JEE Main 2021 | Units and Dimensions

Question 1

(Only one correct answer) 2021

Which of the following equations is dimensionally incorrect?

Where t = time, h = height, s = surface tension, θ = angle, ρ = density, a, r = radius, g = acceleration due to gravity, v = volume, p = pressure, W = work done, τ = torque, ε = permittivity, E = electric field, J = current density, L = length.

- (a) $J = \varepsilon \frac{\delta E}{\delta t}$
- (b) $v = \frac{\pi p a^4}{8 \eta L}$
- (c) $h = \frac{2s \cos \theta}{\rho r g}$
- (d) $W = \tau \theta$

Question 2

(Only one correct answer) 2021

If velocity $[V]$ time $[T]$ and force $[F]$ are chosen as the base quantities, the dimensions of the mass will be :

- (a) $[FVT^{-1}]$
- (b) $[FT^{-1}V^{-1}]$
- (c) $[FT^2V]$
- (d) $[FTV^{-1}]$

Question 3

(Integer type question) 2021

The diameter of a spherical bob is measured using a Vernier calipers 9 divisions of the main scale, in the Vernier calipers, are equal to 10 divisions of Vernier scale. One main scale division is $1\ mm$. The main scale reading is $10\ mm$ and 8^{th} division of Vernier scale was found to coincide exactly with one of the main scale division. If the given Vernier calipers has positive zero error of $0.04\ cm$, then the radius of the bob is ..... $\times 10^{-2}\ cm$.

Question 4

(Only one correct answer)

2021

Match List-I with List-II.

List - I List - II

(a) R_H (Rydberg constant) (I) $kg\, m^{-1}\, s^{-1}$

(b) h (Planck's constant) (ii) $kg\, m^{-2}\, s^{-1}$

(c) μ_B (Magnetic filed energy density (iii) m^{-1}

(d) η (coefficient of viscosity) (iv) $kg\, m^{-1}\, s^{-2}$

Choose the most appropriate answer from the options given below:

- (a) (a) - (iv), (b) - (ii), (c) - (i), (d) - (iii)
- (b) (a) - (ii), (b) - (iii), (c) - (iv), (d) - (i)
- (c) (a) - (iii), (b) - (ii), (c) - (iv), (d) - (i)
- (d) (a) - (iii), (b) - (ii), (c) - (i), (d) - (iv)

Question 5

(Only one correct answer)

2021

A physical quantity $'y'$ is represented by the formula $y = m^2 r^{-4} g^x l^{-3/2}$. If the percentage errors found in $y,\ m,\ r,\ l$ and g are $18,\ 1,\ 0.5,\ 4$ and p respectively, then find the value of x and p.

- (a) 4 and ± 3
- (b) 8 and ± 2
- (c) $\frac{16}{3}$ and $\pm\frac{3}{2}$
- (d) 5 and ± 2

Question 6

(Only one correct answer)

2021

If $E,\ L,\ M$ and G denote the quantities as energy, angular momentum, mass and constant of gravitation respectively, then the dimension of P in the formula $P = EL^2 M^{-5} G^{-2}$ are:

- (a) $[M^1 L^1 T^{-2}]$
- (b) $[M^{-1} L^{-1} T^2]$
- (c) $[M^0 L^1 T^0]$
- (d) $[M^0 L^0 T^0]$

Question 7

(Only one correct answer)

2021

One main scale division of a Vernier callipers is $'a'\ cm$ and n^{th} division of the Vernier scale coincide with $(n-1)^{th}$ division of the main scale. The least count of the callipers in mm is :

- (a) $\frac{10na}{(n-1)}$
- (b) $\frac{(n-1)}{10n}a$
- (c) $\frac{10a}{(n-1)}$
- (d) $\frac{10a}{n}$

Question 8

(Integer type question) 2021

The acceleration due to gravity is found up to an accuracy of 4% on a planet. The energy supplied to a simple pendulum of known mass m to undertake oscillations of time period T is being estimated. If time period is measured to an accuracy of 3%, the accuracy to which E is known as ..... %.

Question 9

(Only one correct answer) 2021

Match List-I with List-II.

