MCQ TYPE QUESTIONS

1. Which of the following sets of quantities can be taken as fundamental quantities of a system.
   a) force, pressure, length
   b) mass, length, density
   c) mass, speed, time
   d) acceleration, length, time
2. Which of the following quantities can’t be derived quantities in MKS system?
   a) force
   b) electrical energy
   c) electric potential
   d) pressure

MCQ TYPE QUESTIONS

3. Which of the following sets cannot enter into the list of fundamental quantities in any system of units?

(a) length, mass and velocity,

(b) length, time and velocity,

(c) mass, time and velocity,

(d) length, time and mass.

4. A physical quantity is measured and the result is expressed as nu where u is the unit used and n is the numerical value. If the result is expressed in various units then

(a) n $\propto$ size of u

(b) n $\propto u^2$

(c) n $\propto \sqrt{u}$

(d) n $\propto \frac{1}{u}$

LENGTH, MASS AND TIME MEASUREMENTS;

XI- SCIENCE

SUBJECT : PHYSICS
CHAPTER NUMBER: 2
CHAPTER NAME : UNITS AND MEASUREMENTS

Website: www.odmegroup.org
Email: info@odmps.org
Toll Free: 1800 120 2316
Sishu Vihar, Infocity Road, Patia, Bhubaneswar- 751024

Measurement of Length

The order of distances varies from 10^{-14} m (radius of nucleus) to 10^{25} m (radius of the Universe)

The distances ranging from 10^{-5} m to 10^{2} m can be measured by direct methods which involves comparison of the distance or length to be measured with the chosen standard length.

Example:

- A metre rod can be used to measure distance as small as 10^{-3} m.
- A vernier callipers can be used to measure as small as 10^{-4} m.
- A screw gauge is used to measure as small as 10^{-5} m.

For very small distances or very large distances indirect methods are used.

Measurement

Measurement can be done by using instruments, or some mathematical methods or some assumptions.

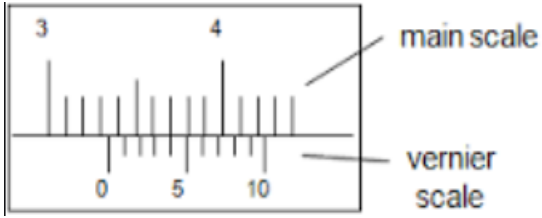
While using an instruments following points are worth noting

Least count (LC)

- It is the least measurement that can be taken by the instrument .
- e.g. : Least count of a meter scale = 1mm =0.1 cm
- Least count of graph paper for measuring length = 0.1 cm
- Least count of graph paper for measuring area = 0.01 cm^2
- Least count of wrist watch = 1 s
- LC of a slide caliper = 1MSD – 1 VSD
- LC of a screw gauge = $\frac{\text{Pitch}}{\text{number of divisions in circular scale}}$

Vernier calliper

LC of a slide caliper = 1MSD – 1 VSD



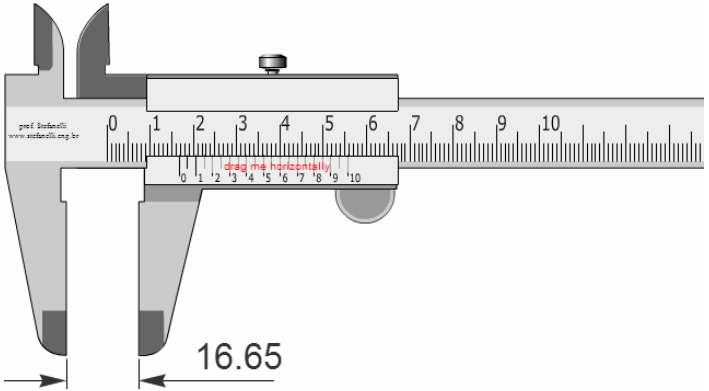
10 VSD = 9 MSD

1 VSD = 0.9MSD = 0.9x0.1cm=0.09cm

LC = 1 MSD – 1 VSD

= 0.1cm – 0.09 cm

= 0.01 cm



Numerical

Question: A slide caliper has 20 divisions in sliding scale or Vernier scale.

