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B.tech Gold Medalist, Awarded with Teaching Excellence by Unacademy. Produced AIR 49 in JEE Advanced, Got AIR 368 in GATE 2016 & AIR 192 in

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HINDI PHYSICS

Units and Measurement Practice Session

Starts on Apr 6, 2022 • 10:00 AM

→ Notes
→ DPP Video solut"
→ practice, paper

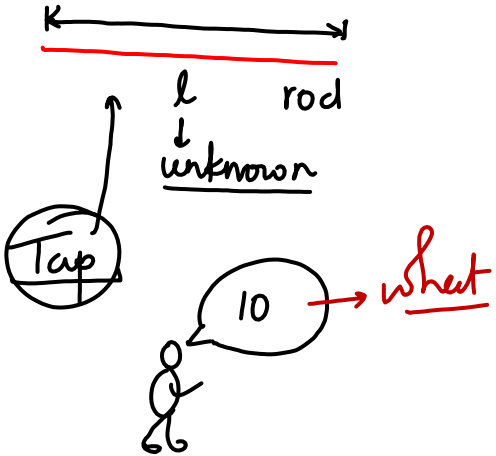
In this session, Mahendra Singh will discuss Units and Measurements. It will be helpful for the aspirants preparing for NEET. This session will be conducted in Hindi and the notes will be provided in English.

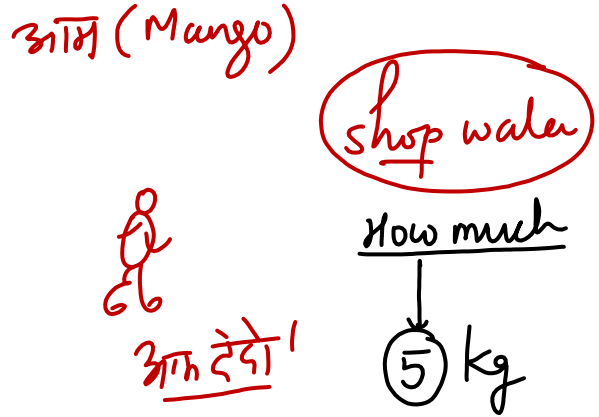
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Let's Understand Why Units are Necessary





PQ → n * u

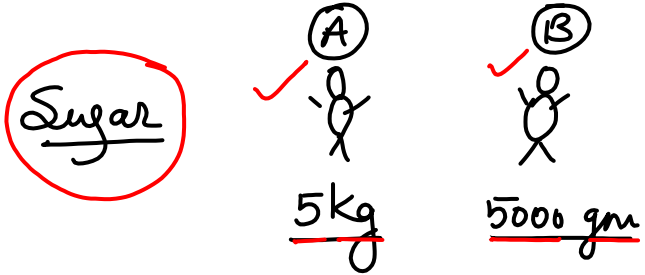
measurable

used to explain laws of physics

Let's Understand Why Units are Necessary

Physical Quantity = Numerical value * Standard of representation

units



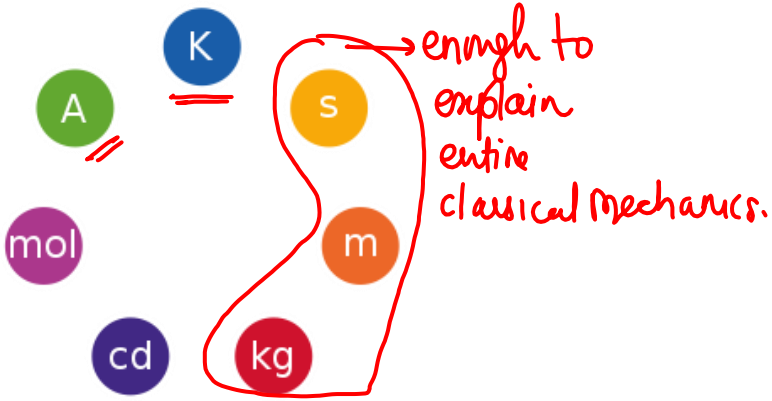
$Q = nu = \text{const}$

$n_1u_1 = n_2u_2$

Types of Physical Quantities

neet

- **Fundamental Quantities** (7)
- **Derived Quantities**
- **Supplementary Quantities**



- plane angle (rad)
- solid angle (steradian)

Fundamental or Base Quantity

- These are the elementary quantities which covers entire span of physics.
  These are independent of each other.
- Any other quantity can be derived from these.

Fundamental or Base Quantity

S. No.	Physical Quantity	Unit	Symbol
1	Length	metre	m [L]
2	Mass	kilogram	kg [M]
3	Time	second	s sec [T]
4	Electric current	ampere	A [A]
5	Thermodynamic Temperature	kelvin	K [K]
6	Amount of Substance	mole	mol [mol]
7	Luminous Intensity	candela	cd [cd]

Dimension

PQ ⇒ (a) → acceleration

$$a = \frac{v}{T} = \frac{L}{TT}$$

$$a = \frac{L}{T^2}$$

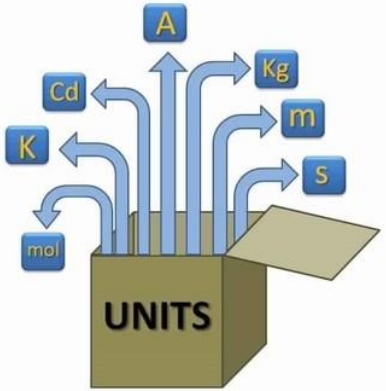
$$[a] = [M^0 L^1 T^{-2}]$$

dimension of (a)

PQ ⇒ (F) → force

$$F = ma = m\frac{L}{T^2}$$

$$[F] = [M^1 L^1 T^{-2}]$$



Dimension

length
height
Diameter
radius
Width

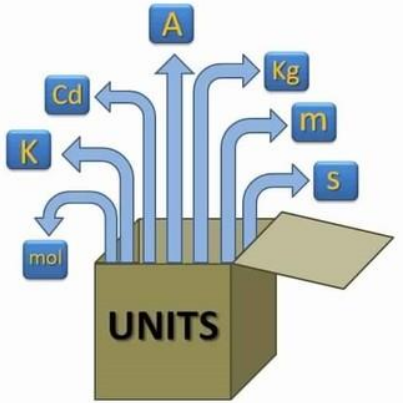
→ length = [L]

Const.