List-I List-II

(a) Torque (i) MLT^{-1}

(b) Impulse (ii) MT^{-2}

(c) Tension (iii) ML^2T^{-2}

(d) Surface (iv) MLT^{-2}

Choose the most **appropriate** answer from the option given below:

- (a) (a)-(iii), (b)-(iv), (c)-(i), (d)-(ii)
- (b) (a)-(ii), (b)-(i), (c)-(iv), (d)-(iii)
- (c) (a)-(i), (b)-(iii), (c)-(iv), (d)-(ii)
- (d) (a)-(iii), (b)-(i), (c)-(iv), (d)-(ii)

Question 10

(Only one correct answer) 2021

In the experiment of Ohm's law, a potential difference of $5.0\ V$ is applied across the end of a conductor of length $10.0\ cm$ and diameter of $5.00\ mm$. The measured current in the conductor is $2.00\ A$. The maximum permissible percentage error in the resistivity of the conductor is :

- (a) 3.9
- (b) 8.4
- (c) 7.5

(d) 3.0

Question 11

(Integer type question) 2021

The radius of a sphere is measured to be $(7.50 \pm 0.85)\ cm$. Suppose the percentage error in its volume is x. The value of x, to the nearest integer, is .....

Question 12

(Only one correct answer) 2021

The force is given in terms of time t and displacement x by the equation

$F = A\cos Bx + C\sin Dt$.

The dimensional formula of $\frac{AD}{B}$ is:

(a) $[ML^2T^{-3}]$

(b) $[M^2L^2T^{-3}]$

(c) $[M^0LT^{-1}]$

(d) $[M^1L^1T^{-2}]$

Question 13

(Only one correct answer) 2021

In a Screw Gauge, fifth division of the circular scale coincides with the reference line when the ratchet is closed. There are 50 divisions on the circular scale, and the main scale moves by $0.5\ mm$ on a complete rotation. For a particular observation the reading on the main scale is $5\ mm$ and the 20^{th} division of the circular scale coincides with reference line. Calculate the true reading.

(a) $5.00\ mm$

(b) $5.20\ mm$

(c) $5.25\ mm$

(d) $5.15\ mm$

Question 14

(Only one correct answer) 2021

If E and H represents the intensity of electric field and magnetizing field respectively, then the unit of E/H will be :

(a) newton

(b) mho

(c) ohm

(d) joule

Question 15

(Only one correct answer) 2021

If force (F), length (L) and time (T) are taken as the fundamental quantities. Then what will be the dimension of density:

(a) $[FL^{-4}T^{2}]$

(b) $[FL^{-5}T^{3}]$

(c) $[FL^{-3}T^{2}]$

(d) $[FL^{-5}T^{2}]$

Question 16

(Only one correct answer) 2021

The time period of a simple pendulum is given by $T = 2\pi\sqrt{\frac{l}{g}}$. The measured value of the length of pendulum is $10\ cm$ known to a $1\ mm$ accuracy. The time for 200 oscillations of the pendulum is found to be 100 second using a clock of $1\ s$ resolution. The percentage accuracy in the determination of $'g'$ using this pendulum is $'x'$. The value of $'x'$ to the nearest integer.

(a) 4 %

(b) 5 %

(c) 2 %

(d) 3 %

Question 17

(Only one correct answer) 2021

If time (t), velocity (v), and angular momentum (l) are taken as the fundamental units. Then the dimension of mass (m) in terms of $t,\ v$ and l is :

(a) $[t^{-1}v^{-2}l^{1}]$

(b) $[t^{-2}v^{-1}l^{1}]$

(c) $[t^{-1}v^{2}l^{-1}]$

(d) $[t^{-1}v^{1}l^{-2}]$

Question 18

(Only one correct answer) 2021

Assertion A : If in five complete rotations of the circular scale, the distance travelled on main scale of the screw gauge is $5\ mm$ and there are 50 total divisions on circular scale, then least count is

$0.001\ cm.$

Reason R : Least Count $= \dfrac{\text{Pitch}}{\text{Total division on circular scale}}$

In the light of the above statements, choose the most appropriate answer from the options given below :

- (a) Both A and R are correct and R is the correct explanation of A.
- (b) A is not correct but R is correct
- (c) A is correct but R is not correct
- (d) Both A and R are correct and R is not the correct explanation of A.

Question 19

(Only one correct answer) 2021

In a typical combustion engine the work done by a gas molecule is given by $W = \alpha^2 \beta e^{\dfrac{-\beta x^2}{kT}}$, where x is the displacement, k is the Boltzmann constant and T is the temperature. If α and β are constants, dimensions of α will be :

- (a) $[MLT^{-2}]$
- (b) $[M^2LT^{-2}]$
- (c) $[M^0LT^0]$
- (d) $[MLT^{-1}]$

Question 20

(Only one correct answer) 2021

Which of the following is not a dimensionless quantity ?

