Lesson 1

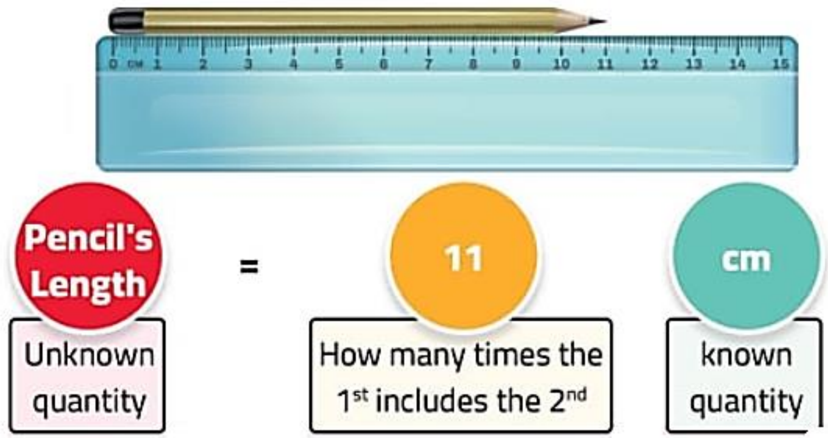
Physical Measurements

Lesson`s Outlines:

1) Physical quantities and Measuring Tools
2) Measuring Units (Systems, SI, Standard Units, Prefixes & Conversion of units)
3) Dimensional Formula

1) Physical quantities and Measuring Tools

Physical Measurement process elements are physical quantity, tool and unit.



a) Physical Quantities: Classified according to derivation

Fundamental

- Quantity that cannot be defined in terms of other
- **Ex: Length, Mass, Time**

Derived

- Quantity that is defined in terms of fundamental
- **Ex: Force, Speed, Work**

Example 1:

The fundamental physical quantities from the following are ....

(a) the length and the area
(b) the velocity and the acceleration
(c) the mass and the volume
(d) the time and the mass

Example 2:

The derived physical quantities from the following are ....

(a) velocity - distance - time
(b) mass - density - volume
(c) work - force - distance
(d) force - volume - density

b) Measuring Tools

- Small distance

- Large distance

- Accurate
- V.Small distances

- V.Accurate
- V.Small distances

- Large objects
-inaccurate

- Ray Balance

-Small object
-accurate

v.old

Based on Conserv. Of Energy

-accurate

Example 3:

The suitable tool for measuring the length of a room is ....

(a)

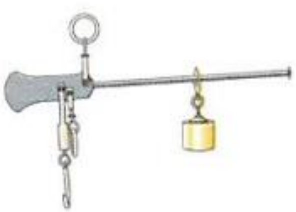
(b)

(c)

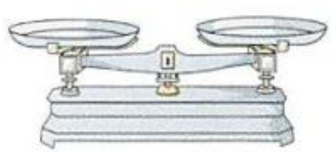
(d)

Example 4:

The suitable tool for measuring the mass of a golden ring is ....



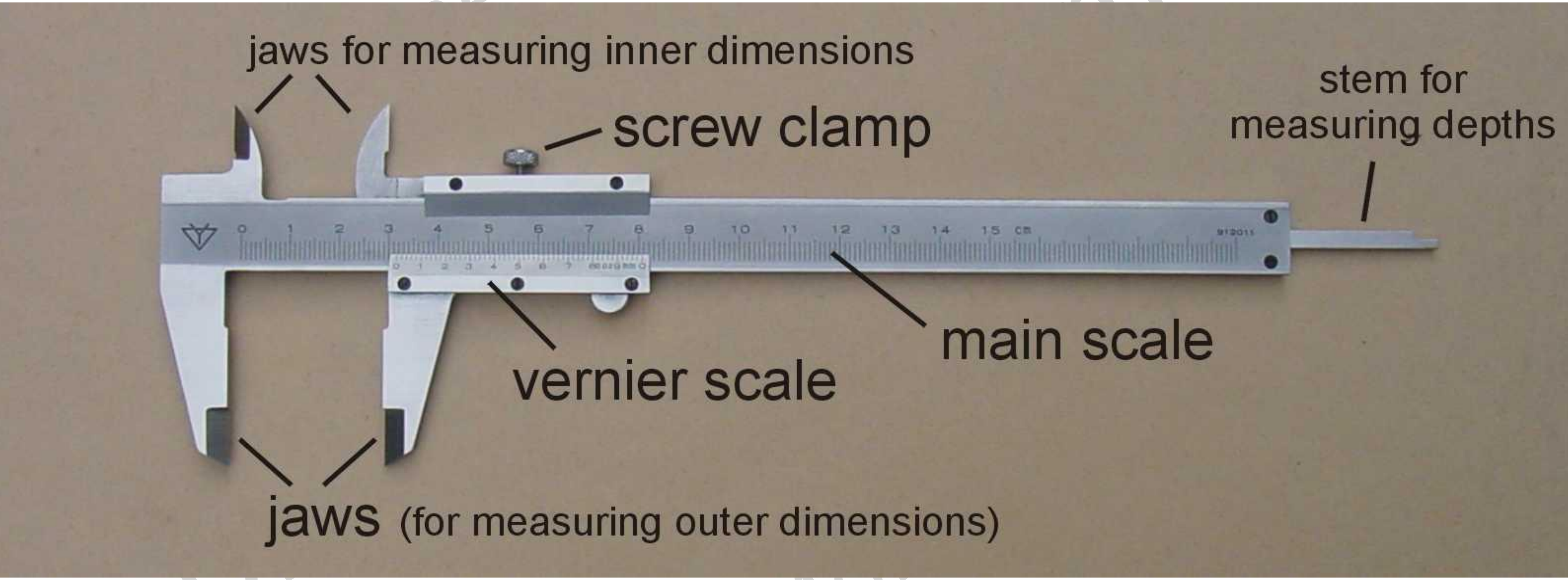
(a)

