Lecture one

Unit and Measurement

Math and Units

- Math- the language of Physics
- SI Units – International System–MKS
- Meter m
- Mass kg
- Time s
- National Bureau of Standards
- Prefixes

The standards of measurements used in science are those of the metric system.

All metric units are based on multiples of 10. As a result, you can convert between units easily.

SI Unit prefixes-part II

Name	Symbol	Factor
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}

There are seven SI base units. From these base units, all other SI units of measurement can be derived.

The Seven Base SI Units

Quntity	Unit	Symbol
Length	meter	m
Mass	Kilogram	kg
Temperature	Kelvin	K
Time	Second	s
Amount of substance	mole	mol
Luminous intensity	candela	cd
Electric current	ampere	a

Derived units are used for measurements such as volume, density, and pressure.

Derived SI Units (examples)

Quantity	unit	symbol
Volume	cubic meter	m^3
Density	kilograms per cubic meter	kg/m^3
Speed	meter per cubic second	m/s
Newton	$kg.m/s^2$	N
Energy	Joule ($kg.m^2/s^2$)	J
Pressure	Pascal ($kg/(ms^2)$)	Pa

Units of Length

In SI, the basic unit of length, or linear measure, is the meter (m). All measurements of length can be expressed in meters. For very large and very small lengths, however, it may be more convenient to use a unit of length that has a prefix.

SI Unit Prefixes for Length

Name	Symbol	Analogy
gigameter	Gm	10^9
megameter	Mm	10^6
kilometer	km	10^3
decimeter	dm	10^{-1}
centemeter	cm	10^{-2}
millimeter	mm	10^{-3}
micrometer	µ	10^{-6}
nanometer	nm	10^{-9}
picometer	pm	10^{-12}

Units of Volume

The space occupied by any sample of matter is called its volume. You calculate the volume of any cubic or rectangular solid by multiplying its length by its width by its height. The unit for volume is thus derived from the units of length.

The SI unit of volume is the amount of space occupied by a cube that is 1 m along each edge. This volume is a cubic meter (m^3). A more convenient unit of volume for everyday use is the liter, a non-SI unit. A liter (L) is the volume of a cube that is 10 centimeters (10 cm) along each edge (10 cm x 10 cm x 10 cm = 1000 cm^3 = 1 L).

Units of Mass

The mass of an object is measured in comparison to a standard mass of 1 kilogram (kg), which is the basic SI unit of mass. A kilogram was originally defined as the mass of 1 L of liquid water at 4°C. A cube of water at 4°C measuring 10 cm on each edge would have a volume of 1 L and a mass of 1000 grams (g), or 1 kg. A gram (g) is 1/1000 of a kilogram; the mass of 1 cm^3 of water at 4°C is 1 g.

The relationships among units of mass are shown in the table below

Unit	Symbol	Relationship	Example
kilogram (base unit)	kg	1 kg= 10^3 g	Small textbook= 1 kg
Gram	g	1 g= 10^3 kg	Dollar bill ≈ 1 g
Milligram	mg	10^3 mg= 1 g	Ten grams of salt = 1 mg
Microgram	µg	10^6 µg = 1g	Particle of baking powder= 1µg

Units of Energy

The capacity to do work or to produce heat is called energy. The SI unit of energy is the joule (J), named after the English physicist James Prescott Joule (1818–1889). A common non-SI unit of energy is the calorie. One calorie (cal) is the quantity of heat that raises the temperature of 1 g of pure water by 1°C.

Conversions between joules and calories can be carried out using the following relationships.

1 J = 0.2390 cal

1 cal = 4.184 J

A kilojoule is 1000 joules; a kilocalorie is 1000 calories

Temperature Scales

What temperature scientists commonly use?

Temperature is a measure of how hot or cold an object is. An object's temperature determines the direction of heat transfer. When two objects at different temperatures are in contact, heat moves from the object at the higher temperature to the object at the lower temperature.

Temperature is a measure of how hot or cold an object is. An object's temperature determines the direction of heat transfer. When two objects at different temperatures are in contact, heat moves from the object at the higher temperature to the object at the lower temperature.

The liquid in a thermometer expands and contracts more than the volume of the glass, producing changes in the column height of liquid.

The Celsius scale sets the freezing point of water at 0°C and the boiling point of water at 100°C. The distance between these two fixed points is divided into 100 equal intervals, or degrees Celsius (°C).

Another temperature scale used in the physical sciences is the Kelvin, or absolute, scale. This scale is named for Lord Kelvin (1824–1907), a Scottish physicist. On the Kelvin scale, the freezing point of water is 273.15 kelvins (K), and the boiling point is 373.15 (K). Note that with the Kelvin scale, the degree sign is not used.