Standard Units of Measure

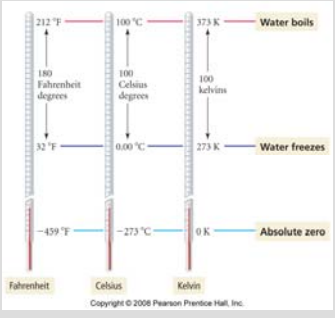
The Standard Units

- Scientists have agreed on a set of international standard units for comparing all our measurements called the SI units
  - *Système International* = International System

Quantity	Unit	Symbol
length	meter	m
mass	kilogram	kg
time	second	s
temperature	kelvin	K

Temperature Scales

- Fahrenheit Scale, °F
  - used in the U.S.
- Celsius Scale, °C
  - used in all other countries
- Kelvin Scale, K
  - absolute scale
    - no negative numbers
  - directly proportional to average amount of kinetic energy
  - 0 K = absolute zero



Fahrenheit vs. Celsius

- a Celsius degree is 1.8 times larger than a Fahrenheit degree
- the standard used for 0° on the Fahrenheit scale is a lower temperature than the standard used for 0° on the Celsius scale

$$°C = \frac{(°F - 32)}{1.8}$$

Kelvin vs. Celsius

- the size of a “degree” on the Kelvin scale is the same as on the Celsius scale
  - though technically, we don’t call the divisions on the Kelvin scale degrees; we called them kelvins!
  - so 1 kelvin is 1.8 times larger than 1°F
- the 0 standard on the Kelvin scale is a much lower temperature than on the Celsius scale

$$K = °C + 273.15$$

EXAMPLE 1.2 Converting between Temperature Scales

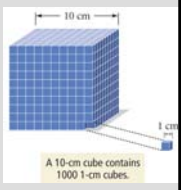
A sick child has a temperature of 40.00 °C. What is the child’s temperature in (a) K and (b) °F?

Common Prefix Multipliers in the SI System

Prefix	Symbol	Decimal Equivalent	Power of 10
mega-	M	1,000,000	Base x 10^{6}
kilo-	k	1,000	Base x 10^{3}
deci-	d	0.1	Base x 10^{-1}
centi-	c	0.01	Base x 10^{-2}
milli-	m	0.001	Base x 10^{-3}
micro-	μ or mc	0.000 001	Base x 10^{-6}
nano-	n	0.000 000 001	Base x 10^{-9}
pico	p	0.000 000 000 001	Base x 10^{-12}

Volume

- Derived unit
  - any length unit cubed
- Measure of the amount of space occupied
- SI unit = cubic meter (m^3)
- Commonly measure solid volume in cubic centimeters (cm^3)
- Commonly measure liquid or gas volume in milliliters (mL)
  - 1 mL = 1 cm^3



Common Units and Their Equivalents

Mass

1 kilogram (km) = 2.205 pounds (lb)
1 pound (lb) = 453.59 grams (g)
1 ounce (oz) = 28.35 grams (g)

Volume

1 liter (L) = 1000 milliliters (mL)
1 liter (L) = 1000 cubic centimeters (cm^3)
1 liter (L) = 1.057 quarts (qt)
1 U.S. gallon (gal) = 3.785 liters (L)

Density

$$Density = \frac{Mass}{Volume}$$

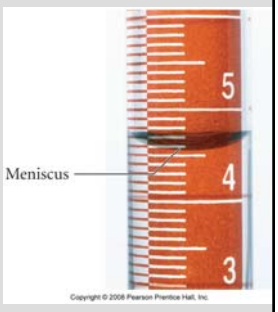
- For equal volumes, denser object has larger mass
- For equal masses, denser object has smaller volume
- Heating an object generally causes it to expand, therefore the density changes with temperature

TABLE 1.4 The Density of Some Common Substances at 20 °C

Substance	Density (g/cm^3)
Charcoal (from oak)	0.57
Ethanol	0.789
Ice	0.917 (at 0 °C)
Water	1.00 (at 4 °C)
Sugar (sucrose)	1.58
Table salt (sodium chloride)	2.16
Glass	2.6
Aluminum	2.70
Titanium	4.51
Iron	7.86
Copper	8.96
Lead	11.4
Mercury	13.55
Gold	19.3
Platinum	21.4

What Is a Measurement?

- quantitative observation
- comparison to an agreed-upon standard
- every measurement has a number and a unit

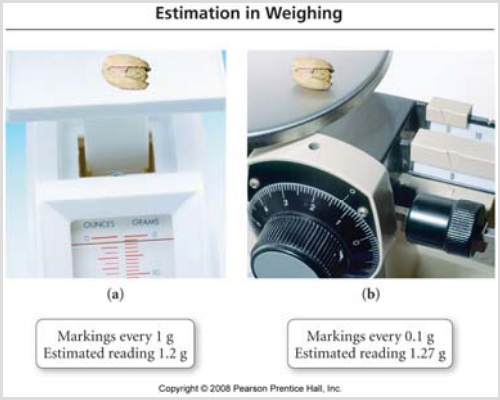


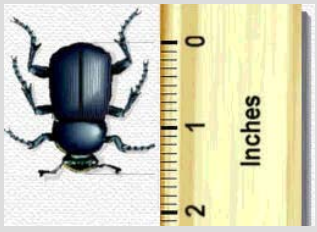
A Measurement

- the unit tells you what standard you are comparing your object to
- the number tells you
  1. what multiple of the standard the object measures
  2. the uncertainty in the measurement
- scientific measurements are reported so that every digit written is certain, except the last one which is estimated

Estimating the Last Digit

- for instruments marked with a scale, you get the last digit by estimating between the marks
  - if possible
- mentally divide the space into 10 equal spaces, then estimate how many spaces over the indicator mark is





Which of the following best describes the length of the beetle's body in the picture to the left?

A)Between 0 and 2 in
b)Between 1 and 2 in
C)Between 1.5 and 1.6 in
D)Between 1.54 and 1.56 in
E)Between 1.546 and 1.547 in

Any measurement made by comparing an object to a scale should include not only the certain digits (1.5 in this case) but also one estimated (uncertain) digit. Because the ruler was marked every tenth of an inch, you must to read the measurement to the nearest hundredth of an inch. You couldn't be certain if the measurement was 1.54, 1.55, or 1.56 cm.

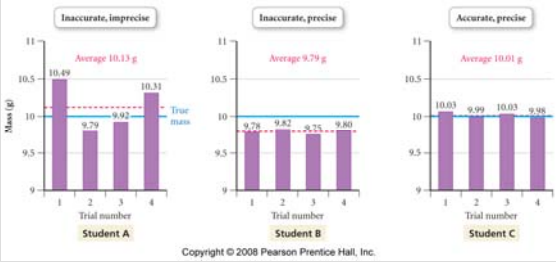
The uncertain digit is in the hundredths place.

Precision
and Accuracy

Uncertainty in Measured Numbers

- uncertainty comes from limitations of the instruments used for comparison, the experimental design, the experimenter, and nature's random behavior
- to understand how reliable a measurement is we need to understand the limitations of the measurement
- accuracy is an indication of how close a measurement comes to the **actual** value of the quantity
- precision is an indication of how reproducible a measurement is

Accuracy vs. Precision



SUPER CHALLENGING QUESTION!

EXAMPLE 1.10 Density as a Conversion Factor

The mass of fuel in a jet must be calculated before each flight to ensure that the jet is not too heavy to fly. A 747 is fueled with 173,231 L of jet fuel. If the density of the fuel is 0.768 g/cm^3, what is the mass of the fuel in kilograms?

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