↑
2
100
e = 2.718

→ dimensionless

$[M^0L^0T^0] = 1$



Dimensions

For Rectangle



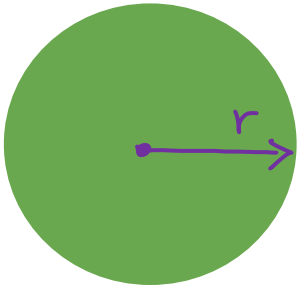
Area = Length × Width

[Area] = [Length] × [Width]

= [L] × [L]

= [L^2]

For circle



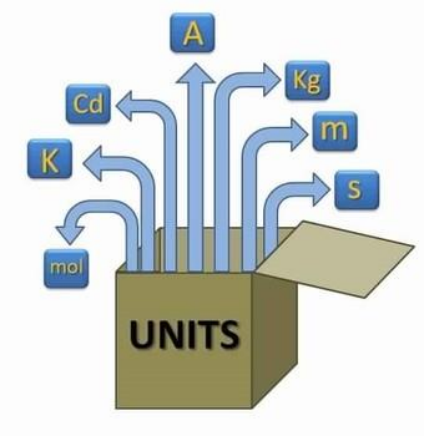
Area = πr^2

[Area] = [π] [r^2]

= [1] [L^2]

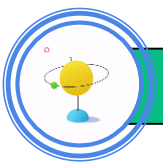
= [L^2]

Dimension



Conclusion

Dimension of a physical quantity will be same, it does not depend on which formula we are using for that quantity.



Example

MCQ type Question [+4 , -1]

A unitless quantity

A. Does not exist

B. Always has a non zero dimension

C. Never have a non zero dimension

D. May have a nonzero dimension

$M^a L^b T^c$

$a \neq 0$, $b \neq 0$, $c \neq 0$

$\sin\theta = \frac{P}{H} = \frac{K}{K}$

↓

unitless

$(M^0 L^0 T^0)$

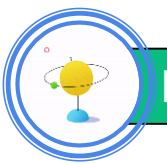
displacement gradient

$\Rightarrow \frac{d(disp)}{dx} = \frac{K}{K}$

⇓

unitless

$(M^0 L^0 T^0)$



Example

MCQ type Question [+4 , -1]

A dimensionless quantity

A. Never has a unit

B. Always has a unit

C. May have a unit

D. Does not exist

$\sin\theta = \frac{P}{H} = \frac{L}{L}$

$\sin\theta$ ↓ d'less ⟶ unitless

$(M^0L^0T^0)$

rad ⟵ $\theta = \frac{arc}{radi} = \frac{L}{L}$

↓

$[M^0L^0T^0]$

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velocity

$(unit) = \frac{m}{sec} \rightarrow \frac{L}{T}$

$[V] = [LT^{-1}]$

$F = m(a)$ — a: non fund PQ

$= m\left(\frac{L}{T^2}\right)$

$[F] = [MLT^{-2}]$

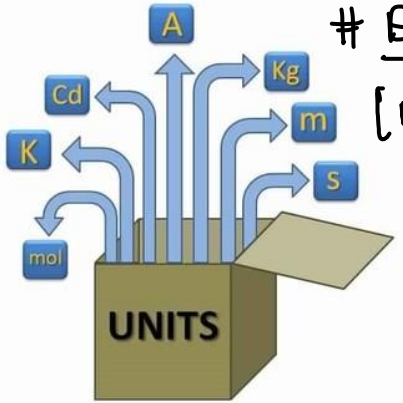
$\text{Power} = \frac{E}{t} = \frac{[ML^2T^{-2}]}{T}$

$[ML^2T^{-3}]$

density $= \frac{M}{V}$ — M: FPQ, V: non FPQ

$= \frac{M}{L^3}$

$[\rho] = [ML^{-3}]$



Energy = work = Force × disp

$[ML^2T^{-2}]$ $= m \times a \times L$

$= m\frac{L}{T^2}L$

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$a = \frac{V}{T} = \frac{L}{TT}$

$\rightarrow V \longrightarrow M^0LT^{-1}$

$a \longrightarrow M^0LT^{-2}$

$F \longrightarrow MLT^{-2}$

$E = W = \tau \longrightarrow ML^2T^{-2}$

$P = \frac{E}{T} \rightarrow ML^2T^{-3}$

$\rho = \frac{M}{V} \rightarrow ML^{-3}T^0$

pressure $= \frac{F}{A} = \frac{MLT^{-2}}{L^2}$

$ML^{-1}T^{-2}$

Electric Potential; $V = \frac{W}{q}$

$V = \frac{ML^2T^{-2}}{AT}$

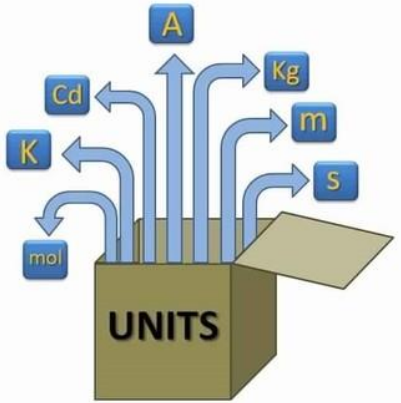
$[V] = [ML^2T^{-3}A^{-1}]$

$i = \frac{q}{t}$

$q = it$

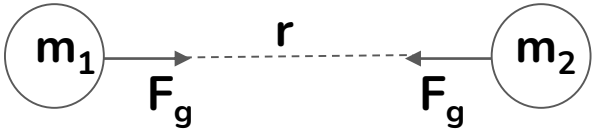
Resistance, $R = \frac{V}{I} = \frac{ML^2T^{-3}A^{-1}}{A}$

$[R] = [ML^2T^{-3}A^{-2}]$



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1. Gravitational constant



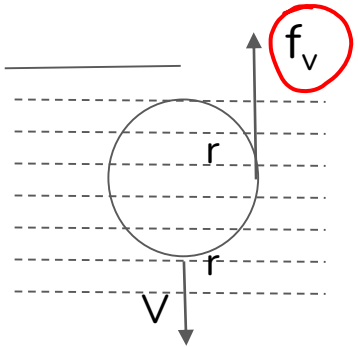
Gravitational Force $F_g = \frac{Gm_1m_2}{r^2}$

$[M L T^{-2}] = G\frac{M^2}{L^2}$

$[G] = [M^{-1} L^3 T^{-2}]$

Dimensions of some physical constants

2. Coefficient of viscosity



$$F_v = 6\pi\eta r v$$

$F_v = 6\pi\eta r v$

$[MLT^{-2}] = \eta [L] \left[\frac{L}{T}\right]$

$\eta = [ML^{-1}T^{-1}]$

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3. Planck's constant

$$E = h\upsilon = h\frac{1}{T}$$

$$h = E\,T = ML^2T^{-2}\,T$$

$$\underline{\underline{h = [ML^2T^{-1}]}}$$

Some special features of Dimensions

1. (Distance - x) = (..... dist .....)

must have dimension of distance

2. (Pressure $\pm$ x) = (..... [Resultant] = [P] .....)

must have dimension of P

$[x] = [P]$

$f = 10N$

$v = 5 m/s$

$f - v \Rightarrow 10 - 5 =$ (N) (m/s) not possible

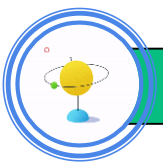
(or) $f + v = ?$

$F_1 = 10N \quad F_2 = 5N$

$\Rightarrow F_1 - F_2 = 10 - 5 = 5N$

Rule NO 1

One quantity can be added/subtracted with similar quantity only and gives rise to similar quantity.