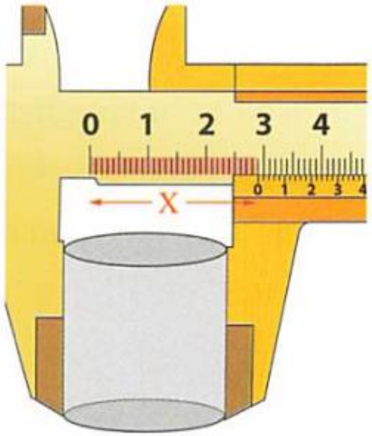


(b)

(c)

(d)


jaws for measuring inner dimensions
screw clamp
stem for
measuring depths
main scale
vernier scale
jaws (for measuring outer dimensions)



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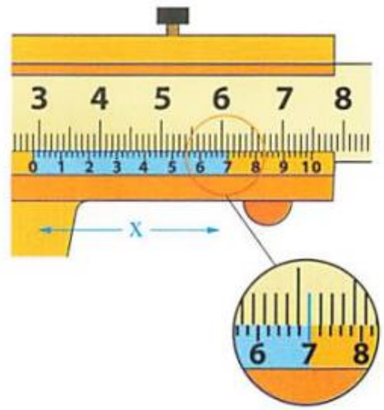
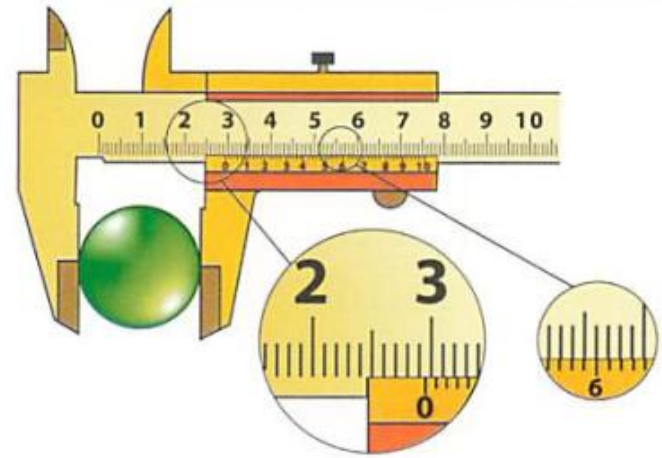


The length = X + x

Example 4 (a):

Using the opposite figure, the external diameter of the ball is ....



ⓐ 29 mm

ⓑ 29.1 mm

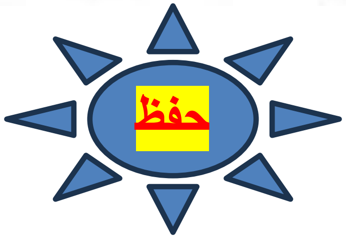
ⓒ 29.6 mm

ⓓ 35 mm

2) Measuring Units (Systems, SI, Standard Units, Prefixes and Conversion of Units)

a) Unit Systems

	Units of measurement		
The fundamental physical quantity / System of units	The French system (Gaussian system) (C.G.S)	The British system (F.P.S)	The Metric system (M.K.S)
Length (ℓ)	Centimeter (cm)	Foot (ft)	Meter (m)
Mass (m)	Gram (g)	Pound (lb)	Kilogram (kg)
Time (t)	Second (s)	Second (s)	Second (s)



b) International System (SI) Unit

The physical quantity	The international unit
1 Length (ℓ)	Meter (m)
2 Mass (m)	Kilogram (kg)
3 Time (t)	Second (s)
4 Electric current intensity (I)	Ampere (A)
5 Absolute temperature (T)	Kelvin (K)
6 Amount of substance (n)	Mole (mol)
7 Luminous intensity (I_v)	Candela (cd)
8 Plane angle	Radian (rad)
9 Solid angle	Steradian (sr)

حفظ

c) Standard Units

The Standard Length (The Standard Meter)

It is the distance between two engraved marks at the ends of a rod made of platinum and iridium alloy kept at 0ºC.

The Standard Mass (The Standard Kilogram)

It is the mass of a cylinder made of platinum and iridium alloy of specific dimensions kept at 0ºC.

