4}

Powers of 10 are used to express the very large and very small numbers necessary for scientific measurements:

$$10^2 = 10 \times 10 = 100$$

$$10^3 = 10 \times 10 \times 10 = 1000$$

$$10^{-2} = \frac{1}{10^2} = \frac{1}{100} = 0.01$$

Decimal place Shifted 5 places to left
360,000 becomes 3.6×10^5

Decimal place Shifted 2 places to left
246.7 becomes 2.467×10^2

The exponent, or power of 10, is *increased* by 1 for every place the decimal place is shifted to the *left*

Decimal place Shifted 2 places to right
0.0694 becomes 6.94×10^{-2}

Decimal place Shifted 5 places to right
0.000011 becomes 1.1×10^{-5}

The exponent, or power of 10, is *decreased* by 1 for every place the decimal place is shifted to the *right*

Note: the **number in front of the decimal point must be between 1 and 9.** Examples:

0.243×10^3 is incorrect and should be written as 2.43×10^2
31.42×10^{-4} is incorrect and should be written as 3.142×10^{-3}

This only applies to a final result you are reporting. In middle calculations you can use an incorrect form of scientific notation. Sometimes you may even have to, but the final result must have the correct form. Example:

$2.34 \times 10^3 + 1.4 \times 10^2 = 2.34 \times 10^3 + 0.14 \times 10^3 = 2.48 \times 10^3$

http://science.widener.edu/svb/tutorial/scinotcsn7.html

Using significant figures in calculations

Multiplication and division: The result can only have as many s.f. as the least number of s.f. in the factors. Examples:

3.42 x 1.2 x 0.7955 = 3.264732 = 3.3 (2 s.f. since 1.2 had only 2 s.f.)

2.45 x 1.308 / 4.223 = 0.7588444 = 0.759 (3 s.f. since 2.45.had only 3 s.f.)

Addition and subtraction: The result will have as many decimal places (d.p., digits after the decimal point) as the least number of decimal places in the addenda. Examples:

12.45 + 0.302 = 12.752 = 12.75 (2 d.p. since 12.45 had only 2 d.p.)

It is convenient to write the numbers under each other to evaluate the number of d.p. required:

```
 12.45|
  0.30|2
 -------
 12.75|2  =  12.75
```

109.45 - 108.2 = 1.25 = 1.3 (1 d.p. since 108.2 had only 1 d.p.)

$$\frac{7.428 - 7.413}{7.428}\ 100\% = \frac{0.015}{7.428}\ 100\% = 0.20\%$$

Note: when there is a mixture of additions/subtractions and multiplications/divisions, carry out the additions/subtractions first using the rules for decimal places, then do the multiplications/divisions using the correct significant figures. The example here has 2 s.f. in the result since 0.015 had 2 s.f. The 100 in 100% is exact since it is a definition of percent.

Using log (or ln) the number of decimal places in the result equals the number of significant figures in the original number. Examples:

log 3.24 = 0.511545 = 0.512 (3 d.p.)

log 108.9 = 2.03703 = 2.0370 (4 d.p.)

log 3.1 x 10^4 = 4.491362 = 4.49 (2 d.p.)

Examples:

1. If you divide 6.8 by 1.67 you will get an answer of 4.0718563 on your calculator. This number of digits is meaningless for this problem because the answer has seven decimal places and the original numbers have only one or two.

6.8	/	1.67	=	4.1
Limiting term 2 significant figures		(3 s.f.)		4.0718563 rounded to 2 significant figures

Only report as many significant figures in the result as there are in the quantity with the *least* number of significant figures. (6.8 has 2 s.f.'s)

In Problem Solving the number of significant figures in final result should be same as least significant input value.

Report only the proper number of significant figures in the final result. Keep extra digits during the calculation.

It is a good strategy to keep many digits through a calculation, because it is sometimes necessary to do this to get the right answer to a sufficient number of significant figures. At the end of a calculation, however, the result should be given to only as many figures as are significant.

2. You measure the radius of a wheel to be 4.16 cm. If you multiply by 2 to get the diameter, should you write the result as 8 cm or as 8.32 cm? Justify your answer.