Example

MCQ type Question [+4 , -1]

If $x = at + bt^2$, where x is the distance travelled by the body in kilometers while t is the time in seconds, then the unit of b is ***[1989]***

(a) km/s (b) kms

(c) km/s^2 (d) kms^2

$[x] = [at] = [bt^2]$

$[L] = b\,T^2$

$b = \frac{L \rightarrow km}{T^2 \; sec}$

Example

MCQ type Question [+4 , -1]

The velocity v of a particle at time t is given by

$v = at + \frac{b}{t+c}$, where a, b and c are constant.

The dimensions of a, b and c are respectively

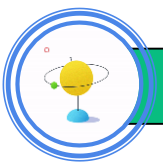
[2006]

(a) L^2, T and LT^2 (b) LT^2, LT and L

(c) L, LT and T^2 (d) LT^{-2}, L and T

$(t+c) \rightarrow [T]$

$[T+T] = [2T]$ X



Example

MCQ type Question [+4 , -1]

An equation is given as : $\left(P+\frac{a}{V^2}\right)=b\frac{\theta}{V}$

where P = Pressure, V = Volume & θ = Absolute temperature. If a and b are constants, then dimensions of a will be ***[1996]***

(a) $[ML^5T^{-2}]$ (b) $[M^{-1}L^5T^2]$

(c) $[ML^{-5}T^{-1}]$ (d) $[ML^5T^1]$

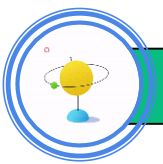
$\forall \rightarrow L^3$

$\forall^2 = (L^3)^2 = L^6$

$[P] = \left[\frac{a}{\forall^2}\right]$

$[a] = [P \forall^2]$

$= [ML^{-1}T^{-2} \times L^6]$



Example

MCQ type Question [+4 , -1]

neet

HW

10Am

$$\frac{\alpha}{t^2} = Fv + \frac{\beta}{x^2}$$

(here V = velocity, F = force , x = distance) Find the dimensions of α and $\boldsymbol{\beta}$

Example

MCQ type Question [+4 , -1]

neet

The van der waals equation of state for some gases can be expressed as HW

$$\left(p+\frac{a}{v^2}\right)(v-b)=RT$$

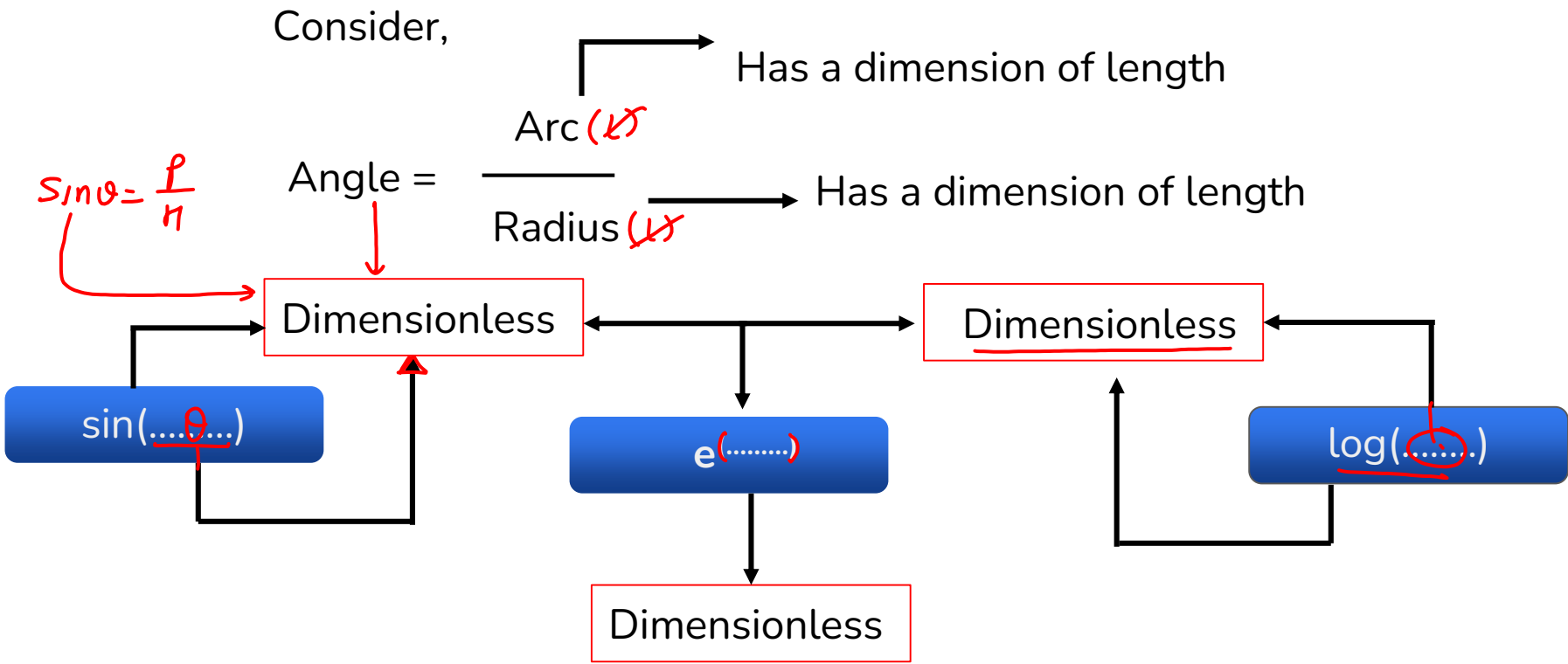
where P is the pressure, V is the molar volume, and T is the absolute temperature of the given sample of gas and a, b, and R are constants.

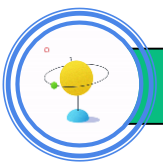
The dimension of a are

A. ML^5T^{-2} B. $ML^{-1}T^{-2}$

C. L^3 D. L^6

Rule NO 2


Consider,
Has a dimension of length
Arc (L)
Angle =
Radius (L)
Has a dimension of length
sinθ = P/H
Dimensionless
Dimensionless
sin(....θ...)
e(.....)
log(.....)
Dimensionless



Example

MCQ type Question [+4 , -1]

neet

$$\alpha = \frac{F}{V^2}\left(\sin \beta t\right)$$

$\sin(\beta t) \rightarrow M^0L^0T^0$

(here V = velocity, F = force , t = time) Find the dimensions of α and β

$\sin(\beta t) \rightarrow M^0L^0T^0 = \beta(T)$

$\beta = [M^0L^0T^{-1}]$

$[\alpha] = \left[\frac{F}{V^2}\right]$

$[\alpha] = \frac{MLT^{-2}}{LT^{-1}} = ML^0T^{-1}$

Example

MCQ type Question [+4 , -1]

The equation of the stationary wave is

$$y = 2A \sin\left(\frac{2\pi ct}{\lambda}\right)\cos\left(\frac{2\pi x}{\lambda}\right)$$

Which of the following statements is wrong ?

