# Physical world and Measurements

## Question1

**The least count of a screw guage is 0.01 mm . If the pitch is increased by $75\%$ and number of divisions on the circular scale is reduced by $50\%$, the new least count will be ________ $\times 10^{-3}$ mm**

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**Answer: 35**

## Solution:



The least count (L.C.) of a screw gauge is given by:

$\text{L.C.} = \dfrac{\text{Pitch}}{\text{Number of Divisions on Circular Scale}}$

Let the original pitch be $p$ and the original number of divisions be $n$. Then, the original least count is:

$\frac{p}{n} = 0.01 \text{ mm}$

After modifications:

The pitch is increased by 75%, so the new pitch is:

$p_{\text{new}} = p + 0.75p = 1.75p$

The number of divisions is reduced by 50%, so the new number of divisions is:

$n_{\text{new}} = 0.5n$

The new least count is then:

$\text{L.C.}_{\text{new}} = \frac{p_{\text{new}}}{n_{\text{new}}} = \frac{1.75p}{0.5n} = \frac{1.75}{0.5} \times \frac{p}{n} = 3.5 \times \frac{p}{n}$

Substitute the original least count:

$\text{L.C.}_{\text{new}} = 3.5 \times 0.01 \text{ mm} = 0.035 \text{ mm}$

Expressed in the form $\times 10^{-3}$ mm, this becomes:

$0.035\,\mathrm{mm} = 35 \times 10^{-3}\,\mathrm{mm}$

Thus, the new least count is:

$35 \times 10^{-3}\,\mathrm{mm}$

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# Question2

## A tiny metallic rectangular sheet has length and breadth of 5 mm and 2.5 mm , respectively. Using a specially designed screw gauge which has pitch of 0.75 mm and 15 divisions in the circular scale, you are asked to find the area of the sheet. In this measurement, the maximum fractional error will be $\frac{x}{100}$ where $x$ is _______ .

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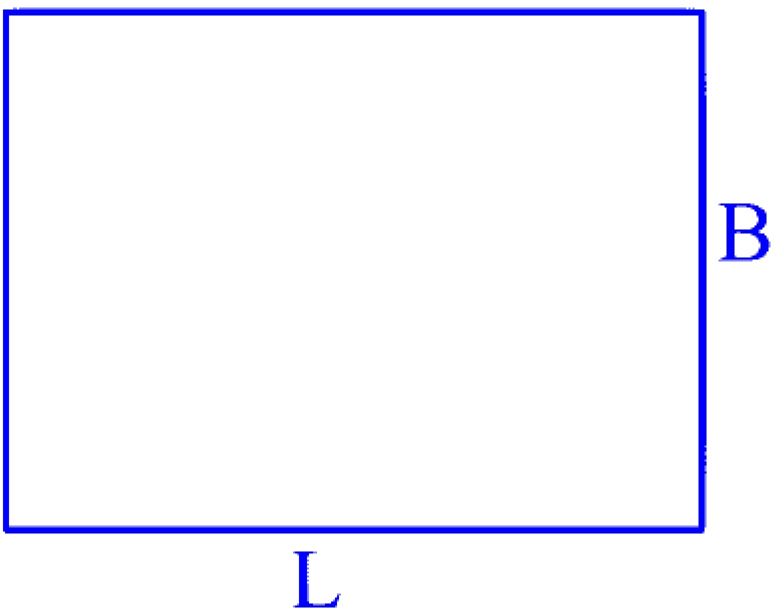
**Answer: 3**



### Solution:




Given, L = 5 mm, B = 2.5 mm

We know, least count of a screw gauge,

$L.C. = \frac{Pitch\ length}{No.\ of\ division\ on\ circular\ scale}$

$\Rightarrow L.C. = \frac{0.75}{15} = 0.05\,mm$

We know, $A = LB$

By taking $ln$ on both sides,

$\Rightarrow \ln A = \ln L + \ln B$

by differentiating both sides,

$\Rightarrow \frac{dA}{A} = \frac{dL}{L} + \frac{dB}{B}$

Here, $dL = dB = 0.05\,mm$ (L.C.)

