General Physics I
Chapter 1: Measurement

Spring 2011

Scientific Notation (Powers of 10)

- *Scientific Notation* involves expressing a number in terms of a power of 10. The number is written as: (a number between 1 and 10) times (10 raised to a power). Examples:

$$0.000136 = 1.36 \times 10^{-4}.$$

$$1230000 = 1.23 \times 10^{6}.$$

$$1.36 \times 10^{-4} \times 1.23 \times 10^{6} = (1.36 \times 1.23) \times 10^{-4+6}$$
$$= 1.67 \times 10^{2}.$$

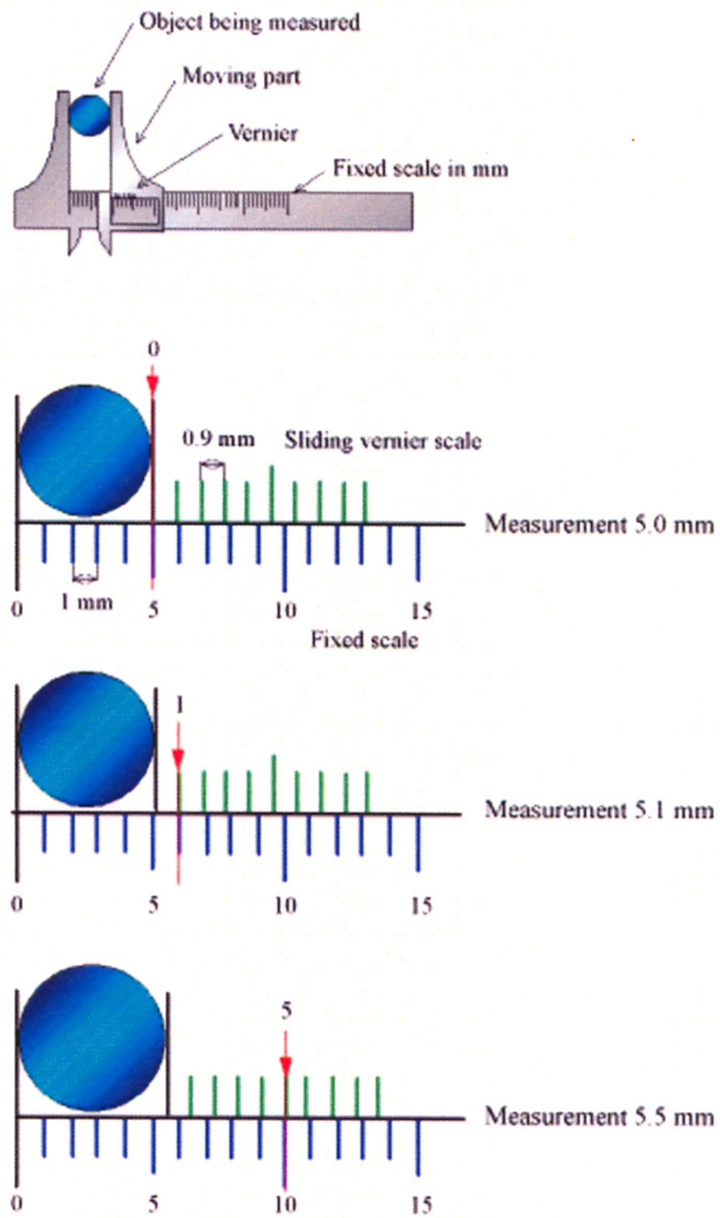
Measurement and Uncertainty

- Physics is a quantitative, experimental science. To do physics, *one has to make measurements.*
- Every measurement has an uncertainty; no measuring instrument is perfect.
- Uncertainty may be written explicitly, e.g., height of a table = 72.3±0.1cm

These calipers have a precision of 0.001 in.

A tape measure has a precision of about 1 mm.

Using Vernier Calipers (Non-Digital)



Significant Figures

- Without writing the uncertainty explicitly, one can convey the uncertainty in a measured value using *significant figures.*
- The number of significant figures in a value is the number of digits that are *reliably known*. The last digit, however, is uncertain to some degree. For example, 5.324 has *four* sig. figs. The last digit (4) is uncertain, so the value is roughly equivalent to 5.324 ± 0.001
- 0.00112 has *three* sig. figs. because the zeroes immediately after the decimal point are "placeholders" to specify the power of ten and so are *not* significant. Note that $0.00112 = 1.12 \times 10^{-3}$, which shows clearly that there are, in fact, three sig. figs. in 0.00112.

Algebra with Significant Figures

- If two or more quantities having different numbers of significant figures are multiplied or divided, the final result must be rounded to have *the same number of sig. figs. as the quantity with the fewest sig. figs in the calculation.* Example:

$$\frac{2.05\times10^{4}}{8.645\times10^{-2}}=\frac{2.05}{8.645}\times10^{4-(-2)}=0.237\times10^{6}=2.37\times10^{5}.$$

- For addition and subtraction, the final result must be rounded to have *the same number of decimal places as the quantity with the fewest decimal places*. Example:

$$5.32+12.587=17.91.$$

Exercise

$$3.652 \times 4.25 - \frac{56.328}{15.32} = ?$$

Workbook: Chapter 1, Question 16

Units

- A *unit* is a standard measure of a physical quantity with a numerical value of exactly one.
- For example, the *meter* is the standard of length in the SI system of units. The SI system is based upon standards for a few fundamental physical quantities, including length, mass, and time.

TABLE 1.1 Common SI units

Quantity	Unit	Abbreviation
time	second	s
length	meter	m
mass	kilogram	kg

Unit Prefixes

- Unit prefixes represent certain *multiples* or *fractions* of a unit. They are helpful especially when dealing with large numbers of or small fractions of a unit.

TABLE 1.2 Common prefixes

Prefix	Abbreviation	Power of 10
mega-	M	10^6
kilo-	k	10^3
centi-	c	10^{-2}
milli-	m	10^{-3}
micro-	μ	10^{-6}
nano-	n	10^{-9}

Unit Conversions

- When two physical quantities are multiplied or divided to give a product or a ratio, the resulting unit is the product or ratio, respectively, of the individual units. Example:

$$\text{Speed} = \frac{\text{distance}}{\text{time}} = \frac{370\ \text{miles}}{6.4\ \text{hours}} = 57\ \frac{\text{miles}}{\text{hour}} = 57\ \text{mi/h.}$$

- When two physical quantities are added or subtracted, their units must be the same. If they are in different units, then we need to convert one unit to the other. To convert units, we simply multiply the unit to be converted by a *conversion factor,* which has the value of exactly *one*.

Common Unit Conversions

1 inch (in) = 2.54 cm

1 foot (ft) = 0.305 m

1 mile (mi) = 1.609 km

1 mile per hour (mph) = 0.447 m/s

1 m = 39.37 in

1 km = 0.621 mi

1 m/s = 2.24 mph

Unit Conversion Example

Usain Bolt runs 100 m in 9.58 s. What is his speed in m/s? mi/h?

Solution:

Speed in m/s is: $\frac{100\text{ m}}{9.58\text{ s}} = 10.4\text{ m/s}$

$$10.4\text{ m/s} = 10.4\frac{\text{m}}{\text{s}} \times \underbrace{\left(\frac{6.21\times10^{-4}\text{ mi}}{1\text{ m}}\right)}_{=1} \times \underbrace{\left(\frac{3600\text{ s}}{1\text{ hr}}\right)}_{=1} = 23.3\text{ mi/h}.$$

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