(A) the unit of ct is same as that of λ

(B) the unit of x is same as that of λ

(C) the unit of $2\pi\, c/\lambda$ is same as that of $2\pi x/\lambda t$

(D) the unit of c/λ is same as that of x/λ

$\frac{c}{\lambda} \rightarrow \frac{m}{sec\ m} = \frac{1}{sec}$

$\frac{x}{\lambda t} = \frac{m}{m\ sec} = \frac{1}{sec}$

Example

MCQ type Question [+4 , -1]

The time dependence of a physical quantity p is given by $p = p_0 \exp(-\alpha t^2)$, where α is a constant and t is the time. The constant α *[1993]*

(a) is dimensionless

(b) has dimensions T^{-2}

(c) has dimensions T^2

(d) has dimensions of p

$p = p_0 e^{(-\alpha t^2)}$

$M^0 L^0 T^0 = \alpha T^2$

Application of dimensional analysis

neet

unit conversion

$$Q = nu = \text{const}$$

$$n_1 u_1 = n_2 u_2$$

$$n_2 = n_1 \left[\frac{u_1}{u_2}\right]$$

$F = MLT^{-2}$

$n_1 = 10$

$F = 10N = 10 \frac{kg\,m}{sec^2}$

$F = ?$ $kg \rightarrow gm$

CGS $m \rightarrow cm$

$sec \rightarrow sec$

$$n_2 = 10\left[\frac{M_1}{M_2}\right]^1\left[\frac{L_1}{L_2}\right]^1\left[\frac{T_1}{T_2}\right]^{-2}$$

$$= 10\left[\frac{kg}{gm}\right]^1\left[\frac{m}{cm}\right]^1\left[\frac{sec}{sec}\right]^{-2}$$

$$= 10\left[\frac{1000\,gm}{gm}\right]^1\left[\frac{100\,cm}{cm}\right]$$

$$= 10 \times 10^5 \text{ dyne}$$

Application of dimensional analysis

1. **Conversion of Units**:-

For any physical quantity

measurement = numerical value X unit

$Q = \text{const}$







1 kg



1000 gm

Application of dimensional analysis

neet

1. **Conversion of Units:-**

For any physical quantity

= Measurement = Numerical value x Unit

As measured value is constant,

= Numerical value x Unit = Constant

Or $n_1[u_1] = n_2[u_2]$

Example

MCQ type Question [+4 , -1]

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If u_1 and u_2 are the units selected in two systems of measurement and n_1 and n_2 their numerical values, then

A. $n_1u_1 = n_2u_2$

B. $n_1u_1 + n_2u_2 = 0$

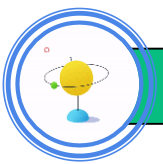
C. $n_1n_2 = u_1u_2$

D. $(n_1+u_1) = (n_2+u_2)$

Application of dimensional analysis

If Physical Quantity has dimensions $M^{\propto}L^{\beta}T^{r}$
We can write

$$= n_1[M_1^{\propto}L_1^{\beta}T_1^{r}] = n_2[M_2^{\propto}L_2^{\beta}T_2^{r}]$$



Example

MCQ type Question [+4 , -1]

neet

Conversion between ‘N’ and ‘dyne’ (CGS)

$1\ N = 1\ kg\ m/s^2$

$= 10^5\ \frac{gm\ cm}{sec^2}$

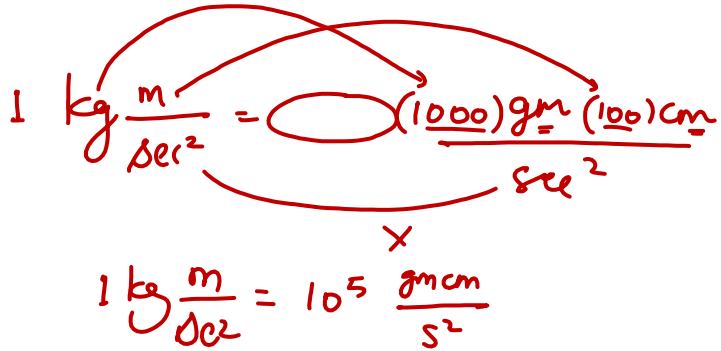
Example

MCQ type Question [+4 , -1]

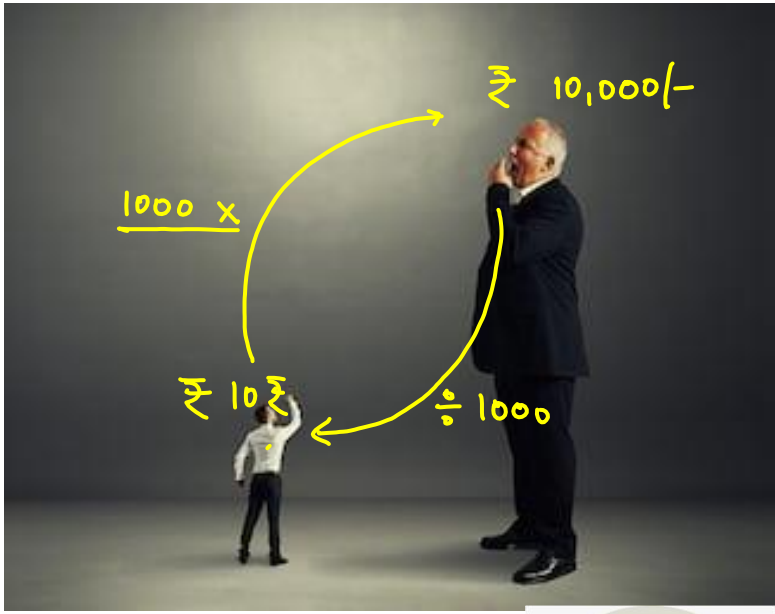
Method 2

Conversion between ‘N’ and ‘dyne’ (CGS)

1 N = 1 kg m/s^2



Mahi



Application of dimensional analysis

neet

Application of dimensional analysis

neet

Example

MCQ type Question [+4 , -1]

The density of material in CGS system of units is $4 g/cm^3$. In a system of units in which unit of length is 10 cm and unit of mass is 100 g, the value of density of material will be *[2011M]*

(a) 0.4 (b) 40

(c) 400 (d) 0.04

1 cm → 10 cm

1 gm → 100 gm

$$n_2 = n_1 \frac{u_1}{u_2} = 4\left[\frac{gm}{100\,gm}\right]\left[\frac{10\times10\times10\ cm^3}{cm^3}\right]$$

$$4\frac{g}{cm^3} = n_2 \frac{100\,gm}{(10\,cm)^3}$$

$$4\frac{g}{cm^3} = n_2 \frac{100}{10\times10\times10}\frac{g}{cm^3}$$

$n_2 = 40$

$n_2 = 40$

100 gm, $1\,gm = \frac{1}{100}$

$$4\frac{g}{cm^3} = n_2 \frac{\frac{1}{100}}{\left(\frac{1}{10}\right)^3} = n_2 \frac{10\times10\times10}{100}$$

