



Units and Measurements

1. Units - Fundamental and derived units
2. Different systems of units - SI units
3. Measurement of length, mass and time  
Range of measurements for these quantities.





We define a physical quantity by setting up a standard and assigning a unit to that standard.

For eg. we assign a specific length,  
say it is 1 metre.

Now any other length is expressed as a multiple of this length. Something which is twice as long as the standard length  
→ 2 m.





say it is 1 metre.  
Now any other length is expressed as a multiple of this length. Something which is twice as long as the standard length  
→ 2 m.  
as small as radius of a hydrogen atom  
or as large as distance from moon to earth  
standard length → unit length.





standard length  $\rightarrow$  unit length.

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Physical quantity  $Q = n \times u$

$n \rightarrow$  magnitude of the quantity

$u \rightarrow$  unit

The same quantity can be expressed in different





u → unit

The same quantity can be expressed in different sets of units.

$Q = n_1 u_1$  ← In unit 1,  $u_1$

Same  $Q$  in unit  $u_2$  measures  $n_2$ .

Since  $Q$  is the same,

$$n_1 u_1 = n_2 u_2$$






A large number of physical quantities  
(e.g. length, area, volume, speed, acceleration,  
mass, force, time ...).

We require only a few quantities which are  
independent and the other (dependent) quantities  
can be expressed in terms of these independent  
quantities.

— — —





mass, force, volume

We require only a few quantities which are independent and the other (dependent) quantities can be expressed in terms of these independent quantities.

Independent quantities — Fundamental units.  
Other quantities — Derived units

Derived quantities are obtained by multiplication or division of powers of fundamental quantities.





Note1 - Windows Journal

File Edit View Insert Actions Tools Help


derived quantities) — system of units

Different units of measurement

Till 1970's 3 major systems

a) CGS system of units

centimetre	used for length
gram	used for mass
— sec	used for t



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10:48 AM 10 Aug 18







The screenshot shows a Windows Journal window titled "Note1 - Windows Journal". The window contains handwritten notes in black ink on a white background. The notes are organized into two sections, labeled b) and c). Section b) describes the FPS system, and section c) describes the MKS system. A small video inset in the bottom right corner shows a man in a white shirt standing in front of a chalkboard that has "Units and Measurements" written on it. The Windows taskbar is visible at the bottom of the window, showing various application icons and the system clock.

b) FPS system  
Foot was used for length  
Pound was used for mass  
Sec was used for time

c) MKS system  
Metre was used for length  
Kilogram used for mass  
Second used for time



## Units of measurement, systems of units, SI units, fundamental.. (CH\_22)

The screenshot shows a Windows Journal window titled "Note1 - Windows Journal". The notes are handwritten in black ink on a white background. The text is as follows:

- Kilogram used for time
- second used for time
- Systems of units → standardized
- SI units (System International units)
- ↓
- based on decimal system
- SI units → seven base units used

The journal window includes a menu bar (File, Edit, View, Insert, Actions, Tools, Help), a toolbar with various drawing tools, and a color palette. The Windows taskbar is visible at the bottom of the window, showing icons for the Start menu, Internet Explorer, Google Chrome, and other applications. The system tray shows the time as 10:11 AM and the date as 10/10/10.

20:43 / 58:27



# Units of measurement, systems of units, SI units, fundamental.. (CH\_22)



Note1 - Windows Journal

Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Temperature	Kelvin	K
Amount of substance	mole	mol

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23:07 / 58:27



# Units of measurement, systems of units, SI units, fundamental.. (CH\_22)



Note1 - Windows Journal

Electric current	ampere	A
Temperature	Kelvin	K
Amount of substance	mole	mol
Luminous Intensity	Candela	cd

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23:35 / 58:27





Note1 - Windows Journal

File Edit View Insert Actions Tools Help

2 dimensionless units defined  
units for angles

1) Planar case  
radian

Diagram illustrating a circular sector. The radius is labeled  $r$ , the angle is labeled  $\theta$ , and the arc length is labeled  $s$ . The text "Circular arc" is written next to the arc.