So fractional error,

$\frac{dA}{A} = \frac{0.05}{5} + \frac{0.05}{2.5}$

$= \frac{1}{100} + \frac{2}{100} = \frac{3}{100} = \frac{x}{100}$ (given)

Hence, $x = 3$.

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# Question3

A physical quantity $Q$ is related to four observables $a,b,c,d$ as follows :

$$Q = \frac{ab^4}{cd}$$



**where,**
$\mathrm{a} = (60 \pm 3)\mathrm{Pa}; \mathrm{b} = (20 \pm 0.1)\mathrm{m}; \mathrm{c} = (40 \pm 0.2)\mathrm{Nsm}^{-2}$ **and** $\mathrm{d} = (50 \pm 0.1)\mathrm{m}$**, then the percentage error in Q is** $\frac{x}{1000}$**, where** $x =$ ________ **.**

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**Answer: 7700**

## Solution:

Given, $Q = \frac{ab^4}{cd}$

$a = (60 \pm 3)\,Pa \Rightarrow a = 60\,Pa,\ \Delta a = 3Pa$

$b = (20 \pm 0.1)\, m \Rightarrow b = 20m,\ \Delta b = 0.1\, m$

$c = (40 \pm 0.2)\, Nsm^{-2} \Rightarrow c = 40\, Nsm^{-2},\ \Delta c = 0.2\, Nsm^{-2}$

$d = (50 \pm 0.1)\, m \Rightarrow\ d = 50\, m,\ \Delta d = 0.1m$

As, $Q = \frac{ab^4}{cd}$

by taking ln on both sides,

$\ln Q = \ln a + u \ln b - \ln c - \ln d$

Now, by differentiating,

$\frac{dQ}{Q} = \frac{da}{a} + 4\frac{db}{b} - \frac{dc}{c} - \frac{dd}{d}$

So, maximum fractional error in Q is given by,

$\frac{\Delta Q}{Q} = \frac{\Delta a}{a} + 4\frac{\Delta b}{b} + \frac{\Delta c}{c} + \frac{\Delta d}{d}$

$\Rightarrow \frac{\Delta Q}{Q} = \frac{3}{60} + 4\left(\frac{0.1}{20}\right) + \frac{0.2}{40} + \frac{0.1}{40}$

$= \frac{1}{20} + \frac{1}{50} + \frac{1}{200} + \frac{1}{500}$

$\Rightarrow \frac{\Delta Q}{Q} = \frac{50+20+5+2}{1000} = \frac{77}{1000}$

Hence the % error in $Q = \frac{\Delta Q}{Q} \times 100\%$

$= \frac{7700}{1000}\% = \frac{x}{1000}$ (given)



So, $x = 7700$

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# Question4

## A physical quantity C is related to four other quantities p, q, r and s as follows

$$C = \frac{pq^2}{r^3\sqrt{s}}$$

## The percentage errors in the measurement of p, q, r and s are $1\%, 2\%, 3\%$ and $2\%$, respectively. The percentage error in the measurement of $C$ will be__________%

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**Answer: 15**

## Solution:

To determine the percentage error in the measurement of $C$, which is related to $p$, $q$, $r$, and $s$ as:

$C = \frac{pq^2}{r^3\sqrt{s}}$

we first express it in terms of powers:

$C = p^1 q^2 r^{-3} s^{-1/2}$

The percentage error in $C$ can be calculated using the formula for the propagation of error, which is:

$\left(\frac{\Delta C}{C}\right)_{\max} = \frac{\Delta p}{p}\Big| + 2\left|\frac{\Delta q}{q}\right| + 3\left|\frac{\Delta r}{r}\right| + \frac{1}{2}\left|\frac{\Delta s}{s}\right|$

Given the percentage errors for $p$, $q$, $r$, and $s$ are $1\%$, $2\%$, $3\%$, and $2\%$ respectively, we substitute these values into the formula:

$\left(\frac{\Delta C}{C}\right)_{\max} = 1\% + 2 \times 2\% + 3 \times 3\% + \frac{1}{2} \times 2\%$

Calculating each part:

Contribution from $p$: $1\%$

Contribution from $q$: $4\%$ (since $2 \times 2\% = 4\%$)



Contribution from $r$: $9\%$ (since $3 \times 3\% = 9\%$)

Contribution from $s$: $1\%$ (since $\frac{1}{2} \times 2\% = 1\%$)

Adding these contributions together:

$1\% + 4\% + 9\% + 1\% = 15\%$

Thus, the maximum percentage error in the measurement of $C$ is $15\%$.