Application of dimensional analysis

neet

Derive any result :-

$E \propto m^a, L^b, T^c$

$E = [k][M]^a[L]^b[T]^c$

$ML^2T^{-2} = M^aL^bT^c$

$a=1$
$b=2$
$c=-2$

$m \propto E^a, F^b, V^c$

$[M] = [ML^2T^{-2}]^a[MLT^{-2}]^b[LT^{-1}]^c$

$M^1L^0T^0 = M^{(a+b)}L^{(2a+b+c)}T^{(-2a-2b-c)}$

$a+b=1 \quad -①$

$2a+b+c=0$

$-2a-2b-c=0$

$-b=0$

$b=0$

$a=1$

$c=-2$

$m = k\frac{E^1F^0}{V^2}$

$m = k\frac{E}{V^2}$

Example

MCQ type Question [+4 , -1]

A physical quantity of the dimensions of length that can be formed out of c, G and $\left(\frac{e^2}{4\pi\varepsilon_0}\right)$ is [c is velocity of light, G is universal constant of gravitation and e is charge] ***[2017]***

(a) $c^2\left[G\frac{e^2}{4\pi\varepsilon_0}\right]^{1/2}$ (b) $\frac{1}{c^2}\left[\frac{e^2}{G4\pi\varepsilon_0}\right]^{1/2}$

(c) $\frac{1}{c}G\frac{e^2}{4\pi\varepsilon_0}$ (d) $\frac{1}{c^2}\left[G\frac{e^2}{4\pi\varepsilon_0}\right]^{1/2}$

$L \propto c^a G^b K^c$

$K = \frac{e^2}{4\pi\varepsilon_0} = \frac{q_1 q_2}{4\pi\varepsilon_0} = F r^2$; ML^3T^{-2}

$q_1 \leftarrow \quad \rightarrow q_2$

$F = \frac{q_1 q_2}{4\pi\varepsilon_0 r^2}$

L

C (LT^{-1}) G $M^{-1}L^3T^{-2}$ K ML^3T^{-2}

$\frac{\sqrt{GK}}{c^2} = \sqrt{L^6T^{-4}} = L^3T^{-2}$

Example

MCQ type Question [+4 , -1]

If energy (E), velocity (V) and time (T) are chosen as the fundamental quantities, the dimensional formula of surface tension will be : ***[2015]***

(a) $[EV^{-1}T^{-2}]$ (b) $[EV^{-2}T^{-2}]$

(c) $[E^{-2}V^{-1}T^{-3}]$ (d) $[EV^{-2}T^{-1}]$

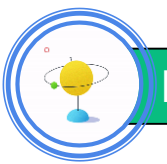
$\sigma = MT^{-2}$

E	V	T
ML^2T^{-2}	LT^{-1}	T

$ST = \frac{F}{l} = \sigma = \frac{ML^2T^{-2}}{L^2}$

MT^{-2}

$\frac{E}{T^2V^2} = \frac{ML^2T^{-2}}{L^2T^{-2}} = \frac{M}{T^2} = MT^{-2}$



Example

MCQ type Question [+4 , -1]

neet

Express L in terms of G, h and c-

(A) $G^{-1/2}, h^{1/2} c^{1/2}$

(B) $G^{1/2} h^{1/2} c^{-3/2}$

(C) $G^{1/2} h^{1/2} c^{-5/2}$

(D) G h c

L

$M^0 T^0$

G

$M^{-1} L^3 T^{-2}$

h

$M L^2 T^{-1}$

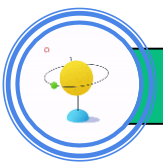
c

$L T^{-1}$

$\frac{5}{2} - \frac{3}{2} = 1$

$Gh = L^5 T^{-3}$

$\frac{\sqrt{Gh}}{c^{3/2}} = \frac{L^{5/2} T^{-3/2}}{L^{3/2} T^{-3/2}}$



Example

MCQ type Question [+4 , -1]

If the dimensions of a physical quantity are given by $M^a L^b T^c$, then the physical quantity will be:

(a) Velocity if $a = 1, b = 0, c = -1$ ***[2009]***

(b) Acceleration if $a = 1, b = 1, c = -2$

(c) Force if $a = 0, b = -1, c = -2$

(d) Pressure if $a = 1, b = -1, c = -2$

HW

Example

MCQ type Question [+4 , -1]

Turpentine oil is flowing through a tube of length ℓ and radius r. The pressure difference between the two ends of the tube is p. The viscosity of oil is given by

HW

$$\eta = \frac{p\left(r^2 - x^2\right)}{4vl}$$

where v is the velocity of oil at a distance x from the axis of the tube. The dimensions of η are

(a) $[M^0L^0T^0]$ (b) $[MLT^{-1}]$ ***[1993]***

(c) $[ML^2T^{-2}]$ (d) $[ML^{-1}T^{-1}]$

P represents radiation pressure, c represents speed of light and S represents radiation energy striking unit area per sec. The non zero integers x, y, z such that $P^x S^y c^z$ is dimensionless are

HW

[1992]

(a) $x=1, y=1, z=1$ (b) $x=-1, y=1, z=1$

(c) $x=1, y=-1, z=1$ (d) $x=1, y=1, z=-1$

$p = \frac{F}{A} = ML^{-1}T^{-2}$

$c = LT^{-1}$

$S = \frac{E}{tA} = \frac{ML^2T^{-2}}{TL^2} = MT^{-3}$

$[ML^{-1}T^{-2}]^x [MT^{-3}]^y [LT^{-1}]^z = M^0L^0T^0$

$M^{(x+y)} L^{(-x+z)} T^{(-2x-3y-z)} = M^0L^0T^0$

$x+y=0$

$-x+z=0$

$-2x-3y-z=0$

$x = -y$

$-(-y)+z=0$

$z = -y = x$

1yr, 2yr

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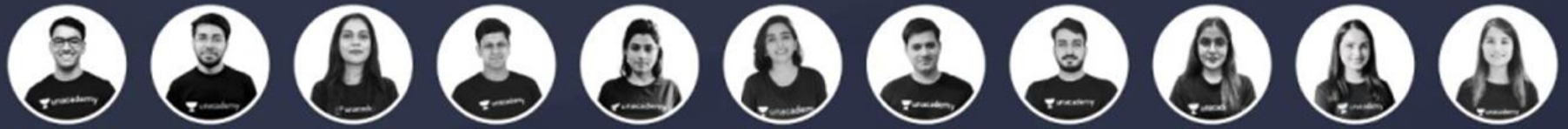
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Rules for finding significant figures ⇒ all readable digit + ① non readable

Rule 1: For numbers bigger than one

All the non zero digits are significant no matter what is the place of decimal.

2341 → (4)

2341678 ⇒ (7) 2.341678

Trailing zeros in a number without decimal is not significant

4300

(2)

Rule 1: Continue.....

Trailing zeros in a number with decimal are significant

43.00 → 4

4300 → 4

All the **zeros between two non-zero** digits are significant.

2008 → 4

287100340018 → 12

Rules for finding significant figures

Rule 1: For numbers less than one

Zeros to the left of the first non-zero digit are not significant.