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# Units of measurement, systems of units, SI units, fundamental.. (CH\_22)



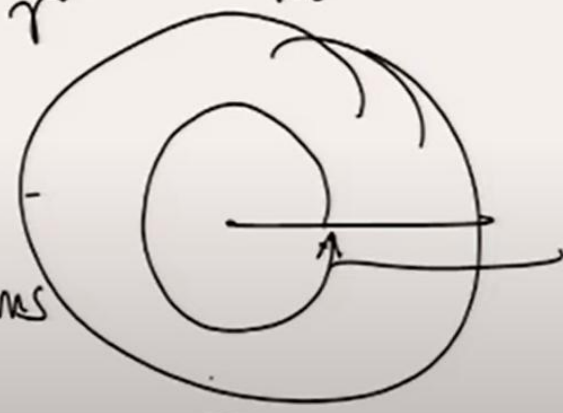
Note1 - Windows Journal

File Edit View Insert Actions Tools Help

radian


$$\theta = \frac{s}{r} \text{ in radians}$$

$\frac{2\pi r}{r} = 2\pi$  radians



degrees =  $360^\circ$

3/8

11:00 AM



Note1 - Windows Journal

File Edit View Insert Actions Tools Help

100%

B / [Color palette]

$$1^\circ = \frac{2\pi}{360} \text{ radians} = \frac{\pi}{180} \text{ rad}$$

2) Solid angle  
spherical surface

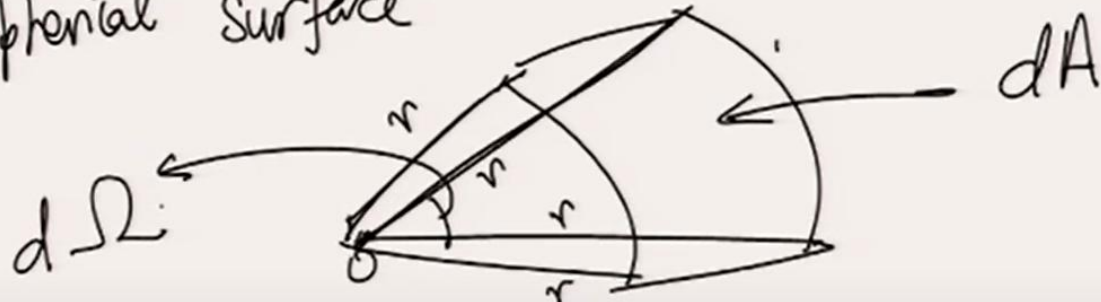


# Units of measurement, systems of units, SI units, fundamental.. (CH 22)

Press Esc to exit full screen

360

2) Solid angle  
spherical surface



$\frac{dA}{r^2} = d\Omega$

Units of measurement, systems of units, SI units, fundamental.. (CH\_22)



spherical surface

The diagram shows a spherical surface with a center point 'O'. A radius 'r' is drawn from 'O' to the surface. A differential area element 'dA' is shown on the surface. A differential solid angle 'dΩ' is indicated by a small area on the surface. The diagram illustrates the relationship between the differential area element and the differential solid angle.

$$\frac{dA}{r^2} = d\Omega \text{ (in steradian)}$$


## Units of measurement, systems of units, SI units, fundamental.. (CH\_22)

The screenshot shows a Windows Journal window titled "Note1 - Windows Journal". The window contains handwritten text in black ink on a white background. The text is as follows:

Time  $\rightarrow$  1 sec -  
1 minute = 60 sec  
1 hour = 3600 sec  
1 day = 86400 sec  
Angle  $\rightarrow$  radian

The window also shows a standard Windows interface with a menu bar (File, Edit, View, Insert, Actions, Tools, Help), a toolbar with various drawing tools, and a color palette. The taskbar at the bottom of the window shows several application icons and the system tray with the date and time (10/05/2010).





time      1 s

1 minute = 60 s

1 hour = 60 min = 3600 s

Length - large distances

Light year → distance travelled by  
light in 1 year





Note1 - Windows Journal

Light year  $\rightarrow$  distance travelled by light in 1 year

- prefixes

$10^3$	kilo	$10^9$	giga	$10^{15}$	peta
$10^6$	mega	$10^{12}$	tera		

10 / 11

11:19 AM



## Units of measurement, systems of units, SI units, fundamental.. (CH\_22)

The screenshot shows a Windows Journal window titled "Note1 - Windows Journal". The window contains handwritten notes in black ink. At the top, the number "10" is written. Below it, the word "mega" is written. A horizontal line is drawn across the page. Below the line, the following units are listed in a column:

$10^{-2}$	centi
$10^{-3}$	milli
$10^{-6}$	micro
$10^{-9}$	nano
$10^{-12}$	pico


The window also shows a standard Windows taskbar at the bottom with various application icons and system tray icons. The system clock shows 10:15 AM on 08/08/2020.

37:22 / 58:27



Measurement of length

Direct measurement of length — metre scale  
range of  $10^{-3}$  m to  $10^2$  m.