1 MSD = 0.1 cm. Calculate its least count.

Solution:

Generally for a slide caliper if vernier scale has n divisions then,

n vernier scale divisions = (n-1) main scale divisions

So, here

20 VSD = 19 MSD = 1.9 cm

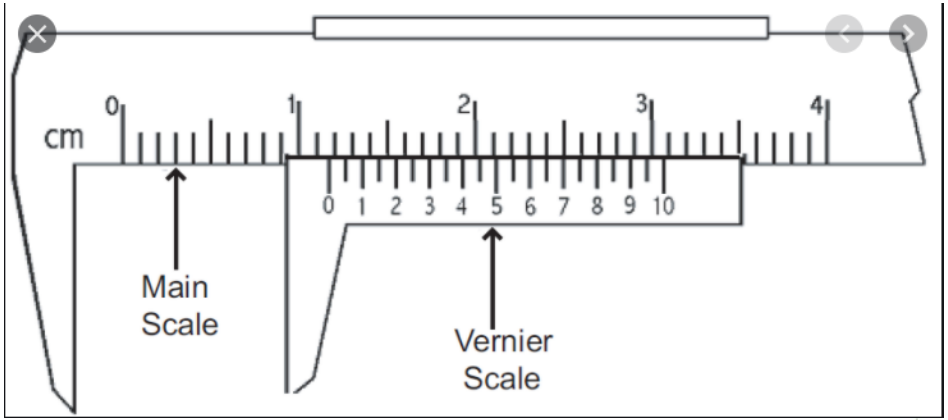
1 VSD = (1.9 cm / 20)

= 0.095 cm

LC = 1 MSD – 1 VSD

= 0.1cm – 0.095 cm

= 0.005 cm

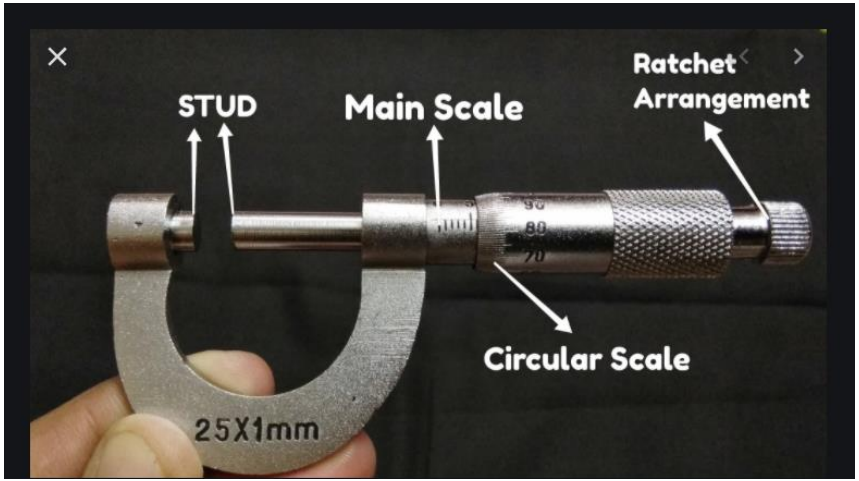


Numerical

Question: A screw gauge has pitch 1mm and 100 divisions on the circular scale. Calculate its least count.

Solution:

LC of a screw gauge = $\frac{\text{Pitch}}{\text{number of divisions in circular scale}} = \frac{.01\text{ cm}}{100} = 0.001\text{ cm}$



Numerical

Question: An optical instrument can measure length upto a range wavelength of light. What is its least count.