- (a) Permeability of free space (μ_0)
- (b) Relative magnetic permeability (μ_r)
- (c) Power factor
- (d) Quality factor

Question 21

(Only one correct answer) 2021

In order to determine the Young's Modulus of a wire of radius $0.2\ cm$ (measured using a scale of least count $= 0.001\ cm$) and length $1\ m$ (measured using a scale of least count $= 1\ mm$), a weight of mass $1\ kg$ (measured using a scale of lest count $= 1\ g$) was hanged to get the elongation of $0.5\ cm$ (measured using a scale of least count $0.001\ cm$). What will be the fractional error in the value of Young's Modulus determined by this experiment ?

(a) 0.14 %

(b) 0.9 %

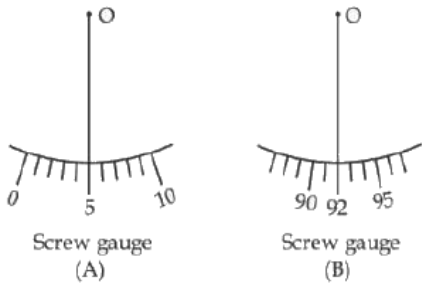
(c) 1.4 %

(d) 9 %

Question 22

(Integer type question) 2021

Student A and student B used two screw gauges of equal pitch and 100 equal circular divisions to measure the radius of a given wire. The actual value of the radius of the wire is $0.322\ cm$. The absolute value of the difference between the final circular scale readings observed by the students A and B is ..... [Figures shows position of reference $'O'$ when jaws of screw gauge are closed] Given pitch $= 0.1\ cm$.



Question 23

(Only one correct answer) 2021

Match List-I with List-II :

List-I List-II

(a) h (Planck's constant) (i) $[MLT^{-1}]$

(b) E (kinetic energy) (ii) $[ML^2T^{-1}]$

(c) V (electric potential) (iii) $[ML^2T^{-2}]$

(d) P (Linear momentum) (iv) $[ML^2I^{-1}T^{-3}]$

Choose the correct answer from the options given below:

(a) (a) $\rightarrow$ (ii), (b) $\rightarrow$ (iii), (c) $\rightarrow$ (iv), (d) $\rightarrow$ (i)

(b) (a) $\rightarrow$ (iii), (b) $\rightarrow$ (ii), (c) $\rightarrow$ (iv), (d) $\rightarrow$ (i)

(c) (a) $\rightarrow$ (iii), (b) $\rightarrow$ (iv), (c) $\rightarrow$ (ii), (d) $\rightarrow$ (i)

(d) (a) $\rightarrow$ (i), (b) $\rightarrow$ (ii), (c) $\rightarrow$ (iv), (d) $\rightarrow$ (iii)

Question 24

(Only one correct answer) 2021

Match List - I with List - II :

List - I List - II

(a) Magnetic Induction (i) $ML^2T^{-2}A^{-1}$

(b) Magnetic Flux (ii) $M^0L^{-1}A$

(c) Magnetic Permeability (iii) $MT^{-2}A^{-1}$

(d) Magnetization (iv) $MLT^{-2}A^{-2}$

Choose the most appropriate answer form the options given below :

- (a) (a) - (iii), (b) - (ii), (c) - (iv), (d) - (i)
- (b) (a) - (iii), (b) - (i), (c) - (iv), (d) - (ii)
- (c) (a) - (ii), (b) - (iv), (c) - (i), (d) - (iii)
- (d) (a) - (ii), (b) - (i), (c) - (iv), (d) - (iii)

Question 25

(Integer type question) 2021

The resistance $R = \frac{V}{I}$, where $V = (50 \pm 2)\ V$ and $I = (20 \pm 0.2)\ A$. The percentage error in R is $'x'$ %. The value of $'x'$ to the nearest integer is .....

Question 26

(Only one correct answer) 2021

The work done by a gas molecule in an isolated system is given by, $W = \alpha\beta^2 e^{-\frac{x^2}{\alpha kT}}$, where x is the displacement, k is the Boltzmann constant and T is the temperature. α and β are constants. Then the dimensions of β will be :

- (a) $[MLT^{-2}]$
- (b) $[M^0LT^0]$
- (c) $[ML^2T^{-2}]$
- (d) $[M^2LT^2]$

Question 27

(Only one correct answer) 2021

The period of oscillation of a simple pendulum is $T = 2\pi\sqrt{\frac{L}{g}}$. Measured value of $'L'$ is $1.0\ m$ from meter scale having a minimum division of $1\ mm$ and time of one complete oscillation is $1.95\ s$ measured from stopwatch of $0.01\ s$ resolution. The percentage error in the determination of $'g'$ will be:

