Chapter one

Physics and measurments

Classical Physics: Includes the theories, concept laws and experiments in classical mechanics, thermodynamics, optics and electromagnatism.

Modern physics: The two most important developments in this medern era were the theories of relativity and quantum mechanics (Einsteins theory of relativity).

Standard of length, mass and time: The three basic quantities are length, mass and time. An international committee established a set of standards for the fundamental quantities of science. It is called the (SI) system international and it is units of length, mass and time are the (meter, kilogram and second) respectively. Other SI standards established by the committee are those for temperature (the kelvin), electric current (the ampere) luminous intensity (the candela), and the amount of the substance (the mole).

Length: The meter was defined as (the distance between two lines on a specific platinum-iridium bar stored under controlled conditions in france). In 1960, the meter was defined as (1,650,763.73 wave length of orange-red light emitted from a krypton 86 Kr^{86} lamp). In 1983, the meter (m) was defined as (the distance traveled by light in vacuum during a time of 1/299792458 second). This last definition established that the speed of light in vacuum is precisely (299792458 meters per second).

Examples:

- Mean redius of the earth = $6.73*10^6$m
- Mean distance from the earth to the moon = $3.84*10^8$ m
- One light year = $9.46*10^{15}$ m
- Size of smallest dust particles ≈ 10^{-4} m
- Diameter of a hydrogen atom ≈ 10^{-10} m

Mass: The SI unit of mass, (kg) is defined as (the mass of a specific platinum-iridum alloy cylinder kept at the international bureau of weights and measures at sevres, france).

Examples: Sun mass = $1.99*10^{30}$ kg, Earth mass= $5.98*10^{24}$ kg.

Time:

Before 1960, the standard of time was defined in terms of (the mean **solar day**: defined as the time interval between successive appearances of the sun at the highest point it reaches in the sky each day).

* **The second** was defined as (1/60) (1/60)(1/24) of a mean solar day, or, defined as (9192631770) times the period of variation from the cesium atom.

* **Period**: the time interval needed for one complete vibration.

Atomic clock, uses the characteristic frequency of the cesium 133 atom as the "reference clock"

Customary system: Another system of units that is still used i the USA. In this system the units of length, mass and time are foot (ft), slug and second respectively.

Density and atomic mass:

Density (ρ): is the mass per unit volume (ρ= m/v)

Examples: $\rho_{alaminum} = 2.7\ g/cm^3$, $\rho_{lead} = 11.39\ g/cm^3$

Atomic mass: is the mass of a single atom of the element measured in atomic mass units (u) where: $1u= 1.6605387*10^{-27}$ kg.

Examples: the atomic mass of lead= 207u, for aluminum=27u.

The ratio of atomic masses is (207u/27u=7.67), does not correspond to the ratio of densities ($11.3*10^3/2.7*10^3=4.19$), this discrepancy is due to the difference in atomic spacing and atomic arrangements in the crystal structure of the two elements.

Example: A solid cube of aluminum (ρ =2.7 g/cm^3) has a volume of (0.200 cm^3). It is known that (27.0 g) of aluminum contains ($6.02*10^{23}$ atoms). How many aluminum atoms are contained in the cube?

Solution: the mass of cube (m) = ρv = (2.7g)(0.200 m^3) = 0.540g.

$m_{sample} / m_{27g} = N_{sample} / N_{27g} \longrightarrow (0.540g/27g) = (N_{sample}/6.02*10^{23} atoms)$

$N_{sample} = 1.20*10^{22}$ atoms

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

Dimensional analysis:

* Used to check the final expression

* Dimentions treated as algebraic quantities. Quantities can be added or subtracted only if they have the same dimentions. The terms on both sides of an equation must have the same dimentions. The relation ship can be correct only if the dimentions on both sides of the equation are the same.

Example: check the validity of $\mathbf{x=(1/2)at^2}$

Solution: The right side = $(L/T^2)\ T^2 = L$ = left side

Example: $\mathbf{x \quad a^n \; t^m}$ where $[\mathbf{a^n.t^m}] = L = L^1\ T^0$

$(L / T^2)^n\ (T)^m = L^1\ T^0 \longrightarrow (L^n.T^{m-2n}) = L^1\ T^0$

n = 1 and m-2n = 0 $\longrightarrow$ m = 2, but ($\mathbf{x \quad a^n \; t^m}$), so that ($\mathbf{x \quad a.t^2}$)

This result differs by a factor of (1/2) from the correct equation $\mathbf{x = (1/2)\ a.t^2}$

system	Area (L^2)	volume (L^3)	speed (L/T)	acceleration (L/T^2)
SI	m^2	m^3	m/s	m/s^2
U.S Customary	ft^2	ft^3	ft/s	ft/s^2

Conversion:

* **Length**

1 in = 2.54 cm, 1 m = 39.37 in = 3.281 ft, 1 ft = 0.3048 m, 1 yd = 3 ft, 1 ft = 12 in, 1 mi = 1.609 km, 1 km = 0.621m, 1 light year = $9.461*10^{15}$ m.