Solution:

LC = $10^{-7}\text{m} = 10^{-5}\text{cm} = 0.00001\ \text{cm}$

Measurement

Precision

- It is the degree of uncertainty in a measurement by an instrument.
- The observations by an instrument is said to be more precise if the readings are closer to each other. E.g. If we take observations by a meter scale, then two close readings may be 3.5 cm and 3.6 cm differing by 0.1 cm .
- If we take observations by a slide caliper, then two close readings may be 3.51 cm and 3.52 cm differing by 0.01 cm.
- So observations by slide caliper are more precise than observations by meter scale.
- So device with less least count is more precise.

Numerical

Question: Which of the followings is more precise device?

a) A slide caliper has 20 divisions in sliding scale or vernier scale. 1 MSD = 0.1 cm.

b) A screw gauge has pitch 1mm and 100 divisions on the circular scale.

c) An optical instrument can measure length to within a wavelength of light. What is its least count?

Solution:

a) LC = 0.005cm

b) LC = 0.001 cm

c) LC = 0.00001 cm

As lowest least count

Measurement

Accuracy

- Accuracy is how close is a measurement to the true value .
- e.g. : Let length of a cylinder be 2.0345 cm .
- Now if an instrument measures the length as 2.03 cm

  and other instrument measures as 2.002 cm

  then 1st reading is more accurate while the 2nd one is more precise.

Measurement of Large Distances

The following indirect methods may be used to measure very large distances:

Parallax method

Let us consider a far away planet ‘P’ at a distance ‘D’ from our two eyes.

Suppose that the lines joining the planet to the left eye (L) and the right eye (R) subtend an angle θ (in radians).

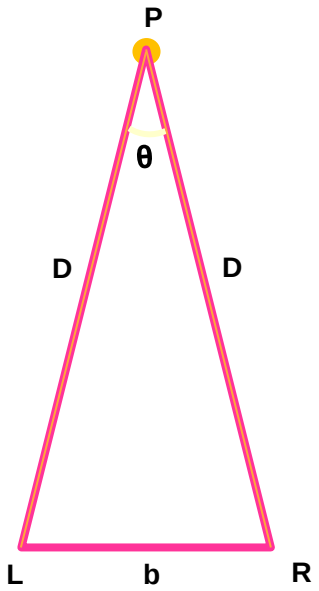
The angle θ is called ‘parallax angle’ or ‘parallactic angle’ and the distance LR = b is called ‘basis’.

As the planet is far away, b/D << 1, and therefore θ is very small

$$\theta = \frac{LR}{D} = \frac{b}{D}$$

Then, taking the distance LR = b as a circular arc of radius D, we have

$$D = \frac{b}{\theta}$$



System of Units

- Except seven fundamental quantities two more dimensionless quantities are also chosen in S.I. system as supplementary quantities.
  - Angle: S.I. unit is radian
    - 1 rad $=\frac{180^0}{\pi}$
    - $1^0 = \left(\frac{\pi}{180}\right) \text{rad} = 1.745\text{x}10^{-2}\ \text{rad}$
    - $1' = \left(\frac{1}{60}\right)^0 = 2.908\text{x}10^{-4}\ \text{rad}$
    - $1'' = \left(\frac{1}{60}\right)' = \left(\frac{1}{60\text{x}60}\right)^0 = \left(\frac{\pi}{180\text{x}60\text{x}60}\right) = 4.85\text{x}10^{-6}\ \text{rad}$
  - Solid Angle: S.I. unit is steradian (sr)

NUMERICALS

Question: The moon is observed from two diametrically opposite points A and B on earth. The angle θ subtended at the moon by the two directions of observation is 1°54'. Given the diameter of the earth to be about $1.276\text{x}10^{7}$ m, compute the distance of the moon from the earth.