Eg : 0.00531 has 3 significant digits.

Zeros to the right of the last non-zero digit are significant.

Eg : 0.09520 and 30.00 both have 4 significant figures.

Knowledge bullet for Siggi Figgi

Powers of ten are not counted in significant figures.

Eg : 4.7×10^5 has → Scientific notation

(2)

Number of significant figure does not vary with choice of units.

Eg : 4m, 40cm & 400mm has same significant figure.

$4 \quad 4 \times 10^1 \quad 4 \times 10^2$

Example

Find number of significant figures in following:

A. 42.3 → 3
B. 243.4 → 4
C. 24.123 → 5
D. 5.03 → 6
E. 5.604 → 4
F. 4.004 → 4
G. 0.543 → 3

Example

Find number of significant figures in following:

A. $0.045 \rightarrow 2$

B. $0.006 \rightarrow 1$

C. $4.330 \rightarrow 4$

D. $433.00 \rightarrow 5$

E. $343.000 \rightarrow 6$

F. $1.32 \times 10^{-2} \rightarrow 3$

G. $1.32 \times 10^{4} \rightarrow 3$

Rules for rounding off the numbers

While rounding off measurements, apply these:

1. If the digit to be dropped is less than 5, then the preceding digit remains the same.

   Eg : (i) 5.34 is rounded off to 5.3

   (ii) 4.92 ≈ 4.9

   remain same ≤5

1. If the digit to be dropped is greater than 5, increase the preceding digit by 'one'.

   Eg : (i) 12.26 >5 ≈ 12.3

   3.3 (ii) 3.29

Rules for rounding off the numbers

3. If the digit to be dropped is 5 followed by digits other than zero, increase the preceding digit by '1'.

Eg : (i) 3.251 ≈ 3 3

(ii) 13.353 ≈ 13 4

4. If the digit to be dropped is 5 followed by zeros, then the preceding digit remaining as it is if it is even.

Eg : (i) 3.250 ≈ 3 2

(ii) 13.450 ≈ 13 4

3350 → 34

Rules for rounding off the numbers

5. If the digit to be dropped is 5 followed by zeros, then increase the preceding digit by '1' if it is odd.

Eg: (i) 42.350 $\simeq$ 42.4

(ii) 0.750 $\simeq$ 0.8

Example

Round off the following

1. Up to two significant figures

A. 7.82

B. 6.87

C. 3.94

D. 6.758

E. 3.250

F. 3.750

Example

Round off the following to three places.

A. 12.78

B. 16.351

C. 12.650

D. 16.150

Significant figures in calculation

Rules :

1. The result of an addition or subtraction in the number having different precision should be reported to the same no. of decimal places as are present in the number having the least number of decimal places.

(3) (3) (3) X

$33.3 + 3.11 + 0.313 = 36.723 \simeq 36.7$

DP (1) DP (2) DP (3)

$3.1421 + 0.241 + 0.09 = 3.4731 \simeq 3.47$

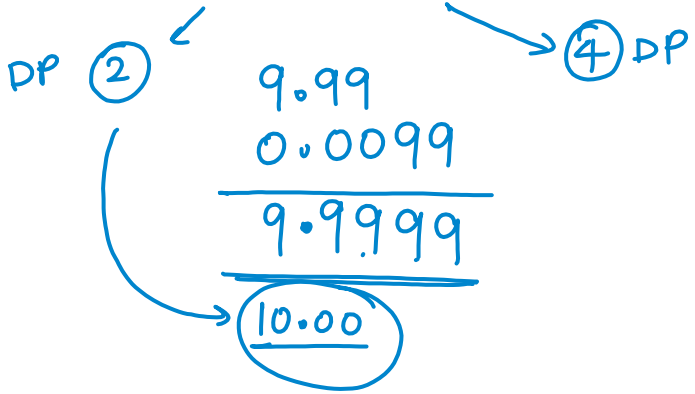
$62.831 - 24.5492 = 38.2818 \simeq 38.281$

Example

Taking into account the significant figures, what is the value of

9.99 m + **0.0099** m ?

NEET 2020



Significant figures in calculation

Rules :

2. The answer to a multiplication or division is rounded off to the same number of significant figures as is possessed by the least precise term used in the calculation.

SF (5) SF (2) 32.7 X

142.06 x 0.23 = 32.6738 ≈ 33

2.4750 / 3.50 = 0.707142....

Example

The mass of a box measured by a grocer's balance is **2.3** kg. Two gold pieces of masses **20.15** g and **20.17** g are added to the box. What is the total mass of the box and the difference in the masses of the pieces to correct significant figures ?

HW 10AM

A. 2.34 kg, 0 g

B. 2.3 kg, 0.02 g

C. 2.34 kg, 0.02 g

D. 2.3 kg, 0 g

Example

If the value of resistance is **10.845** Ω and the value of current is **3.23** A, the potential difference is **35.02935** V. Find its value in significant number.

A. 35.0

B. 35.03

C. 35

D. 35.1

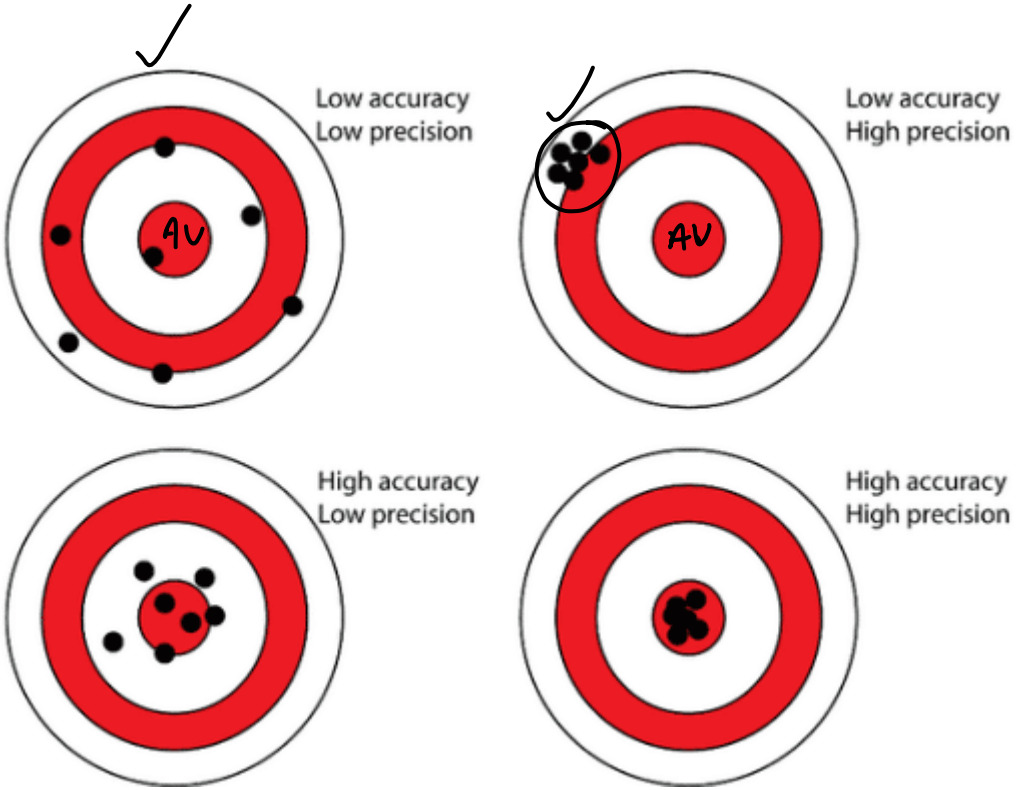
Accuracy and Precision

PQ

measurement

measured value

True value



Accuracy and Precision

Precision:

- It is the degree of exactness of a measurement.
- It defines the limitation of measuring instrument.
- It is not the result of human error or lack of calibration.