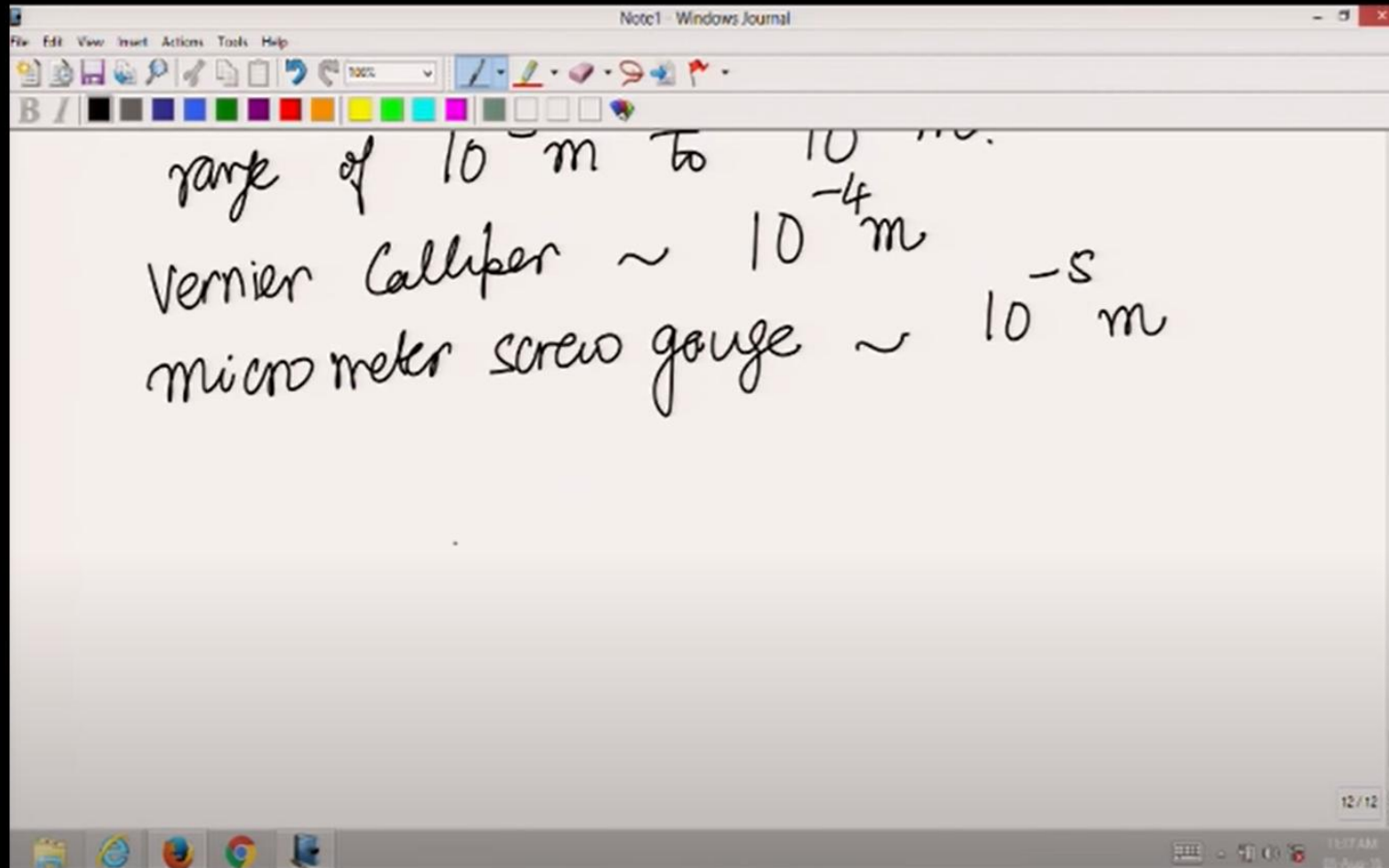


12/12

10:10 AM  
10 Aug 18



## Units of measurement, systems of units, SI units, fundamental.. (CH\_22)

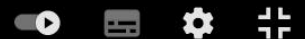


range of  $10^{-2}$  m to  $10^{-10}$  m.

Vernier Calliper  $\sim 10^{-4}$  m

micrometer screw gauge  $\sim 10^{-5}$  m

39:40 / 58:27







Large distances are measured by method of parallax.

When the same point is observed by two different observation points, it seems that position of the point has changed. This shift is called parallax.



The distance between the 2 observation points  $\rightarrow$   
basis. (b)

$\cdot S$  observe  $S$   
from A and  
from B.

$\cdot A$   $\cdot B$

Units and Measurements

13/13

15:27 AM





Distance from S to A or S to B is given by D.

Distance between A & B (basic) = b

observe S from A and from B.



