Questions related to Units & dimensional formulae

INDUCTIVE ACADEMICS

1. Which of the following is not equal to a watt?

a. Joule / second

b. Ampere x volt

c. $(\text{Ampere})^2$ x ohm

d. Ampere / volt ✓

$\text{Power} = \frac{\text{Work}}{\text{Time}} \rightarrow \frac{\text{Joule}}{\text{sec}}$

$\text{Power} = VI \rightarrow \text{Volt} \times \text{Ampere}$

$\text{Power} = I^2R \rightarrow (\text{Ampere})^2 \times \text{ohm}$

2. Horse power is unit of

a. Distance

b. Time

c. Power

d. Current

INDUCTIVE ACADEMICS

3. The dimensional formula for Planck's constant is

a. $[ML^2T^{-1}]$ ✓

b. $[M^2L^2T^{-1}]$

c. $[MLT]$

d. $[ML^1T^{-1}]$

$E = h\nu$

E → Energy; h → Planck's constant; ν → frequency

$$[h] = \frac{[E]}{[\nu]} = \frac{[ML^2T^{-2}]}{[T^{-1}]}$$

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

INDUCTIVE ACADEMICS

4. Newton second is the unit of

a. Velocity LT^{-1}

b. Angular Momentum ML^2T^{-1}

~~c.~~ Momentum MLT^{-1}

d. Energy ML^2T^{-2}

Force × Time

↓

$[MLT^{-2}] \times [T]$

$[MLT^{-1}]$

INDUCTIVE ACADEMICS

5. Joule second is the unit of

a. Work → $[ML^2T^{-2}]$

b. Angular Momentum → $[ML^2T^{-1}]$

c. Momentum → $[MLT^{-1}]$

d. Pressure → $[ML^{-1}T^{-2}]$

$[Energy] \times [Time]$

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

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

INDUCTIVE ACADEMICS

6. A suitable unit for gravitational constant is

a. Kg m sec $^{-1}$

b. N m^{-1} sec

c. N m^2 Kg^{-2}

d. Kg m sec^{-1}

$$F = G \times \frac{m_1 m_2}{r^2}$$

$$G = \frac{F r^2}{m_1 \times m_2}$$

$$\frac{N m^2}{Kg^2}$$

$$N m^2 Kg^{-2}$$

7. Young's modulus of a material has the same units as

a. presssure

b. strain

c. compressibility

d. Force

INDUCTIVE ACADEMICS

$$Y = \frac{\text{Stress}}{\text{strain}} = \frac{\left(\frac{F}{A}\right)}{\left(\frac{\Delta l}{l}\right)} = \text{Pressure}$$

strain has no units!

8. Kilowatt hour is a unit of
a. Energy
b. Power
c. Electric charge
d. Force

KW x hour

Power x Time = Energy

INDUCTIVE
ACADEMICS

9. Which of the following is not represented in correct unit

a) Stress / Strain	N/m^2
b) Surface tension	N/m
c) Energy	Kg m / sec
d) Pressure	N/ m^2

10. Dyne/ cm^2 is not a unit of

a. Stress

b. Strain

c. Pressure

d. Young's modulus

INDUCTIVE ACADEMICS

11. The ratio of the dimensions of planck's constant and that of moment of inertia , is equal to the dimensions of

a. Time

b. Frequency

c. Angular momentum

d. velocity

INDUCTIVE ACADEMICS

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

12. Which of the following does not have dimensions of force
a. Potential gradient
b. Weight
c. Energy gradient
d. Rate of change of linear momentum

INDUCTIVE
ACADEMICS

13. A dimensionless quantity
a. Never has a unit
b. Always has a unit
c. may have a unit ✓
d. Is not possible

$$\text{Strain} = \frac{\Delta l}{l}$$

It is Dimensionless and unitless

$$\text{Angular displacement} = \frac{\text{arc}}{\text{length}}$$

It is dimensionless but it has units (e.g Radians)

14. A unitless quantity

a. Never has any non zero dimensions

b. Always have non zero dimensions

c. May have non zero dimensions

d. Does not exist

Units → also Dimensions

Unitless → also Dimensionless

Strain, π, e → unitless

Dimensions → also units

Dimensionless → may or may not have units

	mass	Length	Time
S.I	Kg	m	S
CGS	g	cm	S
MKS	Kg	m	S
FPS	Pound	Feet	S

INDUCTIVE ACADEMICS

Applications of dimensional analysis

- *Conversion from one system of units to other*
- *Dimensional Consistency of an equation*
- *To derive the relation between physical quantities*