- (a) 1.30%
- (b) 1.03%

(c) 1.33%

(d) 1.13%

Question 28

(Only one correct answer) 2021

Match List I with List II

	List I		List II
(a)	Capacitance, C	(i)	$M^1L^1T^{-3}A^{-2}$
(b)	Permittivity of free space, ε_0	(ii)	$M^{-1}L^{-3}T^4A^2$
(c)	Permeability of free space, μ_0	(iii)	$M^{-1}L^{-2}T^4A^2$
(d)	Electric field, E	(iv)	$M^1L^1T^{-2}A^2$

Choose the correct answer from the given below :

(a) (a) $\rightarrow$ (iii), (b) $\rightarrow$ (iv), (c) $\rightarrow$ (ii), (d) $\rightarrow$ (i)

(b) (a) $\rightarrow$ (iii), (b) $\rightarrow$ (ii), (c) $\rightarrow$ (iv), (d) $\rightarrow$ (i)

(c) (a) $\rightarrow$ (iv), (b) $\rightarrow$ (ii), (c) $\rightarrow$ (iii), (d) $\rightarrow$ (i)

(d) (a) $\rightarrow$ (iv), (b) $\rightarrow$ (iii), (c) $\rightarrow$ (ii), (d) $\rightarrow$ (i)

Question 29

(Only one correct answer) 2021

The Vernier scale used for measurement has a positive zero error of $0.2\ mm$. If while taking a measurement it was noted that $'0'$ on the Vernier scale lies between $8.5\ cm$ and $8.6\ cm$, Vernier coincidence is 6, then the correct value of measurement is ..... cm.

(a) $8.58\ cm$

(b) $8.54\ cm$

(c) $8.56\ cm$

(d) $8.36\ cm$

Question 30

(Only one correct answer) 2021

The entropy of any system is given by $S = \alpha^2\beta \ln\left[\frac{\mu k R}{J\beta^2} + 3\right]$, where α and β are the constants. $\mu,\ J$ and R are no. of moles, mechanical equivalent of heat, Boltzmann constant and gas constant respectively. [Take $S = \frac{dQ}{T}$] Choose the incorrect options from the following :

(a) S and α have different dimensions.

(b) $S,\ \beta,\ k$ and μR have the same dimensions.

(c) α and J have the same dimensions.

(d) α and k have the same dimensions.

Question 31

(Only one correct answer) 2021

The pitch of the screw gauge is $1\ mm$ and there are 100 divisions on the circular scale. When nothing is put in between the jaws, the zero of the circular scale lies 8 divisions below the reference line. When a wire is placed between the jaws, the first linear scale division is clearly visible while 72^{nd} division on circular scale coincides with the reference line. The radius of the wire is :

(a) $1.64\ mm$

(b) $1.80\ mm$

(c) $0.90\ mm$

(d) $0.82\ mm$

Question 32

(Only one correct answer) 2021

If $'C'$ and $'V'$ represent capacity and voltage respectively then what are the dimensions of λ where $\frac{C}{V} = \lambda$?

(a) $[M^{-2}L^{-4}I^{3}T^{7}]$

(b) $[M^{-2}L^{-3}I^{2}T^{6}]$

(c) $[M^{-1}L^{-3}I^{-2}T^{7}]$

(d) $[M^{-3}L^{-4}I^{3}T^{7}]$

Question 33

(Only one correct answer) 2021

If e is the electronic charge, c is the speed of light in free space and h is Planck's constant, the quantity $\frac{1}{4\pi\varepsilon_0}\frac{|e|^2}{hc}$ has dimensions of:

(a) $[M^{0}L^{0}T^{0}]$

(b) $[LC^{-1}]$

(c) $[MLT^{-1}]$

(d) $[MLT^{0}]$

Answer 1

Correct answers is B

Solution:

Correct option is (b).

Answer 2

Correct answers is D

Solution:

$[M]^1 = [V]^a[T]^b[F]^c$

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

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

Thus $c = 1$,

$a + c = 0 \implies a = -1$,

$b - a - 2c = 0 \implies b = -1 + 2 = 1$

Thus $[M] = [V]^{-1}[T]^1[F]^1$

Answer 3

Solution:

$9\ MSD = 10\ VSD$

$1\ VSD = 0.9\ mm$

$1\ MSD = 1\ mm$

$\therefore L.C. = \dfrac{MSD - VSD}{MSD}$

$= \dfrac{1 - 0.9}{1} = 0.1$

Reading = Main scale reading + L.C. $\times$ Vernier scale reading

$= 10 + 0.1 \times 8 = 10.8$

Reading of diameter $= 10.8\ mm - 0.04\ cm = 10.4\ mm$

radius of the bob $= 5.2\ mm = 0.52\ cm = 52 \times 10^{-2}\ cm$

Answer 4

Correct answers is C

Solution:

Correct option is (c).