Solution:

The result should be written as 8.32 cm. The factor of 2 used to convert radius to diameter is exact - it has no uncertainty, and so does not change the number of significant figures.

3. Express the sine of 30.0° with the correct number of significant figures.

Solution:

sin 30.0° = 0.500

4. Round off each of the following:

(a) 26.142 to three significant figures.

Solution:

The 4 is the first digit to be removed and is less than 5. Then, 26.142 → 26.1

(b) 10.063 to three significant figures.

Solution:

The 6 is the first digit to be removed. (Here the zero on each side of the decimal point are significant because they have nonzero digits on both sides or are "captive" zeros.) Then, 10.063 → 10.1

(c) 0.09970 to two significant figures.

Solution:
In this case the first nondigit to be removed is the 7. (The zeros to the immediate left and right of the decimal point are not significant but only locate the decimal point. They are called "leading" zeros.) Since 7 is greater than 5, 0.0997 → 0.10

(d) The result of the product of the measured numbers 5.0 x 356.

Solution:

Performing the multiplication, 5.0 x 356 = 1780
Since the result should have only two significant figures as limited by the 5.0, we round off
1780 → 1800

Homework 1:

Answer the following questions

1. The age of the universe is thought to be about 14 billion years. Assuming two significant figures, write this in powers of ten in (a) years, (b) seconds.

2. How many significant figures do each of the following numbers have: (a) 214, (b) 81.60, (c) 7.03, (d) 0.013, (e) 0.086, (f) 3236, and (g) 8700 ?

3. Write the following numbers in powers of ten notation: (a) 1.156, (b) 21.8, (c) 0.0068, (d) 27.635, (e) 0.219, and (f) 444.

4. Write out the following numbers in full with the correct number of zeros: (a) 8.69×10^4, (b) 9.1×10^3, (c) 8.8×10^{-1}, (d) 4.76×10^2, and (e) 3.62×10^{-5}.

5. Time intervals measured with a stopwatch typically have an uncertainty of about 0.2 s, due to human reaction time at the start and stop moments. What is the percent uncertainty of a hand timed measurement of (a) 5 s, (b) 50 s, (c) 5 min.?

6. Multiply 2.079×10^2 m by 0.082×10^{-1}, taking into account significant figures.

Week 1: Lesson 2:

1.5 Units, Standards, and the SI System

We measure many objects with different types and sizes of units. Some fundamental physical quantities are length, mass and time.
A standard unit is a fixed value for taking accurate measurements.
A group of standard units is called a system of units. Two major systems of units are in use today, the International System of Units **(SI)** or **metric system** and the **British system**.
The SI system (from the French for International system) is often called the mks system, (length = meters, mass = kilograms, time = seconds).
Other systems: cgs; units are grams, centimeters, and seconds.

We will be working in the SI system, where the basic units are kilograms, meters, and seconds.

Length

The first truly international standard metric unit of length is the meter (m), it is defined as the distance travelled by light in a vacuum in 1/299,792,458 s.
The foot is the standard unit of length in the British system.

Mass

Mass is the amount of matter an object contains. The standard metric unit of mass is the kilogram (kg).
Mass is not the same as **weight.** Weight is not a fundamental quantity because the amount of a substance (mass) remains the same (constant) no matter where you are. It depends on the force of gravity which changes depending on whether you are on the earth, the moon or another planet. For example, the weight of an object on the moon is 1/6 of what it is on the Earth.

Time

The standard unit of time for all systems is the second (s).Time is defined by the frequency of radiation of a cesium atom.

Quantity	**Unit**	**Standard**
Length	**Meter**	**Length of the path traveled by light in 1/299,792,458 second.**
Time	**Second**	**Time required for 9,192,631,770 periods of radiation emitted by cesium atoms**
Mass	**Kilogram**	**Platinum cylinder in International Bureau of Weights and Measures, Paris**

The table below shows the seven base units of the mks system:

TABLE 1–5 SI Base Quantities and Units

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

The table below shows the standard SI prefixes for indicating powers of 10.