Conversion from one system of units to other

15. The density of wood is 0.5 g/cc in the CGS system of units. The corresponding value in MKS system will be

a. 500
b. 5
c. 0.5
d. 5000

Density = Mass / Volume

$[M^1 L^{-3} T^0]$

a = 1
b = -3
c = 0

CGS

$M_1 = 1\,g$

$L_1 = 1\,cm$

$T_1 = 1\,sec$

$n_1 = 0.5\ g/cm^3$

MKS

$M_2 = 1\,Kg = 10^3\,g$

$L_2 = 1\,m = 10^2\,cm$

$T_2 = 1\,sec$

$n_2 = ?$

INDUCTIVE ACADEMICS

INDUCTIVE ACADEMICS

$$\frac{n_2}{n_1} = \left(\frac{M_1}{M_2}\right)^a \times \left(\frac{L_1}{L_2}\right)^b \times \left(\frac{T_1}{T_2}\right)^c$$

$$\frac{n_2}{0.5} = \left(\frac{1g}{10^3 g}\right)^1 \times \left(\frac{1cm}{10^2 cm}\right)^{-3} \times \left(\frac{1 sec}{1 sec}\right)^0$$

$$n_2 = 0.5 \times 10^{-3} \times \left(10^{-2}\right)^{-3} \times 1$$

$$n_2 = 0.5 \times 10^{-3} \times 10^{6}$$

$$n_2 = 0.5 \times 10^{3}\ Kg/m^3$$

$$n_2 = 5 \times 10^{2}\ Kg/m^3 = 500\ Kg/m^3$$

16. The surface tension of a liquid is 70 dyne/cm. In MKS system its value is?

a. 7×10^2 N/m
b. 7×10^3 N/m
c. 70 N/m
d. 7×10^{-2} N/m

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

a = 1
b = 0
c = -2

CGS	MKS
$M_1 = 1g$	$M_2 = 10^3 g$
$L_1 = 1cm$	$L_2 = 10^2 cm$
$T_1 = 1sec$	$T_2 = 1sec$
$n_1 = 70$ dyne/cm	$n_2 = ?$

INDUCTIVE ACADEMICS

$$n_2 = n_1 \left(\frac{M_1}{M_2}\right)^a \times \left(\frac{L_1}{L_2}\right)^b \times \left(\frac{T_1}{T_2}\right)^c$$

$$n_2 = 70 \times \left(\frac{1g}{10^3 g}\right)^1 \times \left(\frac{1cm}{10^2 cm}\right)^0 \times \left(\frac{1 sec}{1 sec}\right)^{-2}$$

$$n_2 = 70 \times 10^{-3} \times 1 \times 1$$

$$n_2 = 70 \times 10^{-3} \ N/m$$

$$n_2 = 7 \times 10^{-2} \ N/m$$

INDUCTIVE ACADEMICS

17. Find the value of 50 J per min in a system, that has 100g, 100cm and 1 min as the base units

S.I

$M_1 = 1\text{kg} = 10^3\text{ g}$

$L_1 = 1\text{ m} = 10^2\text{ cm}$

$T_1 = 1\text{ sec}$

$n_1 = \frac{5}{6}\text{ watt}$

New System

$M_2 = 100\text{g}$

$L_2 = 100\text{cm}$

$T_2 = 1\text{ min} = 60\text{ sec}$

$n_2 = ?$

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

$a = 1$

$b = 2$

$T = -3$

$$n_2 = n_1 \left(\frac{M_1}{M_2}\right)^a \times \left(\frac{L_1}{L_2}\right)^b \times \left(\frac{T_1}{T_2}\right)^c$$

$$n_2 = \frac{5}{6} \times \left(\frac{10^3}{10^2}\right)^1 \times \left(\frac{10^2}{10^2}\right)^2 \times \left(\frac{1\,sec}{60\,sec}\right)^{-3}$$

$$n_2 = \frac{5}{6} \times 10 \times 1 \times \overset{10}{60} \times 60 \times 60$$