Accuracy:

- It is the extent to which a reported measurement approaches the true value.
- It depends upon the number of significant figures in it.
- Larger the significant figures, higher the accuracy.
- Accuracy decreases due to errors, human error, method error, instrument error.

Errors of Measurement

The measuring process is essentially a process of comparison. In Spite of our best efforts, the measured value of a quantity is always somewhat different from its actual value, or true value. This difference in the true value of a quantity is called error of measurement.

"Absolute Error"

$x = (5 \pm 0.01)\,m$

absolute error = $|\text{True value} - MV|$

Absolute error = true value - measured value

$x = 4.99$ ✓

$x = 5.01$ ✓

Mean Absolute Error

$(a_1 + a_2 + a_3 + a_4)/4$

$a_1\ a_2\ a_3\ a_4$ $\quad \bar{a}_m, \quad (a_i - a_m) = \Delta a$

It is the arithmetic mean of the magnitudes of absolute errors in all the measurements of the quantity. It is represented by **Δ**a.

$$\overline{\Delta a} = \frac{\Delta a_1 + \Delta a_2 + \Delta a_{3+\ldots} + \Delta a_n}{n}$$

Mean absolute error

Mean Absolute Error

$\frac{\Delta a}{a}$ = relative error

$\frac{\Delta a}{a} \times 100 \Rightarrow$ percentage error

$$a = a_m \pm \overline{\Delta a}$$

mean absolute error

$\Rightarrow$ absolute error

a_m → mean value

incase of absence of TV

$MV \cong TV$

neet

Propagation of Errors

Error in Addition/Subtraction of the Quantities

$A_1 = x \pm \Delta x$

$A_2 = y \pm \Delta y$

$Z = A_1 + A_2$ $\qquad$ $Z = A_1 - A_2$

$\Delta Z = ?$ $\qquad$ $\Delta Z = ?$

$\Delta Z = \pm (\Delta x + \Delta y)$

$\Rightarrow Z \pm \Delta Z$

Example

If the value of resistance is $R_1 = (3 \pm 0.03)\ \Omega$ and the value of resistance is $R_2 = (6 \pm 0.06)\ \Omega$, then the equivalent resistance of their series combination with maximum permissible error is

$R_s = R_1 + R_2$

A. $(9 \pm 0.09)\ \Omega$

B. $(9 \pm 0.03)\ \Omega$

C. $(9 \pm 0.06)\ \Omega$

D. $(9 \pm 0.02)\ \Omega$

Error in Addition/Subtraction of the Quantities

Conclusion:-

If the quantities having absolute error to be added or subtracted than the absolute error in the resultant quantity will be sum of absolute errors of individual quantities.

Error in Multiplication/Division of Quantities

$Q_1 = x \pm \Delta x$

$Q_2 = y \pm \Delta y$

$Z = \frac{Q_1}{Q_2}$ or $Q_1 \times Q_2$

$$\left(\frac{\Delta Z}{Z}\right) = \pm \left(\frac{\Delta x}{x} + \frac{\Delta y}{y}\right)$$

$$\Delta Z = \pm \left(\frac{\Delta x}{x} + \frac{\Delta y}{y}\right) Z$$

$Z \pm \Delta Z$

Example

If the value of length is a = (**6** ± 0.06) cm and the value of width is b = (3 ± 0.03) cm, then the value of area of rectangle with maximum permissible error is

A. (**18** ± 0.36) cm^2

B. (**18** ± 0.09) cm^2

C. (**18** ± 0.03) cm^2

D. (**18** ± 0.02) cm^2

$\frac{\Delta A}{A} = \pm \left(\frac{\Delta l}{l} + \frac{\Delta b}{b} \right)$

$= \pm \left(\frac{0.01}{6} + \frac{0.01}{3} \right)$

$A = 3 \times 6 = 18\ cm^2$

$\Delta A = ?$

$\Delta A = \pm 0.02 \times 18$

$= \pm 0.36$

Error in Addition/Subtraction of the Quantities

Conclusion:-

If the quantities having absolute error to be multiplied or divide than the relative absolute error in the resultant quantity will be sum of relative absolute errors of individual quantities.

Error in the Quantity raised to some Power

$$x = m^n$$

$$\frac{\Delta x}{x} = n\frac{\Delta m}{m}$$

$$y = x^2 = x \cdot x$$

$$\frac{\Delta y}{y} = \frac{\Delta x}{x} + \frac{\Delta x}{x} = 2\left(\frac{\Delta x}{x}\right)$$

Example

A physical quantity x is calculated from the relation

$$x = \frac{a^2 b^3}{c\sqrt{d}} = a^2 b^3 c^{-1} d^{-1/2}$$

If the percentage error in a,b,c, and d are 2%, 1%, 3%, and 4% respectively, what is the percentage error in x ?

A. 8% B. 10% C. 12% D. 6%

$$\frac{\Delta x}{x} 100 = \left[2\frac{\Delta a}{a} + 3\frac{\Delta b}{b} + 1\frac{\Delta c}{c} + \frac{1}{2}\frac{\Delta d}{d}\right] \times 100$$

$$= 2(2\%) + 3(1\%) + 1(3\%) + \frac{1}{2}(4\%)$$

$$= 12\%$$

Example

While measuring acceleration due to gravity by a simple pendulum, a student makes a positive error of **2%** in the length of the pendulum and a positive error of **1%** in the value of time period. His actual percentage error in the measurement of the value of **g** will be

A. 8% B. 10% C. 12% D. 4%

$$T = 2\pi\sqrt{\frac{l}{g}}$$

$$T^2 = 4\pi^2\frac{l}{g}$$

$$g \propto \frac{l}{T^2}$$

Example

The heat generated in a circuit is given by $Q = I^2Rt$, where **I** is current, **R** is resistance, and **t** is time. If the percentage errors in measuring **I**, **R**, and **t** are **2%**, **1%**, and **1%**, respectively, then the maximum error in measuring heat will be

A. 8% B. 10% C. 12% D. 6%

Example

A physical quantity X is given by

$$x = \frac{2^{k^3} l^2}{m\sqrt{n}}$$

The percentage error in the measurements of k, l, m, and n are **1**%, **2**%, **3**%, and **4**% respectively. The value of **X** is uncertain by