## Units of measurement, systems of units, SI units, fundamental.. (CH\_22)

The screenshot shows a Windows Journal window titled "Note1 - Windows Journal". The interface includes a menu bar (File, Edit, View, Insert, Actions, Tools, Help), a toolbar with various drawing tools, and a color palette. The handwritten content is as follows:

A & B (units)  $\longleftrightarrow$  b  
= b

Measure the angle between the two directions along

---

which S is viewed.

If  $\frac{b}{D} \ll 1$

The diagram shows two points, A and B, with a double-headed arrow between them labeled 'b'. Below this, the text says "Measure the angle between the two directions along". A horizontal line separates this from the text "which S is viewed." and "If  $\frac{b}{D} \ll 1$ ".



Measure the angle  $\theta$

which  $S$  is viewed.

If  $\frac{b}{D} \ll 1$ , angle  $\theta$  will be small

$AB \rightarrow$  treated as arc of the circle

$b = D \theta \leftarrow \theta$  in radians

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





Note1 - Windows Journal

File Edit View Insert Actions Tools Help

AB  $\rightarrow$  treated as arc of the circle

$$b = r \theta \quad \leftarrow \theta \text{ in radians}$$
$$r = \frac{b}{\theta}$$

If we want to measure the size or angular diameter of a planet

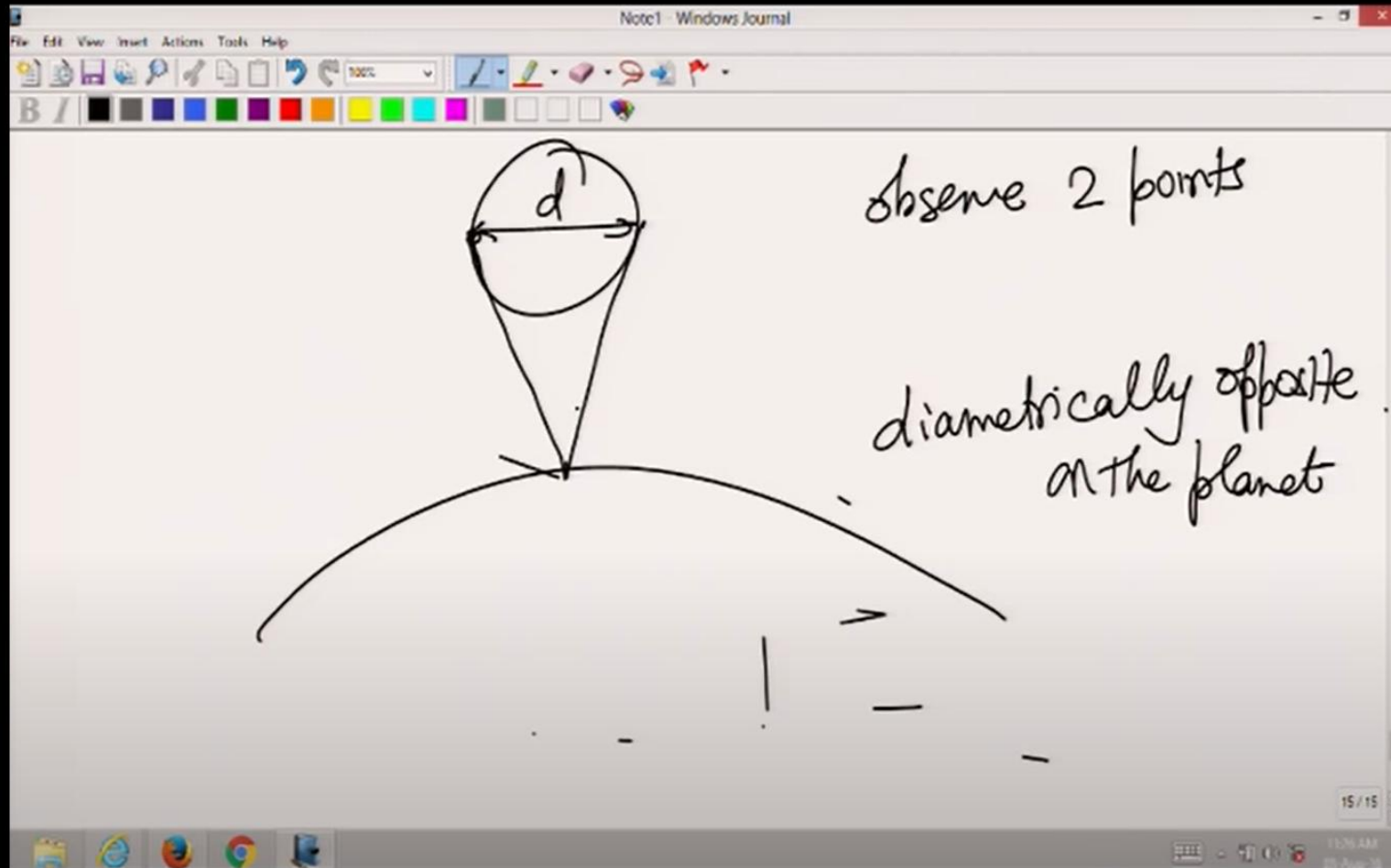
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15:25 AM