Solution:

$$\theta = 1^{0}54' = 60' + 54' = 114'$$

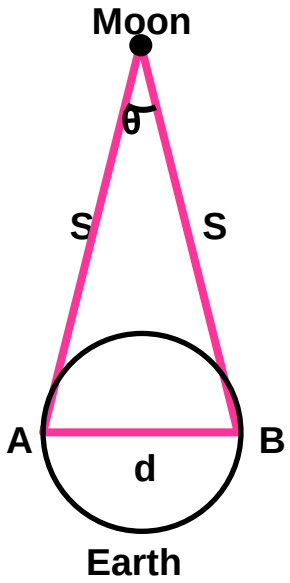
$$= (114\text{x}60)'' = (114\text{x}60)\text{x}(4.85\text{x}\ 10^{-5})\ \text{rad}$$

$$= 3.32\text{x}10^{-2}\ \text{rad}$$

$$\text{AB} = 1.276\text{x}10^{7}\text{m}$$

$$\theta = \frac{\text{d}}{\text{S}}$$

$$\text{S} = \frac{\text{d}}{\theta} = \frac{1.276\text{x}10^{7}\text{m}}{3.32\text{x}10^{-2}\ \text{rad}} = 3.84\text{x}10^{8}\text{m}$$



Measurement of the size or angular diameter of an astronomical object

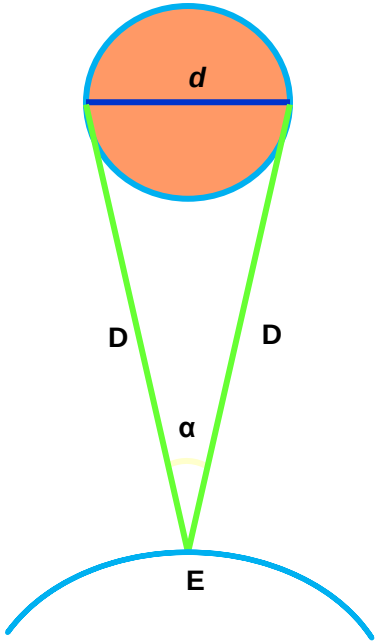
If '*d*' is the diameter of the planet and 'α' is the angular size of the planet (the angle subtended by *d* at the Earth E), then

$$\alpha = d/D \qquad \textit{(angular diameter)}$$

The angle α can be measured from the same location on the earth.

It is the angle between the two directions when two diametrically opposite points of the planet are viewed through the telescope.

Since *D* is known, the diameter *d* of the planet can be determined from



$d = \alpha D$

NUMERICALS

Question: The sun's angular diameter is measured to be 1920". The distance of the sun from the earth is $1.496\text{x}10^{11}\text{m}$. What is the diameter of the sun?

Solution:

α = *angular diameter*

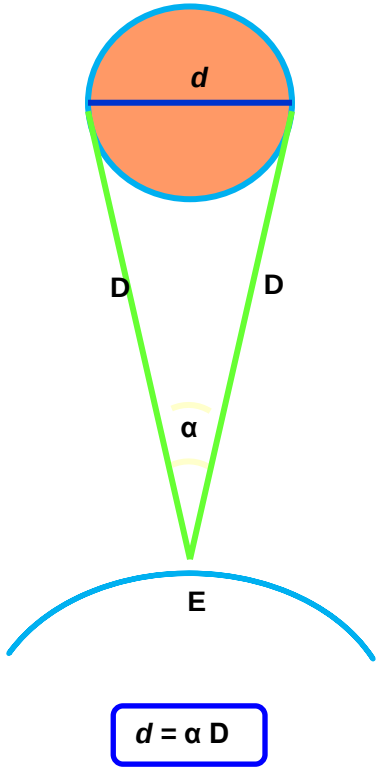
$= 1920\ \text{x}4.85\text{x}10^{-6}$

$= 9.31\text{x}10^{-3} rad$

α = *d/D*

$\text{d} = \alpha\text{D}$

$\text{d} = 9.31\text{x}10^{-3}\text{x}1.496\text{x}10^{11}\text{m} = 1.39\text{x}10^{9}\text{m}$



Measurement of Lengths

Astronomical Unit (AU)