TABLE 1–4 Metric (SI) Prefixes

Prefix	Abbreviation	Value
yotta	Y	10^{24}
zetta	Z	10^{21}
exa	E	10^{18}
peta	P	10^{15}
tera	T	10^{12}
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
hecto	h	10^{2}
deka	da	10^{1}
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro†	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}
femto	f	10^{-15}
atto	a	10^{-18}
zepto	z	10^{-21}
yocto	y	10^{-24}

† μ is the Greek letter "mu."

The table below shows examples of the use of these prefixes:

1 meter (m)	=	100 centimeters (cm)	=	1000 millimeters (mm)
1 kilogram (kg)	=	1000 grams (g)	=	10^6 milligrams (mg)
1 millisecond (ms)	=	0.001 second (s)		
1 megabyte (Mb)	=	10^6 bytes	=	10^3 kilobytes (Kb)

The SI unit used to measure volume is the Litre (L) or cubic decimeter (dm3)

1 Liter (L)	=	1 cubic decimeter (dm^3)	=	1000 cubic centimeter (cm^3)
1 Liter (L)	=	1 cubic decimeter (dm^3)	=	1000 milliliters (mL)

Derived Units

Derived units are multiples or combinations of the basic units. The table below shows examples of the use of some of these units:

Derived Quantity	Unit
Area $(length)^2$	m^2, cm^2, ft^2
Volume $(length)^3$	m^3, cm^3, ft^3
Speed (distance/time)	m/s, cm/s, ft/s

Let's consider a particular quantity with derived units: density

$$\text{Density} = \frac{\text{mass}}{\text{volume}} = \frac{\text{mass}}{(\text{Length})^3} \quad \text{or} \quad \rho = \frac{m}{V}$$

When a combination of fundamental units (mass, length and time) becomes complicated, it is frequently given its own name. Examples: Newton, joules and watts.

Write equations to describe Newtons, Joules and Watts in terms of mass, length and time.

newton (N) = kg x m/s^2
joule (J) = kg x m^2/s^2
watt (W) = kg x m^2/s^3

1-6 Converting Units

Converting between metric units, for example from kg to g, is easy, as all it involves is powers of 10. Converting to and from British units is considerably more work.

For example to convert from inches to cm, the conversion factor is 2.54, because there are 2.54 cm to 1". Hence 5'5" or 65" expressed in cm is:

$$65.0\ \cancel{\text{in}} \times \frac{2.54\ \text{cm}}{1\ \cancel{\text{in}}} = 165\ \text{cm}$$

The units, inches, cancel out.

Units must be reported for all measurements. Examples:

2.34 g 41.2 cm² 25 °C 48.4 s 18 mL

Units must be carried through all calculations. The units in the result come from the calculations. Units can be multiplied or divided, but not added or subtracted. Example:

$$\text{density} = \frac{\text{mass}}{\text{volume}} = \frac{4.39\ \text{g}}{2.42\ \text{cm}^3} = 1.81\ \text{g/cm}^3$$

Writing something like this: $\text{density} = \frac{\text{mass}}{\text{volume}} = \frac{4.39}{2.42} = 1.81\ \text{g/cm}^3$

has no meaning, since mass cannot be 4.39 without a unit, volume cannot be 2.42 without a unit and the unit in the result did not come from the calculation but appeared from nowhere.

Another example: a car is driving 120 km/h. Calculate the speed in m/s.

$$120\ \text{km/h} = \frac{120\ \cancel{\text{km}} \bullet \cancel{\text{h}} \bullet \cancel{\text{min}} \bullet 1000\ \text{m}}{\cancel{\text{h}} \bullet 60\ \cancel{\text{min}} \bullet 60\ \text{s} \bullet \cancel{\text{km}}} = 33.33\ \text{m/s} = 33\ \text{m/s}$$

Note: the result has 2 s.f. since 120 km/h is a measurement and had 2 s.f. The other numbers (1000 and 60) are exact since they are definitions.

Example 1

A silicon chip has an area of 1.25 square inches. Express this in square centimetres.

Solution:

1 inch = 2.54 cm then in 1 in.^{2} = (2.54 cm)^2 = 6.45 cm^2.
So 1.25 in.^{2} = (1.25in.^{2})(2.54 cm/in.)^2 = (1.25 in.^{2})(6.45 cm^2/in.^{2}) = 8.06 cm^2.