Units of measurement, systems of units, SI units, fundamental.. (CH\_22)



48:59 / 58:27



Units of measurement, systems of units, SI units, fundamental.. (CH\_22)

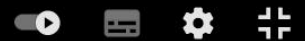


The diagram shows a sphere with a horizontal diameter labeled  $d$ . From a point at a distance  $L$  from the center of the sphere, two lines of sight are drawn to the left and right edges of the sphere, forming an angle labeled  $\alpha$ . The sphere is positioned above a curved line representing the horizon. To the right of the sphere, there are two horizontal lines with arrows pointing right, representing the ground surface.

angle subtended by the 2 opposite points  $= \alpha$

observe 2 points diametrically opposite on the planet

49:24 / 58:27





subtended by the 2 opposite points =  $\alpha$

diametrically opposite on the planet

If distance of planet from earth =  $D$

$$d = \alpha D \Rightarrow \alpha = \frac{d}{D}$$


## Units of measurement, systems of units, SI units, fundamental.. (CH\_22)

degree

$$1 \text{ degree} = \frac{\pi}{180} \text{ rad} = 1.745 \times 10^{-2} \text{ rad}$$
$$1 \text{ degree} = 60 \text{ minutes}$$
$$1 \text{ minute or } 1' = \frac{1}{60}^\circ = \frac{1.745 \times 10^{-2} \text{ rad}}{60}$$

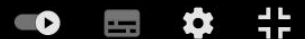
## Units of measurement, systems of units, SI units, fundamental.. (CH\_22)

The screenshot shows a Windows Journal window titled "Note1 - Windows Journal". The window contains handwritten mathematical conversions for angular units. At the top, "1 degree" is written with a horizontal line above it and "180" written below the line. Below this, the following equations are written:

$$1 \text{ degree} = 60 \text{ minutes}$$
$$1 \text{ minute or } 1' = \frac{1}{60}^\circ = \frac{1.745 \times 10^{-2} \text{ rad}}{60}$$
$$1 \text{ sec} = \frac{1}{60} \text{ min} = 1'' = \frac{1.745 \times 10^{-2} \text{ rad}}{60 \times 60}$$

The journal window includes a menu bar (File, Edit, View, Insert, Actions, Tools, Help), a toolbar with various drawing tools, and a color palette. The Windows taskbar is visible at the bottom of the journal window, showing icons for Start, Internet Explorer, and Google Chrome, along with the system clock and taskbar icons.

52:25 / 58:27





Moon is observed from 2 diametrically opposite points on the earth.  
angle subtended by the 2 lines of observation  
 $1^{\circ} 54'$   
Diameter of earth =  $1.276 \times 10^7$  m







Note1 - Windows Journal

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Diameter of earth =  $1.276 \times 10^7$  m

Find distance between earth and moon

$1^\circ 54'$

$D = ?$

$1^\circ 54'$

A B

17/17

11:57 AM

SWAN F





Note1 - Windows Journal

File Edit View Insert Actions Tools Help

Diameter of earth =  $1.276 \times 10^7$  m

Find distance between earth and moon

$D = ?$

$1^\circ 54'$

$1.276 \times 10^7$  m

17/17

11:59 AM





Note1 - Windows Journal

File Edit View Insert Actions Tools Help

$\theta \rightarrow$  Convert to radians

$1^\circ 54' \rightarrow$  radians  $\rightarrow$

$60' + 54' = 114'$

$1.276 \times 10^7 \text{ m} = D \times \frac{114 \times 1.745 \times 10^{-2}}{60}$

10/10





Note1 - Windows Journal

File Edit View Insert Actions Tools Help

$1^{\circ}54' \rightarrow \text{radians}$

$$1.276 \times 10^7 \text{ m} = D \times \frac{114 \times 1.745 \times 10^{-2}}{60}$$
$$D = \frac{1.276 \times 10^7 \times 60}{114 \times 1.745 \times 10^{-2}} \text{ m}$$

10/10

11:55 AM  
20 Aug 18