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# Question5

## Given below are two statements :

## Statement I: In a vernier callipers, one vernier scale division is always smaller than one main scale division.

## Statement II : The vernier constant is given by one main scale division multiplied by the number of vernier scale divisions.

**In the light of the above statements, choose the correct answer from the options given below.**

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**Options:**

A. Both Statement I and Statement II are false

B. Statement I is true but Statement II is false

C. Both Statement I and Statement II are true

D. Statement I is false but Statement II is true

**Answer: B**

## Solution:

In general, one vernier scale division is smaller than one main scale division but in some modified cases it may be not correct. Also least count is given by one main scale division divided by number of vernier scale division for normal vernier calliper.



Hence, option 2 is correct.

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# Question6

### If $B$ is magnetic field and $\mu_0$ is permeability of free space, then the dimensions of $(B/\mu_0)$ is

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**Options:**

A. $\mathrm{MT^{-2}\,A^{-1}}$

B. $\mathrm{L^{-1}\,A}$

C. $\mathrm{ML^{2}\,T^{-2}\,A^{-1}}$

D. $\mathrm{LT^{-2}\ A^{-1}}$

**Answer: B**

## Solution:

To determine the dimensions of $\left(\frac{B}{\mu_0}\right)$, we start with the formula for the magnetic field $B$ inside a solenoid:

$B = \mu_0 n I$

where $n = \frac{N}{L}$ is the number of turns per unit length, $I$ is the current, and $\mu_0$ is the permeability of free space.

Rearranging the formula gives:

$\frac{B}{\mu_0} = nI = \frac{N}{L} I$

From the above, the dimensions of $\left(\frac{B}{\mu_0}\right)$ are:

$\left[\frac{B}{\mu_0}\right] = [L^{-1} A]$

Thus, the dimensional formula of $\left(\frac{B}{\mu_0}\right)$ corresponds to $L^{-1}\mathrm{A}$.

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# Question7



### The maximum percentage error in the measurment of density of a wire is

### [Given, mass of wire $= (0.60 \pm 0.003)\mathrm{g}$

### radius of wire $= (0.50 \pm 0.01)\mathrm{cm}$

### length of wire $= (10.00 \pm 0.05)\mathrm{cm}]$

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**Options:**

A. 7

B. 8

C. 5

D. 4

**Answer: C**

# Solution:

To determine the maximum percentage error in the density of the wire, follow these steps:

The density of the wire is given by the formula for a cylinder:

$\rho = \frac{m}{\pi r^2 l}$

When calculating the maximum percentage (relative) error, you add the relative errors from each variable, taking into account the power to which each variable is raised. Thus, for density:

$\frac{\Delta\rho}{\rho} = \frac{\Delta m}{m} + 2\frac{\Delta r}{r} + \frac{\Delta l}{l}$

Here:

$\frac{\Delta m}{m}$ is the relative error in the mass.

$2\frac{\Delta r}{r}$ is due to the radius being squared.

$\frac{\Delta l}{l}$ is the relative error in the length.



Now plug in the given values:

Mass: $m = 0.60\,\text{g}$ with an error $\Delta m = 0.003\,\text{g}$

$\frac{\Delta m}{m} = \frac{0.003}{0.60} = 0.005$ or $0.5\%$.

Radius: $r = 0.50\,\text{cm}$ with an error $\Delta r = 0.01\,\text{cm}$

$\frac{\Delta r}{r} = \frac{0.01}{0.50} = 0.02$ or $2\%$. Since the radius is squared in the formula, multiply by 2:

$2\frac{\Delta r}{r} = 2 \times 0.02 = 0.04$ or $4\%$.

Length: $l = 10.00\,\text{cm}$ with an error $\Delta l = 0.05\,\text{cm}$

$\frac{\Delta l}{l} = \frac{0.05}{10.00} = 0.005$ or $0.5\%$.

