

Units & Measurement and Dimensions

Question1

If L and C are inductance and capacitance respectively, then the dimensional formula of $(LC)^{-\frac{1}{2}}$ is

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Options:

A.

$$[M^9 L^0 T^{-1}]$$

B.

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

C.

$$[M^9 L^1 T^1]$$

D.

$$[M^9 L^0 T^{-2}]$$

Answer: A

Solution:

We know that the formula for resonance angular frequency is:

$$\omega = \frac{1}{\sqrt{LC}}$$

$$\text{So, } \omega = (LC)^{-1/2}$$

This means the dimensional formula for $(LC)^{-1/2}$ is the same as the dimensional formula for ω .

The dimensional formula for angular frequency ω is time inverse: $[T^{-1}]$.

In full form, this is $[M^0 L^0 T^{-1}]$.



Question2

If A , B and C are three different physical quantities with different dimensional formulae, then the combination which can never give a proper physical quantity is

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Options:

A.

$$\frac{A}{BC}$$

B.

$$\frac{AB-C^2}{BC}$$

C.

$$\frac{A-C}{B}$$

D.

$$AC - B$$

Answer: C

Solution:

According to principle of homogeneity, physical quality can only be added or subtracted if they have the same dimensions.

$\frac{A-C}{B}$ is correct only when A and C must have same dimensions.

Question3

Which of the following statement regarding nature of physical laws is not correct?



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Options:

- A. All conserved quantities are necessarily scalars.
- B. The laws of nature do not change with time.
- C. The laws of nature are same everywhere in the universe.
- D. The law of gravitation is the same both on the moon and the earth.

Answer: A

Solution:

The statement that is not correct is:

Option A: All conserved quantities are necessarily scalars.

In physics, conserved quantities are those that remain constant in time under certain conditions. While some conserved quantities, like mass or energy, can be scalars, angular momentum, and linear momentum are examples of vector quantities that are also conserved. Thus, not all conserved quantities are scalars.

To understand this further, consider:

Energy and Mass are examples of **scalar conserved quantities**.

Linear Momentum can be written as a vector \vec{p} , where $\vec{p} = m\vec{v}$, with m being mass and \vec{v} the velocity vector.

Angular Momentum is given by a vector $\vec{L} = \vec{r} \times \vec{p}$, which is a cross product of position vector \vec{r} and momentum vector \vec{p} .

The remaining options are correct:

Option B: The laws of nature do not change with time, as they are universal and consistent over time.

Option C: The laws of nature are the same everywhere in the universe, reflecting the principle of universality.

Option D: The law of gravitation is the same both on the Moon and the Earth, which illustrates the universality of gravitational law as described by Newton's law of universal gravitation.

Question4

The internal and external diameters of hollow cylinder measured with vernier callipers are (5.73 ± 0.01) cm and (6.01 ± 0.01) cm



respectively. Then, the thickness of the cylinder wall is

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Options:

A. $(0.28 \pm 0.01)\text{cm}$

B. $(0.28 \pm 0.02)\text{cm}$

C. $(0.14 \pm 0.02)\text{cm}$

D. $(0.14 \pm 0.01)\text{cm}$

Answer: C

Solution:

Given,

Internal diameter,

$$d_1 = (5.73 \pm 0.01)\text{cm}$$

External diameter,

$$d_2 = (6.01 \pm 0.01)\text{cm}$$

$$\text{Internal radius, } r_1 = \frac{d_1}{2}$$

$$\text{External radius, } r_2 = \frac{d_2}{2}$$

$$\text{Actual thickness, } t = \frac{1}{2}(d_2 - d_1)$$

$$t = \frac{1}{2}(0.28) = 0.14 \text{ cm}$$

Now, error in thickness,

We know from the properties of error that total error in subtraction operation is addition of each error.

$$\Delta t = \Delta t_1 + \Delta t_2$$

$$\Delta t_1 = 0.01 \text{ cm, } \Delta t_2 = 0.01 \text{ cm}$$

$$\Delta t = 0.02 \text{ cm}$$

$$\text{Hence, } t = (0.14 \pm 0.02)\text{cm}$$

Question5

The error in the measurement of resistance, when (10 ± 05) A current passing through it produces a potential difference of (100 ± 6) V across it is

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Options:

