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Class: 9
Subject: Physics
Topic: Basic Mathematics Application
No. of Questions: 20

1. What is the difference between A^o and A.U.?

   Solution:

   A^0 and A. U. both are the units of distances but 1A^0 = 10^{-10} and 1A.U. = 1.496×10^{11}m.

2. Define S.I. unit of solid angle?

   Solution:

   One Steradian is defined as the angle made by a spherical plane of area 1 square meter at the center of a sphere of radius 1 m.

3. Name physical quantities whose units are electron volt and Pascal?
   Solution:
   Energy and Pressure.

4. When a planet X is at a distance of 824.7 million kilometers from earth its angular diameter is measured to be 35.7211^0 of arc. Calculate the diameter of 'X'.
   Solution:
   R = 824.7×10^6

   θ = 35.72 of arc in 3600 sec(1 hr)

   $\theta = 35.72 \times \frac{\pi}{180}$ radian

   Diameter l = ?

   $l = r\theta$

   $l = 824.7\times10^6\times35.72\times\frac{\pi}{180}$

   $l = 513.6\times10^6$ km

5. A radar signal is beamed towards a planet from the earth and its echo is received seven minutes later. Calculate the velocity of the signal, if the distance between the planet and the earth is $6.3\text{x}10^{10}$m?

Solution:

x = c.t/2

$$\Rightarrow c = \frac{2x}{t} = \frac{2\times 6.3\times 10^{10}}{7\times 60} = 3\times 10^{8} m/s$$

6. Give two methods for measuring time intervals?

Solution:

(A) Radioactive dating – to know age of fossil fuels rocks etc.

(B) Atomic clocks – used to note periodic vibrations taking place within two atoms.

7. Find the dimensions of latent heat and specific heat?

Solution:

(A) Latent Heat = $\frac{Q(Heat\ Energy)}{m(mass)}$

Latent Heat = $\frac{ML^2T^{-2}}{M} = [M^0L^2T^{-2}]$

(B) Specific heat = (s) = $\frac{Q}{m\times T} = \frac{ML^2T^{-2}}{M\times K}$

(s) = $[M^0L^2T^{-2}K^{-1}]$

8. In Vander Waal's equation $\left(P + \frac{a}{V^2}\right)$ $(V - b)$ = RT

Solution: P= $a/V^2 \Rightarrow a = PV^2$

A = $\frac{F}{A} \times V^2$

A = $\frac{MLT^{-2}}{L^2} \times [L^3]^2$

A = $\frac{MLT^{-2}L^6}{L^2}$

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

Also b = V

V = $[M^0L^3T^0]$

9. E, M , I and G denote energy, mass, angular momentum and gravitational constant respectively. Determine the dimensions of EL^2/m^5G^2

(A) E = $[ML^2T^{-2}]$

(B) L = $[ML^2T^{-1}]$

(C) m = [M]

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

Solution:

$\therefore$ Dimensions of $EL^2/m^5G^2 = \frac{[ML^2T^{-2}]\,[ML^2T^{-1}]^2}{[M]^5[M^{-1}L^3T^{-2}]^2}$

$$= \frac{M^3L^6T^{-4}}{M^3L^6T^{-4}} = 1$$

Thus, it is dimension less

10. (A) State which of the following are dimensionally current

(i) Pressure = Energy per unit volume

(ii) Pressure = Momentum × volume × time

(B)The density of cylindrical rod was measured by the formula: - P = $\frac{4\,m}{\pi D^2 L}$ The percentage in m, D and L are 1% , 1.5 % and 0.5% . Calculate the % error in the calculated value of density?

Solution:

(A) (i) Pressure = F/A = $\frac{MLT^{-2}}{L^2} = [ML^{-1}T^{-2}]$

$$[ML^{-1}T^{-2}] = \frac{ML^2T^{-2}}{L^3}$$

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

Hence it is dimensionally correct

(B) $\rho = \frac{4m}{\pi D^2 L}$

$$\frac{\Delta\rho}{\rho} = \frac{\Delta m}{m} + 2\frac{\Delta D}{D} + \frac{\Delta L}{L}$$

$$\frac{\Delta\rho}{\rho}\,\% = 1\% + 2\% \times (1.5)\% + 0.5\%$$

$\%\frac{\Delta L}{L} = 4.5\ \% \ \Rightarrow \frac{\Delta\rho}{\rho}\% = 4.5\ \%$

11. If x = at + bt^2 where x is in meters and t is in seconds. What are the units of a and b?

Solution:

a = $\frac{x}{t} = m/s$

b = $\frac{x}{t} = m/s^2$

12. Fill ups.

(A) 3.0 m/s^2 = …………………… Km / hr^2

(B) 6.67x10^{-11} Nm^2/ Kg^2 = …………………………… g^{-1} cm^{3}s^{-2}

Solution:

(A) 3.0m / s^2 = $\frac{3\times10^{-3}}{\left(\frac{1}{3600}\right)^2}\frac{km}{hr^2} = 1080\ km/hr^2$

(B) 6.67x10^{-11}Nm^2/ kg^2 = g^{-1}cm^{3}s^{-2} = 6.67 ×10^{-11}kg^{-1}m^{3}s^{-2}

= 6.67 ×10^{-11}×10^{-3}×(10^2 cm)^3

= 6.67 ×10^{-8}g^{-1}cm^{3}s^{-2}

13. Write S.I unit of luminous intensity and temperature?

Solution:

S.I unit of luminous intensity is candela (cd) and of temperature is Kelvin (k).