Sum these contributions to find the overall maximum relative error:

$\frac{\Delta\rho}{\rho} = 0.005 + 0.04 + 0.005 = 0.05$

Converting this relative error into a percentage gives:

$0.05 \times 100\% = 5\%$

Thus, the maximum percentage error in the density of the wire is 5%, which corresponds to Option C.

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# Question8

## The position of a particle moving on $x$-axis is given by $x(t) = A\sin t + B\cos^2 t + Ct^2 + D$, where $t$ is time. The dimension of $\frac{ABC}{D}$ is

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**Options:**

A. L

B. $L^3\ T^{-2}$

C. $L^2\ T^{-2}$

D. $L^2$

**Answer: C**



## Solution:

Let's analyze the position function step by step.

The particle's position is given by:

$x(t) = A\sin t + B\cos^2 t + Ct^2 + D,$

where $t$ represents time, which has the dimension $T$.

Since the overall dimensions of position $x(t)$ must be length $(L)$, each term in the expression must also have dimensions of length.

**Term $A\sin t$:**

The sine function, $\sin t$, is dimensionless (its argument must be dimensionless, and by convention, if $t$ is in an appropriate unit where the argument is dimensionless, the function itself is dimensionless).

Therefore, $A$ must carry the dimension of length:

$[A] = L.$

**Term $B\cos^2 t$:**

Similarly, the cosine function is dimensionless, and so is its square.

Thus, $B$ must have the dimension of length:

$[B] = L.$

**Term $Ct^2$:**

Here, $t^2$ has the dimension $T^2$.

To have the overall term with the dimension $L$, we require:

$[C] \times [T^2] = L.$

So, the dimension of $C$ must be:

$[C] = LT^{-2}.$

**Term $D$:**

This is a constant term added to position, so it must also have the dimension of length:

$[D] = L.$

Now, we are asked to find the dimension of:

$\frac{ABC}{D}.$

The dimensions of $A$, $B$, and $C$ are:

$[A] = L, \quad [B] = L, \quad [C] = LT^{-2}.$

Multiplying them together:

$[ABC] = L \times L \times (LT^{-2}) = L^3T^{-2}.$



Since $[D] = L$, dividing by $D$ gives:

$\frac{[ABC]}{[D]} = \frac{L^3T^{-2}}{L} = L^2T^{-2}.$

Thus, the dimension of $\frac{ABC}{D}$ is:

$\boxed{L^2T^{-2}}.$

The correct answer is Option C.

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# Question9

## Match List - I with List - II

| | List - I | | List - II |
|---|---|---|---|
| (A) | Permeability of free space | (I) | $[ML^2T^{-2}]$ |
| (B) | Magnetic field | (II) | $[MT^{-2}A^{-1}]$ |

| | List - I | | List - II |
|---|---|---|---|
| (C) | Magnetic moment | (III) | $\left[MLT^{-2}A^{-2}\right]$ |
| (D) | Torsional constant | (IV) | $\left[L^2A\right]$ |

## Choose the correct answer from the options given below :

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**Options:**

A. (A)-(III), (B)-(II), (C)-(IV), (D)-(I)

B. $(A)-(I),(B)-(IV),(C)-(II),(D)-(III)$

C. $(A)-(II),(B)-(I),(C)-(III),(D)-(IV)$

D. (A)-(IV), (B)-(III), (C)-(I), (D)-(II)



**Answer: A**

## Solution:

The correct matching is:

(A) Permeability of free space has dimensions

$[MLT^{-2}A^{-2}]$

which corresponds to entry **(III)**.

(B) Magnetic field has dimensions

$[MT^{-2}A^{-1}]$

which corresponds to entry **(II)**.

(C) Magnetic moment in SI units is expressed in Ampere-square meters, i.e.,

$[L^2A]$

which corresponds to entry **(IV)**.

(D) Torsional constant (torque per unit angular displacement) has dimensions

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

which corresponds to entry **(I)**.

Thus, the correct answer is:

**Option A: (A)-(III), (B)-(II), (C)-(IV), (D)-(I)**

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# Question10

## The energy of a system is given as $\mathrm{E(t)} = \alpha^3 \mathrm{e}^{-\beta t}$, where t is the time and $\beta = 0.3\ \mathrm{s}^{-1}$. The errors in the measurement of $\alpha$ and $t$ are $1.2\%$ and $1.6\%$, respectively. At $t = 5\ \mathrm{s}$, maximum percentage error in the energy is :

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**Options:**

A. $6\%$

B. $11.6\%$

C. $4\%$



D. $8.4\%$

**Answer: A**

## Solution:

We start with the energy function:

$E(t) = \alpha^3 e^{-\beta t}$,

where $\beta = 0.3\,\mathrm{s}^{-1}$.