- A. 1%
- B. 5.5%
- C. 6.5%
- D. 11%

Answer: D

Solution:

Given, $I = (10 \pm 0.5)$ A

Voltage = (100 ± 6) V

We know that, $V = IR$

$$R = \frac{V}{I}$$

$$\Rightarrow \frac{\Delta R}{R} = \frac{\Delta V}{V} + \frac{\Delta I}{I}$$

$$= \frac{6}{100} + \frac{0.5}{10}$$

$$\frac{\Delta R}{R} = \frac{11}{100}$$

$$\% \text{ error} = \frac{\Delta R}{R} \times 100\%$$

$$= \frac{11}{100} \times 100\% = 11\%$$



Question6

The equation of motion of a damped oscillator is given by $m \frac{d^2x}{dt^2} + b \frac{dx}{dt} + kx = 0$. The dimensional formula of $\frac{b}{\sqrt{km}}$ is

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Options:

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

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

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

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

Answer: A

Solution:

Given the equation of motion,

$$m \frac{d^2x}{dt^2} + b \frac{dx}{dt} + kx = 0$$

We need to find the dimensional formula of $\frac{b}{\sqrt{km}}$.

Here,

$$[b] = [M][T]^{-1}$$

$$[k] = [M][T]^{-2}$$

$$[m] = [M]$$

$$\begin{aligned} \frac{b}{\sqrt{km}} &= \frac{[M][T]^{-1}}{\sqrt{[M][T]^{-2} \cdot [M]}} \\ &= \frac{[M][T]^{-1}}{\sqrt{[M]^2 [T]^{-2}}} = \frac{[M][T]^{-1}}{[M][T]^{-1}} \\ &= [M^0 L^0 T^0] \end{aligned}$$

So, the dimensional formula of $\frac{b}{\sqrt{km}}$ is $[M^0 L^0 T^0]$.



Question7

The number of significant figures in 3.78×10^{22} kg is
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Options:

- A. 19
- B. 25
- C. 3
- D. 22

Answer: C

Solution:

In the given number, 3.78×10^{22} kg, we need to determine the number of significant figures.

Significant figures are the digits in a number that contribute to its precision. They include all non-zero digits, any zeros between significant digits, and any trailing zeros in a decimal number. Here, the number is expressed in scientific notation. The mantissa, 3.78, determines the significant figures.

The digits "3", "7", and "8" in 3.78 are all non-zero digits.

Therefore, the number of significant figures in 3.78×10^{22} kg is 3.

Question8

Which of the following pairs has same dimensions?

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Options:

- A. Current density and charge density
- B. Angular momentum and linear momentum
- C. Spring constant and surface energy
- D. Force and torque

Answer: C



Solution:

Let's analyze the dimensions of each pair:

Current Density vs. Charge Density

Current density (usually denoted as \vec{J}) is the current per unit area:

$$[\vec{J}] = \frac{[I]}{L^2}$$

Charge density (commonly referring to volume charge density, ρ) is the charge per unit volume:

$$[\rho] = \frac{[Q]}{L^3}$$

Since charge Q has dimensions $[I \cdot T]$, charge density becomes:

$$[\rho] = \frac{[I \cdot T]}{L^3}$$

These two are not equivalent because $[\vec{J}] = [IL^{-2}]$ and $[\rho] = [ITL^{-3}]$ have different dimensions.

Angular Momentum vs. Linear Momentum

Linear momentum \vec{p} has dimensions:

$$[\vec{p}] = MLT^{-1}$$

Angular momentum \vec{L} is given by $\vec{r} \times \vec{p}$, so its dimensions are:

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

They differ by a factor of length and are therefore not the same.

Spring Constant vs. Surface Energy

The spring constant k in Hooke's law (where $F = kx$) has dimensions:

$$[k] = \frac{[F]}{[L]} = \frac{MLT^{-2}}{L} = MT^{-2}$$

Surface energy is energy per unit area. Energy has dimensions:

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

Dividing by area L^2 gives:

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

These both have the same dimensions, MT^{-2} .

Force vs. Torque

Force has dimensions:

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

Torque is the cross product of a lever arm (length) and force:



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

They differ by an extra factor of length.

Thus, the pair with the same dimensions is:

Option C: Spring constant and surface energy.