Example 2

Where the posted speed limit is 55 miles per hour (mi/h or mph), what is this speed (a) in meters per second (m/s) and (b) in kilometres per hour (km/h) ?

Solution:

(a) We can write 1 mile as

$$1\,\text{mi} = (5280\,\text{ft})\left(12\frac{\text{in.}}{\text{ft}}\right)\left(2.54\frac{\text{cm}}{\text{in.}}\right)\left(\frac{1\,\text{m}}{100\,\text{cm}}\right) = 1609\,\text{m}.$$

Note that each conversion factor is equal to one. We also know that 1 hour contains 3600 s, so

$$55\frac{\text{mi}}{\text{h}} = \left(55\frac{\text{mi}}{\text{h}}\right)\left(1609\frac{\text{m}}{\text{mi}}\right)\left(\frac{1\,\text{h}}{3600\,\text{s}}\right) = 25\frac{\text{m}}{\text{s}},$$

where we rounded off to two significant figures.

(b) Now we use 1 mi = 1609 m = 1.609 km; then

$$55\frac{\text{mi}}{\text{h}} = \left(55\frac{\text{mi}}{\text{h}}\right)\left(1609\frac{\text{km}}{\text{mi}}\right) = 88\frac{\text{km}}{\text{h}}.$$

Homework 2:

1. Write the following as full (decimal) numbers with standard units: (a) 286.6 mm, (b) 85 μV, (c) 760 mg, (d) 60.0 ps, (e) 22.5 fm, (f) 2.50 gigavolts.

2. Express the following using the prefixes of Table 1-4: (a) 1×10^6 volts, (b) 2×10^{-6} meters, (c) 6×10^3 days, (d) 18×10^2 bucks, and (e) 8×10^{-9} pieces.

3. The Sun, on average, is 93 million miles from Earth. How many meters is this? Express (a) using powers of ten, and (b) using a metric prefix.

4. An airplane travels at 950 km/h, How long does it take to travel 1.00 km?

5. A typical atom has a diameter of about 1.0×10^{-10} m. (a) What is this in inches? (b) Approximately how many atoms are there along a 1.0 cm line?

Week 2: Lesson 1:

Approach to Problem Solving

General Guidelines

Step 1: Read the problem; Write down the given quantities using symbols and include units. If useful make a sketch.

Step 2: Write down what is wanted. Make all units the same.

Step 3: What equations are needed to solve the problem. Do the calculation. Give your answer to the correct number of significant figures with the correct units.

Example:.

Earth goes around the Sun in a nearly circular orbit with a radius of 93 million miles. How many miles does Earth travel in making one revolution about the Sun?

Solution:

Step 1:
Given: r = 93 million miles = 9.3×10^7 mi

Step 2:
The distance (length) or circumference of Earth's orbit in miles is wanted, so

Wanted: $d = ?$ (distance)
The unit of the given quantity is in miles, which is OK. Our answer will then come out in miles.)

Step 3:
The equation for the circumference of a circle is $c = 2\pi r$
The circumference of a circle with the given radius of Earth's orbit is how far Earth travels in one revolution, so

$$d = c = 2\pi r = 2(3.14)(9.3\times10^7 \text{ mi}) = 58\times10^7 \text{ mi} = 5.8\times10^8 \text{ mi}$$

Now answer the following questions:

1. Earth has a radius of 6.4×10^3 km. What is Earth's surface area in square meters? (Consider Earth to be a sphere. The surface area of a sphere is given by $A = 4\pi r^2$.)

2. The thickness of a textbook, not including the covers, is measured to be 3.10 cm. If the last page is numbered 778, what is the average thickness per sheet?

3. A textbook is 3.50 cm thick, including the covers. In a bookstore display, how many of these books could be placed upright on a shelf 1.50 m long?

4. Compute the area in square inches of a pizza with a diameter of
(a) 7.00 in., and
(b) 14.0 in. (Hint: The area of a circle is given by $A = \pi r^2$, where r is the radius.)
(c) The area of the 14.0 in. pizza is how many times larger than that of the 7.00 in. pizza?