**Step 1. Take the Logarithm**

Taking the logarithm of both sides:

$\ln E = 3 \ln \alpha - \beta t$.

**Step 2. Differentiate to Find the Relative Error**

Differentiate both sides:

$\frac{dE}{E} = 3\,\frac{d\alpha}{\alpha} - \beta\,dt$.

For maximum error estimation, we consider the absolute values and sum the contributions:

$\left|\frac{\Delta E}{E}\right| \approx 3\left|\frac{\Delta\alpha}{\alpha}\right| + \beta|\Delta t|.$

### Step 3. Plug in the Given Errors

The percentage error in $\alpha$ is $1.2\%$ (i.e., $\Delta\alpha/\alpha = 0.012$).

The percentage error in $t$ is $1.6\%$, so for $t = 5\,\text{s}$:

$\Delta t = 0.016 \times 5 = 0.08\,\text{s}.$

Now substitute these values:

$\left|\frac{\Delta E}{E}\right| \approx 3(0.012) + 0.3(0.08).$

Calculating each term:

$3(0.012) = 0.036$ (or $3.6\%$),

$0.3(0.08) = 0.024$ (or $2.4\%$).

### Step 4. Compute the Total Maximum Percentage Error

Add the contributions:

$\left|\frac{\Delta E}{E}\right| \approx 0.036 + 0.024 = 0.06,$

which is $6\%$.

Thus, the maximum percentage error in the energy at $t = 5\,\text{s}$ is:



$\boxed{6\%}$

**Answer: Option A (6%).**

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# Question11

## For an experimental expression $y = \frac{32.3\times1125}{27.4}$, where all the digits are significant. Then to report the value of $y$ we should write

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**Options:**

A. $y = 1326.186$

B. $y = 1326.2$

C. $y = 1326.19$

D. $y = 1330$

**Answer: D**

## Solution:

$32.3 \quad (3 \text{ sig figs}), \quad 1125 \quad (4 \text{ sig figs}), \quad 27.4 \quad (3 \text{ sig figs})$

In multiplication and division, the final answer must be reported with the same number of significant figures as the factor with the fewest significant figures, which here is 3.

First, calculate the unrounded result:

$y = \frac{32.3 \times 1125}{27.4} \approx \frac{36337.5}{27.4} \approx 1326.186$

Expressing 1326.186 in scientific notation:

$1326.186 \approx 1.326186 \times 10^3$

Rounding to 3 significant figures:

The first three significant digits are 1, 3, and 2.

Considering the fourth digit (6) causes the last significant digit to round up.

Thus,



$1.326186 \times 10^3 \approx 1.33 \times 10^3$

In standard decimal form, this is written as:

1330

Hence, the final reported value is:

$y = 1330$

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# Question12

## Match List - I with List - II.

| List - I | List - II |
|---|---|
| (A) Angular Impulse | (I) $M^0 L^2 T^{-2}$ |
| (B) Latent Heat | (II) $M L^2 T^{-3} A^{-1}$ |
| (C) Electrical resistivity | (III) $M L^2 T^{-1}$ |
| (D) Electromotive force | (IV) $M L^3 T^{-3} A^{-2}$ |

# Choose the correct answer from the options given below:

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**Options:**

A.

(A)-(II), (B)-(I), (C)-(IV), (D)-(III)

B.

(A)-(I), (B)-(III), (C)-(IV), (D)-(II)

C.

(A)-(III), (B)-(I), (C)-(IV), (D)-(II)

D.

(A)-(III), (B)-(I), (C)-(II), (D)-(IV)

**Answer: C**



# Solution:

Matching the quantities from List - I with their correct dimensions from List - II is crucial to understanding their physical significance. Here is the correct matching:

**(A) Angular Impulse:** The dimensions of angular impulse are equivalent to those of angular momentum, represented as $ML^2T^{-1}$. Hence, (A) corresponds to (III).