$$n_2 = 180 \times 10^4$$

$$n_2 = 1.8 \times 10^6 \text{ units}$$

INDUCTIVE ACADEMICS

Applications of dimensional analysis

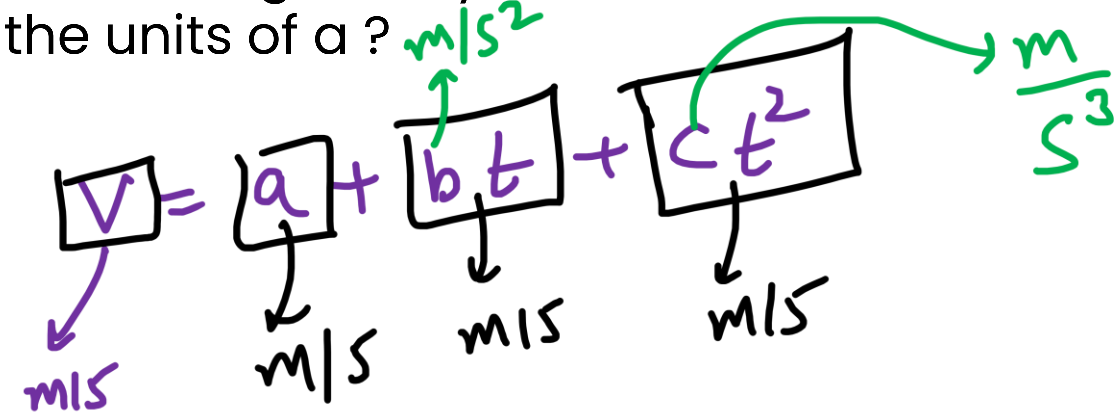
- *Conversion from one system of units to other*
- *Dimensional Consistency of an equation*
- ***To derive the relation between physical quantities***

Dimensional Consistency of an equation

INDUCTIVE ACADEMICS

18. The velocity of a particle is given by v= a + bt + ct^2, If the units of velocity are m/sec , what will be the units of a ?

a. m/sec
b. m/sec^2
c. m/sec^3
d. m^2/sec



SI units of b = m^3

SI units of a = $kg \times m^5 \times s^{-2}$

19. The vander wall's equation for a gas is

$$\left[P + \frac{a}{V^2}\right] \times [V - b] = RT$$

Determine the dimensions of a and b. Also write the SI units of a and b

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

$$[a] = [PV^2]$$

$$[a] = [ML^5T^{-2}]$$

$$[b] = [V]$$

$$[b] = [L^3]$$

Dimensional Consistency of an equation

[T]

20. The equation $t = \sqrt{\frac{2s}{g}}$ Describes the time a freely falling body takes, to reach the ground Under the action of gravity. Check for the dimensional consistency of the equation.

$$\sqrt{\frac{2S}{g}} = \sqrt{\frac{L}{LT^{-2}}} = \sqrt{T^2} = T^{2\times\frac{1}{2}} = [T]$$

Yes, This eqn. is Dimensionally consistent

Applications of dimensional analysis

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INDUCTIVE ACADEMICS

To derive the relation between physical quantities

21) The escape velocity v of a body depends upon
i) Acceleration due to gravity of the planet (g)
ii) Radius of planet (R)

Establish dimensionally the relationship b/w v, g and R.

$$V = K g^{\frac{1}{2}} R^{\frac{1}{2}}$$

$$V = K\sqrt{gR}$$

escape velocity

INDUCTIVE ACADEMICS

To derive the relation between physical quantities

INDUCTIVE ACADEMICS

22) A small steel ball of radius r is allowed to fall under gravity through a column of a viscous liquid of coefficient of viscosity η.
After some time the velocity of the body attains a constant value , which is known as terminal velocity.

The terminal velocity depends upon
(i) the weight of the ball mg
(ii) the coefficient of viscosity and
(iii) the radius of the ball r.

By the method of dimensions, determine the relation expressing terminal velocity.

$$v \propto (mg)^a \eta^b r^c$$

$$v = k\,(mg)^a \eta^b r^c$$

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

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

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

$$0 = a + b \quad \text{—(i)}$$

$$1 = a - b + c \quad \text{—(ii)}$$

$$1 = 2a + b \quad \text{—(iii)}$$

$$a = 1$$

$$b = -1$$

$$c = -1$$

$$V = K (mg)^a \eta^b r^c$$

$$V = K \frac{mg}{\eta r}$$