Calculate the time taken by the light to pass through a nucleus of diameter 1.56 ×10^{-16} m. (speed of light is 3 ×10^{8}m/s)

14. Time $= \frac{distance}{velocity}$

Solution:

Time = $\frac{1.56\times10^{-16}}{3\times10^8}$

T = 5.2 × 10^{-25} sec

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15. If force (F) acceleration (A) and time (T) are taken as fundamental units, then find the dimension of energy.
Solution:
F = MLT^{-2} ; $A = LT^{-2} - - - - - (1)$
F = MA ⇒ M = FA^{-1}→ (2)
From equation 1) L = AT^2
∴ Dimensions of energy = ML^2T^{-2}

$[FA^{-1}A^2T^4T^{-2}] = [FAT^2]$

16. Two resistances R_1 = 100± 3Ω and R_2 = 200± 4Ω are connected in series. Then what is the equivalent resistance?

Solution:
Here R_1= 100± 3 Ω
R_2 = 200± 4Ω
In series $R_{net} = R_1+R_2$
R_{net} = (100± 3 Ω)
R_{net} = (200± 4Ω)
R_{net} = (300± 7) ohms.

17. If velocity, time and force were chosen the basic quantities, find the dimensions of mass?
Solution:
Force= mass × acceleration
Force = mass ×$\frac{velocity}{time}$

$\frac{time \times force}{velocity} = mass$

Mass = $\frac{FT}{V}$

Mass = $[FTV^{-1}]$

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18. Young's modulus of steel is 19 ×100^{10} N/ m^2. Express it in dynes cm^2. Here dynes are the C.G.S. unit of force.

Solution:

Y = $\frac{[F]}{[L^2]} = \frac{MLT^{-2}}{[L^2]} = [ML^{-1}T^{-2}]$

Comparing with $M^aL^bT^c$

a= 1, b = -1, c= -2

$$n_2 = n_1 \left[\frac{M^1}{M_2}\right]^a \left[\frac{L^1}{L^2}\right]^b \left[\frac{T^1}{T_2}\right]^c$$

$$n_2 = 19 \times 10^{10} \left[\frac{1kg}{1g}\right]^1 \left[\frac{1m}{1cm}\right]^{-1} \left[\frac{1\,S}{1S}\right]^{-2}$$

$$n_2 = 19 \times 10^{10} \left[\frac{1000\ g}{1\ g}\right] \left[\frac{100\ cm}{1\ cm}\right]^{-1} [1]^{-2}$$

$$n_2 = 19 \times 10^{10} \left[1000 \times \frac{1}{100} \times 1\right]$$

$$n_2 = 19 \times 10^{11}$$

19. The velocity v of water waves may depend on their wavelength λ density of water ρ and the acceleration due to gravity g. Find relation between these quantities by the method of dimension?

Solution:

$$\upsilon \alpha \lambda^a p^b g^c$$

$$\upsilon = R\lambda^a p^b g^c \text{ ---------- } (1)$$

Where K is dimensionless constant

$$\left[LT^{-1}\right] = [L]^a \left[ML^{-3}\right]^b \left[LT^{-2}\right]^c$$

$$\left[M^o LT^{-1}\right] = [L]^{a-3b+c} [M]^b [T]^{-2c}$$

$$a - 3b + c = 1$$

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$b = 0 \quad \Rightarrow a = \frac{1}{2}$

$-2c = -1$

$c = \frac{1}{2}$ Put these values in equation (1)

$\upsilon = k\lambda^{1/2} P^{o} g^{1/2}$

$\upsilon = k\lambda^{1/2} g^{1/2}$

$$\boxed{\upsilon = k\sqrt{\lambda g}}$$

20. The force acting on an object of mass m traveling at velocity υ in a circle of radius r is giving by F $= \frac{mv^2}{r}$ The measurements recorded as m= 3.5 kg $\pm$ 0.5m

Find the maximum possible (1) fractional error (2) % error in the measurement of force. How will you recorded reading?

Solution:

(i) $F = \frac{m\upsilon^2}{r}$

$$\frac{\Delta F}{F} = \frac{\Delta m}{m} + 2\frac{\Delta v}{\vartheta} + \frac{\Delta r}{r}$$

$$\frac{\Delta F}{F} = \frac{0.1}{3.5} + 2\times\frac{1}{20} + \frac{0.5}{12.5}$$

$$\frac{\Delta F}{F} = 0.17$$

(ii) % error in F = $0.17 \times 100 = 17\%$

(iii) $F = \frac{m\upsilon^2}{r}$, $= \frac{(3.5)\times(20)^2}{12.5}$

$$\boxed{F = 112N}$$

$$\boxed{\Delta F = 19N}$$

$\Delta F = 0.17 \times 112$

Measurement of force = F = (112$\pm$ 19) N