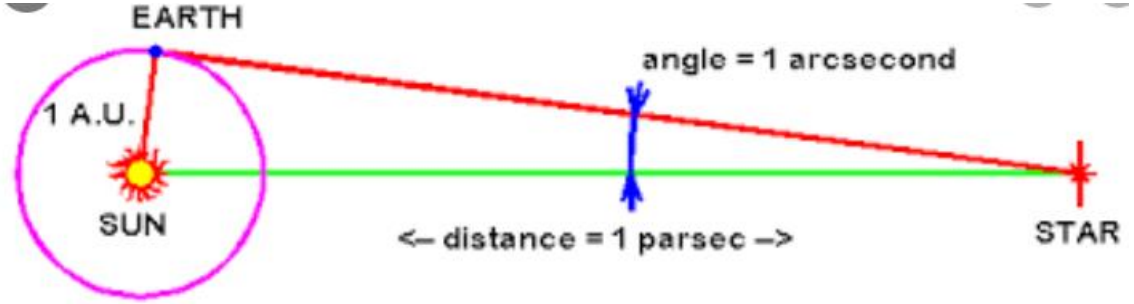
- It is a unit of length used to express astronomical distance. The mean distance between sun and earth. It is equal to $1.496 \text{x} 10^{11} \text{m}$.

Parsec

- It is a unit of length used to express astronomical distance.
- The distance at which the mean radius of earth's orbit subtends an angle of one second of arc.
- It is equal to $3.0857 \text{x} 10^{16} \text{m}$.

Light Year

- It is a unit of length used to express astronomical distance.
- The distance travelled by light in vacuum in one year.
- It is equal to $9.4650 \text{x} 10^{15} \text{m}$.



Measurement of the size or angular diameter of an astronomical object

The size of the objects we come across in the Universe varies over a very wide range.

These may vary from the size of the order of 10^{-14} m of the tiny nucleus of an atom to the size of the order of 10^{26} m of the extent of the observable Universe.

We also use certain special length units for short and large lengths which are given below:

Unit	Symbol	Value	Definition
1 fermi	1 f	10^{-15} m	
1 angstrom	1 Å	10^{-10} m	
1 Astronomical Unit	1 AU	1.496×10^{11} m	Average distance of the Sun from the Earth
1 light year	1 ly	9.46×10^{15} m	The distance that light travels with speed of 3×10^{8} m s^{-1} in 1 year
1 parsec		3.08×10^{16} m (3.26 ly)	The distance at which average radius of Earth's orbit subtends an angle of 1 arc second

Range and Order of Lengths

$(L_{longest} : L_{shortest} = 10^{41} : 1)$

S.No	Size of the object or distance	Length (m)
1	Size of proton	10^{-15}
2	Size of atomic nucleus	10^{-14}
3	Size of the Hydrogen atom	10^{-10}
4	Length of a typical virus	10^{-8}
5	Wavelength of a light	10^{-7}
6	Size of the red blood corpuscle	10^{-5}
7	Thickness of a paper	10^{-4}
8	Height of the Mount Everest from sea level	10^{4}
9	Radius of the Earth	10^{7}
10	Distance of the moon from the earth	10^{8}
11	Distance of the Sun from the earth	10^{11}
12	Distance of the Pluto from the Sun	10^{13}
13	Size of our Galaxy	10^{21}
14	Distance of the Andromeda galaxy	10^{22}
15	Distance of the boundary of observable universe	10^{26}

Measurement

Measurement of Mass

Unified atomic mass unit, $\mathrm{u} = \frac{1}{12}\mathrm{th}$ of the mass of carbon-12 atom

Measurement of Time

CESIUM CLOCK we use an atomic standard of time, which is based on the periodic vibrations produced in a cesium atom. This is the basis of cesium clock or atomic clock.

Home Assignment

1. A slide calliper has 50 divisions on the sliding scale. 1 MSD = 0.1 cm. Calculate its least count.
2. A screw gauge has pitch 0.5 cm. There are 100 divisions on its circular scale. Calculate the least count.
3. You are given with a thread and a meter scale. How can you estimate the diameter of the thread?
4. 1 parsec = ……. Ly = …… A.U.
5. NCERT exercise 2.1 and 2.2

THANKING YOU

ODM EDUCATIONAL GROUP