* **Mass**

1 ton=1000kg, 1 kg= $6.852*10^{-2}$slug, 1 slug=14.59 kg

* **Time**

1 year=365 days=$3.16*10^{7}$ s,, 1 day= 24 hr=$1.44*10^{3}$min=$8.64*10^{4}$s

Convertion of units:

1 mile = 1609 = 1.609 km

1 ft = 0.3048 m = 30.48 cm

1 m = 39.37 in = 3.281 ft

1 in = 0.0254 m = 2.54 cm

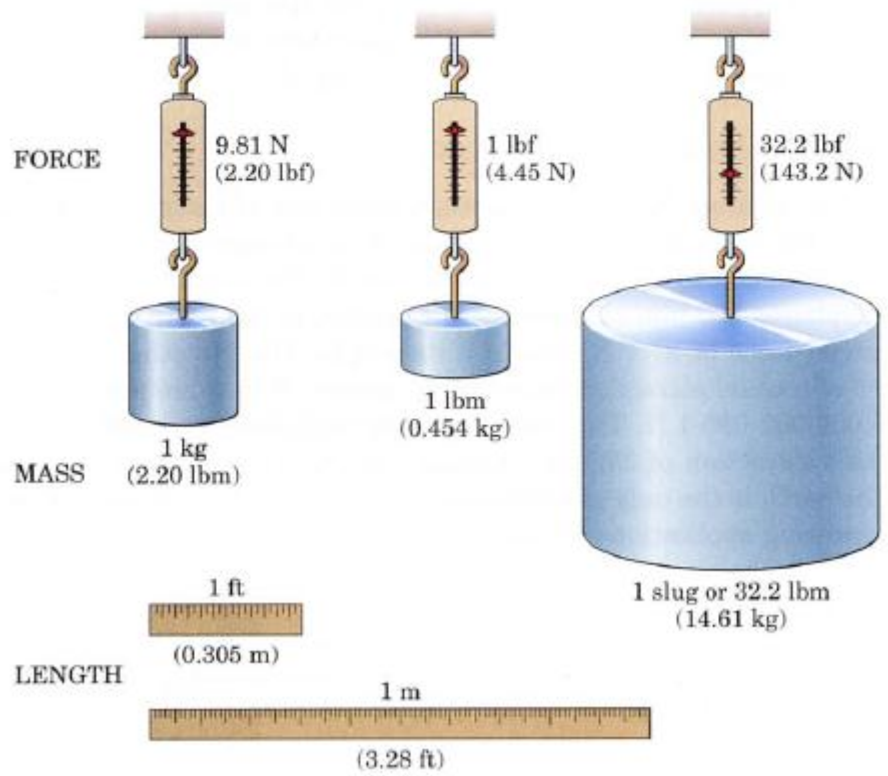
Example: convert 15 in to centimeter

Sloution: 15 in (2.54 cm / 1 in) = 38.1 cm

Example: A car is traveling at a speed of 38.0 m/s. Is this car exceeding the speed limit of 75.0 mil/h ?

Solution: 38.0 m/s (1 mil / 1609 m) = $2.36*10^{-2}$ mil/s

($2.36*10^{-2}$ mil / s) (60 s / 1 min) (60 min / 1 hr) = 85.0 mi/hr



Estimates and order of magnitude calculations:

It is often useful to compute an approximate answer to a given physical problem. Such approximation is usually based on certain assumptions, which must be modified if greater precision is needed. We will some times refer to an (order of magnitude) of a certain quantity as the power of ten of the number that describs that quantity. We use the symbol,~, for‟is on the order of ״.

Thus: $0.0087 \sim 10^{-2}$ & $0.0021 \sim 10^{-3}$ & $740 \sim 10^{3}$. The sesults are reliable to within about a factor of (10).

Example: Estimate the number of steps a person would take walking from new york to los angeles?

Solution:

1- the distance between these two cities is about 300 mil.

2- Each steps covers about 2 ft

3- 1 mil = 5280 ft or 1 mil ≈ 5000 ft

(5000 ft/mil) / (2 ft/steps) = 2500 steps/mil

Steps = ($3*10^3$ mi) ($2.5*10^3$ steps/mi) = $7.5*10^6$ steps ≈ 10^7 steps.

Example: Estimate the number of gallone used each year by all the cars in the united state?

Solution:

No. of people in the united state ≈ 280 million

No. of cars = 100 million

Quessing that there are between 2-3 people/car.

Average distance each car travels per year is 10000 mi

Gazoline consumption of 0.05 gal/mi

Each car uses about 500 gal/year

Total consumption = 500 ga/yr * $100*10^6$ car = $10^{10}*5$ gal ≈ 10^{11}gal/yr

<u>Significant Figures:</u>

When certain quantities are measured, the measured values are known only to within the limits of the experimental uncertainity. The value of this uncertainity can depend on various factors such as

1- quality of apparatus

2- the skill of the experimenter

3- the number of the measurements performed

An example of signifigant figures: suppose that we are asked in a laboratory experiment to measure the area of a computer disk label using a meter stick as a measuring instrument. If the length measured to be 5.5 cm and the accuracy to which we can measure the length of the label is ± 0.1cm. the length lies between 5.4 cm and 5.6 cm. If the label width is 6.4 cm, the actual value lies between 6.3 cm and 6.5 cm. Thus we could write the measured values as 5.5 ± 0.1 cm and 6.4 ± 0.1 cm. The area of the label is 5.5*6.4 = 35.2 cm^2 , it is taken as 35 cm^2. This value can range between (5.4*6.3 = 34 cm^2) and (5.6*6.5 = 36 cm^2).