Answer 5

Correct answers is C

Solution:

$\%y = 2(\%m) + 2(\%r) + x(\%g) + \dfrac{3}{2}(\%l)$

$18 = 2 \times 1 + 4 \times 0.5 + x(p) + \dfrac{3}{2} \times 4$

$18 = 2 + 2 + xp + 6$

$xp = 8$

Only option (c) satisfied.

Answer 6

Correct answers is D

Solution:

$$P = EL^2M^{-5}G^{-2}$$
$$P = [ML^2T^{-2}][ML^2T^{-1}]^2[M^{-5}][M^{-1}L^3T^{-2}]^{-2}$$
$$P = [M^0L^0T^0]$$

Answer 7

Correct answers is D

Solution:

$$n\,VSD = (n-1)\,MSD$$
$$1\,VSD = \frac{(n-1)}{n}\,MSD$$
$$\text{least count} = 1\,MSD - 1\,VSD$$
$$= a - \frac{(n-1)}{n}a$$
$$= a\left[\frac{n-n+1}{n}\right] = a/n\;cm = 10\frac{a}{n}\;mm$$

Answer 8

Solution:

$$T = 2\pi\sqrt{\frac{l}{g}}$$
$$\frac{\Delta g}{g} + \frac{2\Delta T}{T} = \frac{\Delta L}{L}$$
$$4 + 2 \times 3 = 10\%$$
$$E = \frac{1}{2}m\omega^2A^2 = \frac{1}{2}m\frac{g}{l}A^2$$
$$= \frac{\Delta g}{g} + \frac{\Delta L}{L} = 4 + 10 = 14\%$$

Answer 9

Correct answers is D

Solution:

Torque $\overrightarrow{\tau} = \overrightarrow{r} \times \overrightarrow{F}$
$\implies [\tau] = [L][MLT^{-2}]$ or $[\tau] = [ML^2T^{-2}]$

Impulse $J = \int F dt$
$\implies [J] = [MLT^{-2}][T] = [MLT^{-1}]$

Tension T:
$[T] = [MLT^{-2}]$

Surface Tension $T = \dfrac{\text{Force}}{\text{Length}}$
$[T] = [MT^{-2}]$

Answer 10

Correct answers is A

Solution:

$$V = IR = I\frac{\rho l}{A}$$

$$\rho = \frac{VA}{Il}$$

$$\frac{\Delta\rho}{\rho} \times 100 = \left(2\frac{\Delta d}{d} + \frac{\Delta v}{v} + \frac{\Delta I}{I} + \frac{\Delta l}{l}\right) \times 100$$

$$= \left(2 \times \frac{0.01}{5} + \frac{0.1}{5} + \frac{0.01}{2} + \frac{0.1}{10}\right) \times 100$$

$$= 0.4 + 2 + 1 + 0.5 = 3.9\ \%$$

Answer 11

Solution:

$V =$ volume $= \frac{4}{3}\pi r^3$

$$\frac{dv}{v} = \frac{3dr}{r}$$

Percentage error in volume

$$= \frac{3\Delta r}{r} \times 100 = \frac{3 \times 0.85}{7.5} \times 100 = 34\ \%$$

Answer 12

Correct answers is A

Solution:

Dimension of $A = MLT^{-2},\ B = L^{-1},\ D = T^{-1}$

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

Answer 13

Correct answers is D

Solution:

L.C. of screw Gauge $= \frac{0.5}{50} = 0.01\ mm$

Zero error of screw Gauge $= 5 \times L.C. = 5 \times 0.01 = 0.05\ mm$

Note that the given error is positive zero error as the zero of circular scale is below the reference line and it gives a false reading of 0.05 mm when the ratchet is closed and as such, must be subtracted from the measured reading

Reading of screw gauge = main scale reading + circular scale reading $\times L.C.$ - Zero error

$= 5 + 20 \times 0.01 - 0.05 = 5.15\ mm$

Answer 14

Correct answers is C

Solution:

$$\frac{E}{H} = \frac{\frac{F}{q}}{\frac{I}{r}} = \frac{Fr}{I^2t} = \text{joule/(second-Ampere}^2\text{)}$$