Week 2: Lesson 2:

Answer the following questions

1. Express the following sum with the correct number of significant figures: 1.80 m + 142.5 cm + 5.34×10^5 µm.

2. Determine the conversion factor between (a) km/h and mi/h, (b) m/s and ft/s, and (c) km/h and m/s.

3. The diameter of the Moon is 3480 km. (a) What is the surface area of the Moon? (b) How many times larger is the surface area of the Earth ?

Homework 3:

1. What is the volume of a liter in (a) m^3 and (b) mm^3 ?

2. Show that one cubic meter contains 1000 L.

3. Water is sold in a 2.0 L bottle. What is the mass, in kilograms and grams, of the water in such a full bottle?

4. A quantity of water with a mass of 0.085 kg is poured into a graduated cylinder. If the cylinder is graduated in ml., what would be the volume reading of the water?

5. Compute the density in g/cm^3 of a piece of metal that has a mass of 0.500 kg and a volume of 63 cm^3 ?

6. Compute the height in centimetres and meters of a person who is 6.00 ft tall.

7. Compute the height in feet and inches of a woman who is 157 cm tall.

Questions For Extra Practise:

1. Express the following numbers in powers-of-10 notation in conventional form:

(a) 360,000
(b) 246.7
(c) 0.0694
(d) 0.000011

2. Perform the following mathematical operation on a calculator and express the result properly using significant figures and scientific notation:

$$\frac{0.0024}{8.05} = ?$$

3. Write the numbers 6000 and 0.0020 in powers-of-10 notation with two significant figures, and then (a) multiply them together and (b) divide the first by the second.

4. What is the volume of a piece of iron ($\rho = 7.9$ g/cm^3) that has a mass of 0.55 kg?

5. What is the mass of a cube of ice with a side length of 3.0 cm? ($\rho_{ice} = 0.92$ g/cm^3, less than that of water, so ice floats.)

6. A seawater aquarium contains 1.25 m^3 of water. What is the mass of the seawater? ($\rho_{seawater} = 1030$ g/cm^3, greater than fresh water, 1000 kg/m^3, because of dissolved salts.)

7. A car travels through a school zone at a speed of 25 mi/h. What is this speed in km/h?

8. Which is travelling faster, a car going 90 km/h or one going 60 mi/h ? Justify your answer.

9. Round off the following numbers to three figures, and express them in standard powers-of-10 notation.

(a) 0.009992
(b) 6487.33
(c) 0.010559
(d) 87,645

10. Round off the following numbers to two figures, and express them in standard powers-of-10 notation.

(a) 105.25 (b) 0.00208 (c) 9438 (d) 0.000344

11. Perform the operations on the measured quantities, and express the answer properly.
$(3.2 \text{ m} \times 1.04 \text{ m})/0.015 \text{ m}$

12. Write the following numbers as a series of digits.

(a) 7.3×10^4
(b) 3.25×10^{-4}
(c) 0.399×10^3
(d) 0.234×10^{-2}

13. Round off the following numbers to three figures, and express them in standard powers-of-10 notation. (one digit to the left of the decimal).

(a) 4,256,000
(b) 2783
(c) 0.01020
(d) 0.00006279

14. Write the following quantities in standard powers-of-10 notation instead of with metric prefixes.

(a) 255 Ms = (b) 607 km =
(c) 65 μg = (d) 0.18 mL =

15. Fill in the blanks with the correct power of 10.

(a) 0.25 megaton = 2.5 × ___________ tons
(b) 99 mg = 9.9 × ___________ grams
(c) 150 μL = 1.50 × ______________ L
(d) 300 kilobucks = 3.00 × ___________ bucks

Summary of Chapter 1

- Theories are created to explain observations, and then tested based on their predictions.
- A model is like an analogy; it is not intended to be a true picture, but just to provide a familiar way of envisioning a quantity.
- A theory is much more well-developed, and can make testable predictions; a law is a theory that can be explained simply, and which is widely applicable.
- Dimensional analysis is useful for checking calculations.
- Measurements can never be exact; there is always some uncertainty. It is important to write them, as well as other quantities, with the correct number of significant figures.
- The most common system of units in the world is the SI system.
- When converting units, check dimensions to see that the conversion has been done properly.