The Standard Time (The Standard Second)

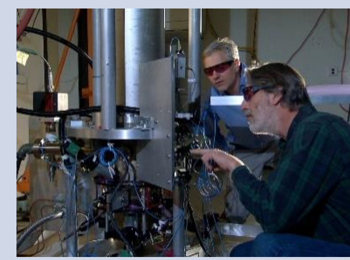
Usually 1 second measured w.r.t. :

Day and night times

$$1 \text{ Sec} = \frac{1}{24\times60\times60} = \frac{1}{86400} \text{ Day}$$

Recently:

An Atomic (Cesium) clock is used [Accurate]



Platinum-iridium alloy is rigid, chemically inactive, and not affected by surrounding temp.

Cesium Clock usage:

1. Determination of the duration of the Earth's spin
2. Checking up on aviation and navigation.
3. Verify the journey schedule of spaceships.

3) Dimensional Formula

It is a form that represents **derived quantities *(infinite numbers)*** in terms of **fundamental quantities** (Length [L], Mass [M], and Time [T]); all must be in capital letters.

$$[A] = [M^{\pm a}\ L^{\pm b}\ T^{\pm c}]$$

Do Not Forget

Important Notes :

1) M not meter (m), it indicates to Mass
L not litter (L), it indicates to Length
T not Tension (T), it indicates to time

2) If the dimensions of both sides are ***identical, so this relation <u>may be correct</u> (not for sure), but*** if the dimensions are ***not the same, so the relation <u>must be incorrect</u>***

3) The dimensional formula ***<u>can be multiplied or divided</u>*** but ***couldn`t be added or subtracted*** and if so , they will give the same dimension.

4) Numbers (2, π) and trigonometric functions (sin, cos, tan) have no units and dimensions

6 Rules of exponents

Rule	Example
$x^0 = 1$	$(2^0) = 1$
$x^1 = x$	$(-4)^1 = -4$
$x^{-m} = \frac{1}{x^m}$	$(3)^{-2} = \frac{1}{(3)^2} = \frac{1}{9}$
$(x^m)^n = x^{mn}$	$(2^2)^3 = (2)^{2\times 3} = (2)^6 = 64$
$(xy)^m = x^m y^m$	$(2\times 3)^2 = (2)^2 \times (3)^2 = 36$
$\left(\frac{x}{y}\right)^m = \frac{x^m}{y^m}$	$\left(\frac{1}{3}\right)^2 = \frac{(1)^2}{(3)^2} = \frac{1}{9}$
$x^m x^n = x^{m+n}$	$(2)^3 \times (2)^{-2} = (2)^{3+(-2)} = (2)^1 = 2$
$\frac{x^m}{x^n} = x^{m-n}$	$\frac{(3)^4}{(3)^{-2}} = (3)^{4-(-2)} = (3)^6 = 729$
$x^{\frac{m}{n}} = \sqrt[n]{x^m}$	$(8)^{\frac{1}{3}} = \sqrt[3]{8} = 2$

Example 11:

What is the dimensional formula of velocity?

Solution:

∵ velocity [v]= distance / time = [L]/[T] = [L][T^{-1}] = [$M^0L^1T^{-1}$]

Example 12:

Verify the relation of the volume of a cube, Volume (V)= $(Length)^2$.

Solution: ∵ L.H.S unit is known to be m^3, so its dimensional formula is [L^3]= [$M^0L^3T^0$]

∵ [R.H.S] dimensions is [L^2].

∴ $L.H.S. \neq R.H.S.$

So, the relation ***is not correct***.

Example 13:

Verify the relation of the volume of cylinder V= 2πr. h.

Solution:

∵ L.H.S unit is known to be m^3, so its dimensions is $[L^3]$

∵ R.H.S is 2πr. h $= [L].[L] = [L^2]$

∴ $L.H.S. \neq R.H.S.$ So, the relation ***is not correct at all***.

Example 14:

Which of the following equations are dimensionally correct?

a) $v_f = v_i + ax$

$$\frac{[L]}{[T]} = \frac{[L]}{[T]} + \frac{[L]}{[T]^2}[L] \rightarrow \frac{[L]}{[T]} = \frac{[L]}{[T]} + \frac{[L]^2}{[T]^2} \rightarrow dimentionally\ incorrect$$

b) $y = (2\,m)\cos(kx)$, where $k = 2\,m^{-1}$. (here m is $meters$)

$$[L] = [L]\cos\left(\frac{1}{[L]}[L]\right) \rightarrow [L] = [L] \rightarrow dimentionally\ correct$$

Example 15:

If the dimensional formula of quantity A is ML^2T^{-2} and the dimensional formula of quantity B is ML^2T^{-2}, then the quantity (2B – A) ....

ⓐ has a dimensional formula of ML^2T^{-2}

ⓑ has a dimensional formula of $M^2L^4T^{-4}$

ⓒ has a dimensional formula of $M^3L^6T^{-6}$

ⓓ isn't a physical quantity

Example 16:

✳ If F is the force that acts on a static body of mass m to reach a velocity v through time t, then the two physical quantities mv and Ft have ....

(Knowing that: $[F] = MLT^{-2}$, $[v] = LT^{-1}$)

(a) different dimensions

(b) the same dimensions

(c) different measuring units

(d) no meaning