Answer 15

Correct answers is A

Solution:

$d \propto F^a L^b T^c$

$[ML^{-3}] = [MLT^{-2}]^a [L^b][T^c]$

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

Comparing :

$a = 1$ ...(i)

$a + b = -3$ ...(ii)

$-2a + c = 0$ ...(iii)

$c = 2; b = -4;$

$\therefore [d] = [FL^{-4}T^2]$

Answer 16

Correct answers is D

Solution:

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

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

Now, Time period $= \frac{1}{200} \times$ time for 200 oscillations, T'

so, $\sqrt{g} = 400\pi\frac{\sqrt{l}}{T'}$

$$\frac{1}{2}\frac{\Delta g}{g} = \frac{\Delta T'}{T'} + \frac{1}{2}\frac{\Delta l}{l}$$

$$\frac{\Delta g}{g} = \frac{2 \times 1}{100} + \frac{1 \times 10^{-3}}{10 \times 10^{-2}}$$

$$\frac{\Delta g}{g} = 0.02 + 0.01 = 0.03$$

Error $= \frac{\Delta g}{g} \times 100 = 3\,\%$

Answer 17

Correct answers is A

Solution:

$M \propto t^x v^y l^z$

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

$M^1L^0T^0 = t^{x-y-z}L^{y+2z}M^z$

On comparing powers

$z = 1$ ...(i)

$x - y - z = 0$ ...(ii)

$y + 2z = 0$ ...(iii)

$y + 2 \times 1 = 0$

$y = -2$

$x - (-2) - 1 = 0$

$x = -1;$

$M \propto t^{-1}v^{-2}l^1;$

$[M] \propto [t^{-1}v^{-2}l]$

Answer 18

Correct answers is B

Solution:

$LC = 1\ mm/50 = 0.02\ mm$

Statement-1 is wrong.

Statement-2 is right.

Answer 19

Correct answers is C

Solution:

$$[KT] = [\beta][x^2]$$
$$[ML^2T^{-2}] = [\beta][L^2]$$
$$[\beta] = MT^{-2}$$
$$\alpha^2\beta = \text{energy} = ML^2T^{-2}$$
$$\alpha^2 = L^2$$
$$\alpha = [L]$$

Answer 20

Correct answers is A

Solution:

Permeability of free space (μ_0):

Recall Magnetic Energy Density $U_B = \dfrac{B^2}{2\mu_0}$

$U_B = \dfrac{Energy}{Volume}$ or $[U_B] = [ML^{-1}T^{-2}]$

$B = \dfrac{Force}{charge,\ q \times velocity,\ v}$ $[B] = [M^1L^0T^{-1}Q^{-1}]$

$\implies [\mu_0] = [M^1L^1T^0Q^{-2}]$ Or, $[\mu_0] = [M^1L^1T^{-2}A^{-2}]$

Relative magnetic permeability (μ_r)

$\mu_r = \dfrac{\mu}{\mu_0}$: Dimensionless

Power Factor ($\cos\phi$)

$\cos\phi = \dfrac{R}{Z}$: Dimensionless

Quality Factor (Q)

$Q = \dfrac{\omega L}{R}$: Dimensionless

Recall ωL have the dimensions of Ohms (Ω)

Answer 21

Correct answers is C

Solution:

$$y = \frac{\text{stress}}{\text{strain}} = \frac{FL}{A\Delta L} = \frac{mgL}{\pi R^2 l}$$

$$\frac{\Delta y}{y} = \frac{\Delta m}{m} + \frac{\Delta L}{L} + 2\frac{\Delta R}{R} + \frac{\Delta l}{l}$$

$$\frac{\Delta y}{y} = \frac{1}{1000} + \frac{1}{1000} + 2\frac{0.001}{0.2} + \frac{0.001}{0.5}$$

$$\frac{\Delta y}{y} \times 100 = \frac{1}{10} + \frac{1}{10} + 1 + \frac{1}{5} = \frac{14}{15} = 1.4\,\%$$

Answer 22

Solution:

The difference between the two student reading

$=$ difference between zero error.

$= 5 - (-8) = 13$

Answer 23

Correct answers is A

Solution:

The correct option is (a).