A. 8% B. 10% C. 12% D. None of these

Example

The percentage error in measuring **M**, L and T are **1**%, **1.5**% and **3**% respectively. Then the percentage error in measuring the physical quantity with dimensions **[M L^{-1} T^{-1}]**

A. 1% B. 3.5% C. 3% D. 5.5%



Example

MCQ type Question [+4 , -1]

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In an experiment, the percentage of error occurred in the measurement of physical quantities A, B, C and D are 1%, 2%, 3% and 4% respectively. Then the maximum percentage of error in the measurement X, where $X = \dfrac{A^2 B^{1/2}}{C^{1/3} D^3}$, will be

(a) 10%
(b) (3/13)%
(c) 16%
(d) −10%

(NEET 2019)

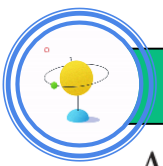
Example

MCQ type Question [+4 , -1]

In an experiment, four quantities a, b, c and d are measured with percentage error 1%, 2%, 3% and 4% respectively. Quantity P is calculated as follows $P = \frac{a^3 b^2}{cd}$. % error in P is

(a) 7% (b) 4% (c) 14% (d) 10%

(NEET 2013)



Example

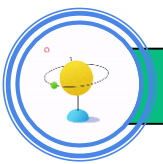
MCQ type Question [+4 , -1]

A student measures the distance traversed in free fall of a body, initially at rest, in a given time. He uses this data to estimate g, the acceleration due to gravity. If the maximum percentage errors in measurement of the distance and the time are e_1 and e_2 respectively, the percentage error in the estimation of g is

(a) $e_2 - e_1$ (b) $e_1 + 2e_2$

(c) $e_1 + e_2$ (d) $e_1 - 2e_2$

(Mains 2010)



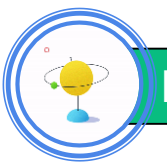
Example

MCQ type Question [+4 , -1]

If the error in the measurement of radius of a sphere is 2%, then the error in the determination of volume of the sphere will be

(a) 8% (b) 2% (c) 4% (d) 6%

(2008)

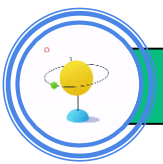


Example

MCQ type Question [+4 , -1]

The density of a cube is measured by measuring its mass and length of its sides. If the maximum error in the measurement of mass and lengths are 3% and 2% respectively, the maximum error in the measurement of density would be

(a) 12%
(b) 14%
(c) 7%
(d) 9%. *(1996)*



Example

MCQ type Question [+4 , -1]

neet

Percentage errors in the measurement of mass and speed are 2% and 3% respectively. The error in the estimate of kinetic energy obtained by measuring mass and speed will be

(a) 8%
(b) 2%
(c) 12%
(d) 10%. *(1995)*

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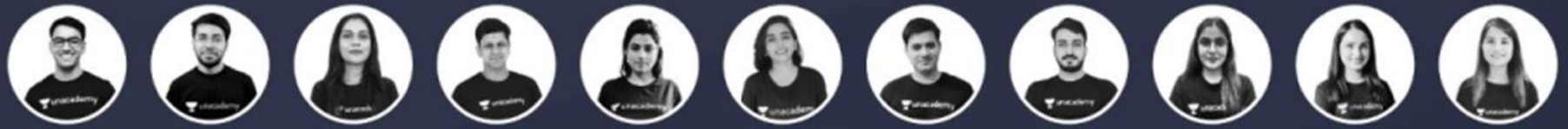
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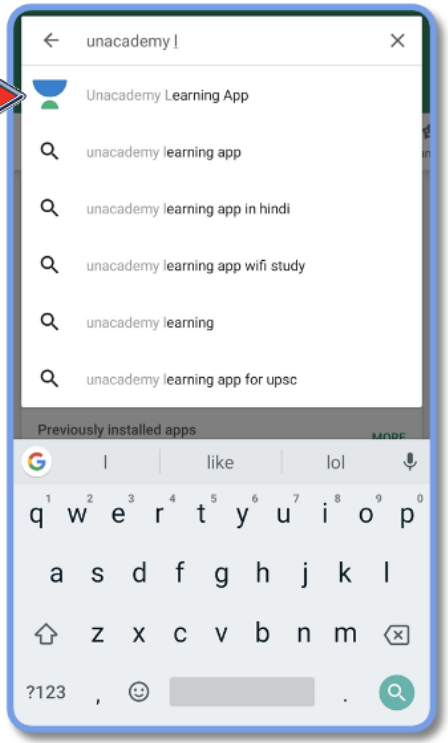
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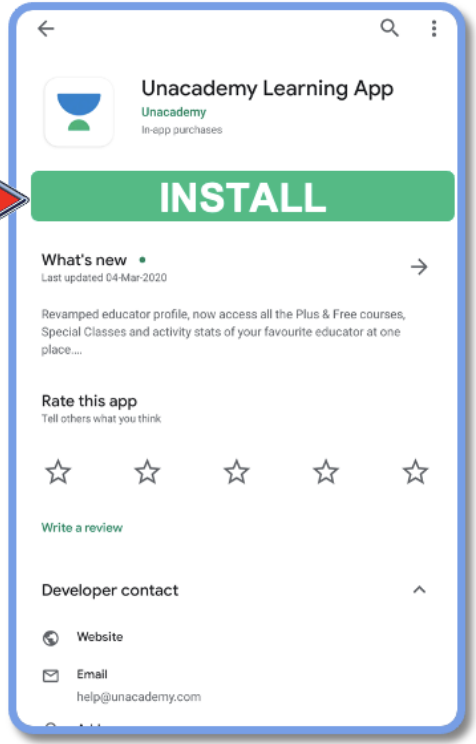
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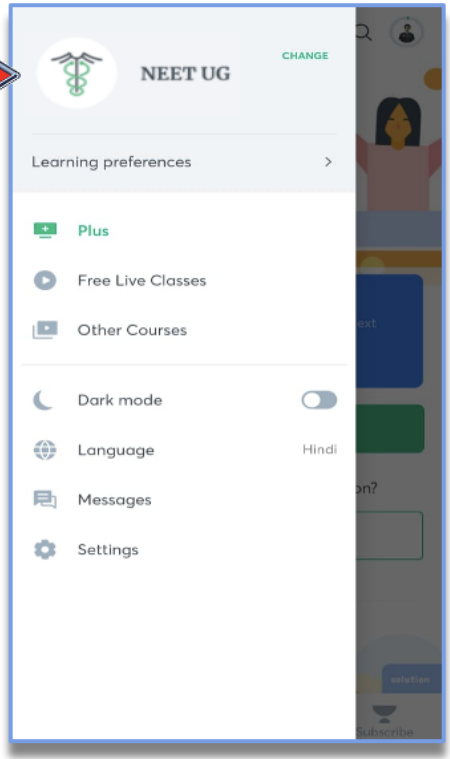
Step 1



Step 2



Step 3



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