Recall:

- $E = h\nu$
- Kinetic energy $= \dfrac{1}{2}mv^2$
- Electric potential $V = \dfrac{U}{q}$ and $q = it$
- Linear momentum $P = mv$

Answer 24

Correct answers is B

Solution:

Magnetic Induction, B

$B = \dfrac{Force}{charge,\ q \times velocity,\ v}$, or, $[B] = [M^1 L^0 T^{-1} Q^{-1}]$

or $[B] = [M^1 L^0 T^{-2} A^{-1}]$

Magnetic Flux, ϕ_B

$\phi_B = \int \overrightarrow{B} . \overrightarrow{dA}$

or $[\phi_B] = [M^1 L^2 T^{-2} A^{-1}]$

Magnetic Permeability (μ_0):

Recall Magnetic Energy Density $U_B = \dfrac{B^2}{2\mu_0}$

$U_B = \dfrac{Energy}{Volume}$ or $[U_B] = [ML^{-1}T^{-2}]$

$B = \dfrac{Force}{charge,\ q \times velocity,\ v}$, or, $[B] = [M^1 L^0 T^{-1} Q^{-1}]$

$\implies [\mu_0] = [M^1 L^1 T^0 Q^{-2}]$ Or, $[\mu_0] = [M^1 L^1 T^{-2} A^{-2}]$

Magnetization $\overrightarrow{M}$

$\overrightarrow{M} = \dfrac{\text{Magnetic Dipole Moment}}{\text{Volume (V)}}$

Magnetic Dipole Moment, $\mu = NiA$, $[\mu] = [L^2 A^1]$

$\implies [M] = [L^{-1} A^1]$

Answer 25

Solution:

From ohm's law

$R = \dfrac{V}{I} = \dfrac{50}{20} = 2.5$

$\dfrac{\Delta R}{R} \times 100 = \left(\dfrac{\Delta V}{V} + \dfrac{\Delta I}{I}\right) \times 100$

$\dfrac{\Delta R}{R}\ \% = \left(\dfrac{2}{50} + \dfrac{0.2}{20}\right) \times 100$

% error in $R = 5$ %

Answer 26

Correct answers is A

Solution:

Dimension $\alpha = \left[\dfrac{L^2}{ML^2T^{-2}}\right] = [M^{-1}T^2]$

Dimension $\beta = \left[\dfrac{M^{\frac{1}{2}} LT^{-1}}{M^{\frac{1}{2}} T^1}\right] = [MLT^{-2}]$

Answer 27

Correct answers is D

Solution:

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

$$\text{Error} \quad \frac{\Delta g}{g} = \frac{\Delta l}{l} + \frac{2\Delta T}{T}$$

$$\frac{\Delta g}{g} = \frac{10^{-3}}{1} + \frac{2 \times 0.01}{1.95} = 0.0113$$

$$\frac{\Delta g}{g}\% = 1.13\%$$

Answer 28

Correct answers is B

Solution:

Capacitance C

$$C = \frac{q}{V}, V = \frac{U}{q}$$

$$[C] = [M^{-1}L^{-2}T^4A^2]$$

Permittivity of free space, ϵ_0

$$F = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r^2}$$

$$[\epsilon_0] = [M^{-1}L^{-3}T^4A^2]$$

Permeability of free space (μ_0):

Recall Magnetic Energy Density $U_B = \frac{B^2}{2\mu_0}$

$$U_B = \frac{Energy}{Volume} \text{ or } [U_B] = [ML^{-1}T^{-2}]$$

$$B = \frac{Force}{charge,\ q \times velocity,\ v} \quad [B] = [M^1L^0T^{-1}Q^{-1}]$$

$$\implies [\mu_0] = [M^1L^1T^0Q^{-2}] \text{ Or, } [\mu_0] = [M^1L^1T^{-2}A^{-2}]$$

or we could have used $C = \frac{\epsilon_0 A}{d}$

Electric field, E

$$E = \frac{F}{q} \implies [E] = [MLT^{-3}A^{-1}]$$

Answer 29

Correct answers is B

Solution:

Actual reading = Main scale reading + Vernier scale reading $\times$ least count - zero error

$= 8.5 + 0.01 \times 6 - 0.02 = 8.54\ cm$

Answer 30

Correct answers is D

Solution:

$$S = \frac{Q}{\Delta T}, [S] = \frac{ML^2T^{-2}}{K}$$

$$k = \frac{\text{energy}}{T}, [k] = [S] = \frac{ML^2T^{-2}}{K}$$

$$R = \frac{\text{energy}}{nT}, [R] = \frac{ML^2T^{-2}}{\text{mol } K}$$

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

Now, $[\mu kR] = [J\beta^2]$;

$$(\text{mol}) \times \frac{ML^2T^{-2}}{K} \times \frac{ML^2T^{-2}}{\text{mol } K} = [\beta^2]$$

$$[\beta] = ML^2T^{-2}K^{-1};$$

$$[\alpha^2] = \left[\frac{S}{\beta}\right] = \frac{ML^2T^{-2}}{K \times ML^2T^{-2}K^{-1}};$$

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

Answer 31

Correct answers is D

Solution:

$$LC = \frac{\text{pitch}}{\text{number of division}} = \frac{1}{100}$$

$$\text{error} = 8 \times \frac{1}{100}$$

$$\text{Reading } (2R) = 1 + 72 \times \frac{1}{100} - 8 \times \frac{1}{100}$$

$$2R = 1.64$$

$$R = 0.82\ mm$$

Answer 32

Correct answers is A

Solution:

$$\frac{C}{V} = \frac{Q}{V(V)} = \frac{Q}{V^2} = \frac{Q}{\left(\frac{W}{Q}\right)^2} = \frac{Q^3}{W^2}$$

$$= \frac{(AT)}{\left(\frac{\text{Work}}{Q}\right)^2} = \frac{(AT)^3}{[ML^2T^{-2}]^2}$$

$$= \frac{A^3T^3}{[M^2L^4T^{-4}]} = [M^{-2}L^{-4}T^7A^3]$$

Answer 33

Correct answers is A

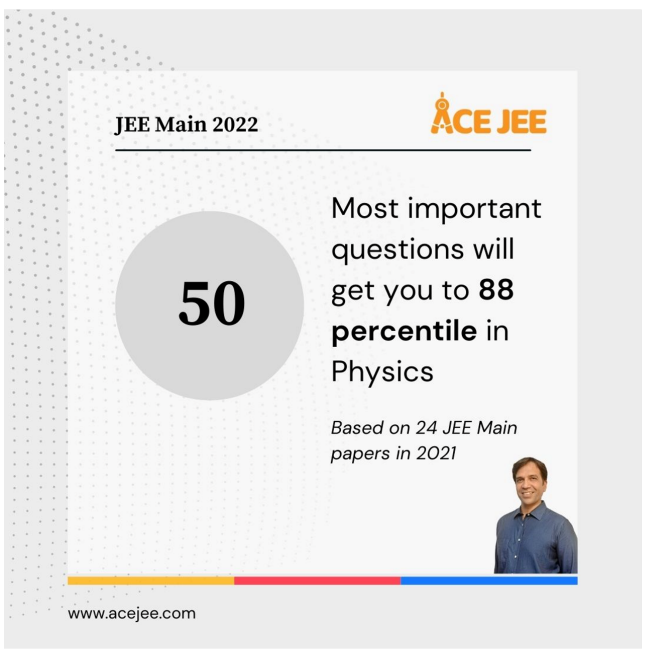
Solution:

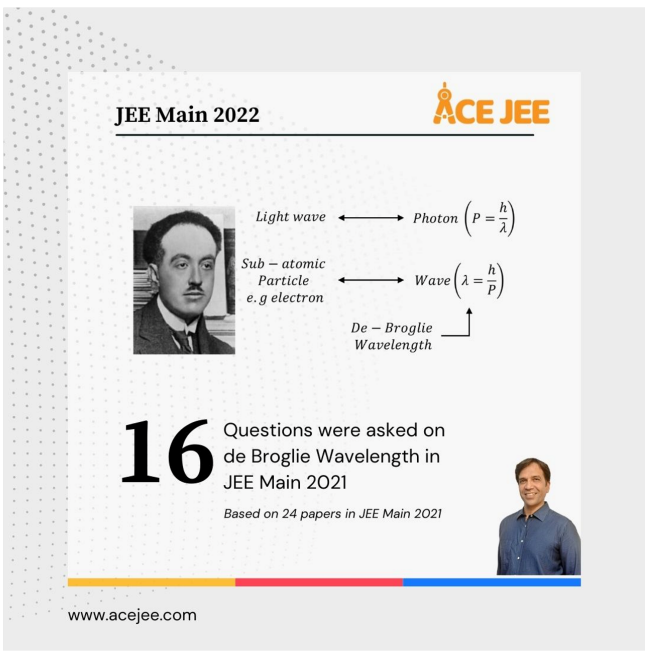
Recall,

Force between two charges is given by $F = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r^2}$

& Energy of photon $E = \frac{hc}{\lambda}$

So, $\frac{1}{4\pi\varepsilon_0}\frac{|e|^2}{hc} \equiv \frac{Fr^2}{hc} = \frac{Fr^2}{E\lambda} = [M^0L^0T^0]$





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