**(B) Latent Heat:** Latent heat has dimensions of energy per unit mass, which simplifies to $M^0L^2T^{-2}$. Hence, (B) corresponds to (I).

**(C) Electrical resistivity:** Electrical resistivity has the dimensions of resistance multiplied by length, which can be represented as $ML^3T^{-3}A^{-2}$. Hence, (C) corresponds to (IV).

**(D) Electromotive force:** Electromotive force (emf) is similar to electric potential difference and has dimensions $ML^2T^{-3}A^{-1}$. Hence, (D) corresponds to (II).

Therefore, the correct answer is **Option C**:

(A)-(III)

(B)-(I)

(C)-(IV)

(D)-(II)

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# Question13

## The expression given below shows the variation of velocity ($v$) with time ($t$),

$v = \mathrm{At}^2 + \frac{\mathrm{Bt}}{\mathrm{C+t}}$.

## The dimension of ABC is :

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**Options:**

A.

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

B.



$[M^0L^2T^{-3}]$

C.

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

D.

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

**Answer: B**

## Solution:

$$\left[\mathrm{LT}^{-1}\right] = [\mathrm{A}]\left[\mathrm{T}^2\right] = \frac{[\mathrm{B}][\mathrm{T}]}{[\mathrm{C}]+[\mathrm{T}]}$$
$$[\mathrm{C}] = [\mathrm{T}]$$
$$[\mathrm{A}] = \left[\mathrm{LT}^{-3}\right]$$
$$[\mathrm{B}] = \left[\mathrm{LT}^{-1}\right]$$
$$[\mathrm{ABC}] = \left[\mathrm{L}^2\,\mathrm{T}^{-3}\right]$$

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# Question14

## The pair of physical quantities not having the same dimensions is :

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**Options:**

A.

Angular momentum and Planck's constant

B.

Torque and energy

C.

Surface tension and impulse

D.



Pressure and Young's modulus

**Answer: C**

## Solution:

$[\tau] = [\mathrm{E}]$
$[\sigma] \neq [\mathrm{I}]$
$[\mathrm{L}] = [\mathrm{h}]$
$[\mathrm{P}] = [\mathrm{Y}]$

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# Question15

## Match List - I with List - II.

| List - I | List - II |
|---|---|
| (A) Young's Modulus | (I) $M L^{-1} T^{-1}$ |
| (B) Torque | (II) $M L^{-1} T^{-2}$ |
| (C) Coefficient of Viscosity | (III) $M^{-1} L^{3} T^{-2}$ |

| | |
|---|---|
| (D) Gravitational Constant | (IV) M $L^2$ $T^{-2}$ |

## Choose the correct answer from the options given below :

## JEE Main 2025 (Online) 29th January Evening Shift

**Options:**

A. (A)-(I), (B)-(III), (C)-(II), (D)-(IV)

B. (A)-(IV), (B)-(II), (C)-(III), (D)-(I)

C. (A)-(II), (B)-(I), (C)-(IV), (D)-(III)

D. (A)-(II), (B)-(IV), (C)-(I), (D)-(III)

**Answer: D**

## Solution:

We know, Young's modulus, $E = \frac{\sigma}{\varepsilon}$ 

$\Rightarrow E = \frac{\frac{F}{A}}{\frac{\Delta L}{L}} = \frac{F}{A}\left(\frac{L}{\Delta L}\right)$

$\Rightarrow [E] = \frac{[F]}{[A]} = \frac{[M^1L^1T^{-2}]}{[L^2]}$

(A) $\Rightarrow [E] = [M^1L^{-1}T^{-2}]$

(B) we know, Torque = $r \times F$

$[\tau] = [r][F]$

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

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

(C) We know, $F = \mu A \frac{u}{y}$

where, F = force, $\mu$ = coefficient of viscosity

A = area $\frac{u}{y}$ = rate of shear deformation

$\Rightarrow \mu = \frac{Fy}{Au}$

$\Rightarrow [\mu] = \frac{[M^1L^1T^{-2}][L]}{[L^2][LT^{-1}]}$

$\Rightarrow [\mu] = [M^1L^{-1}T^{-1}]$

(D) We know, $F=\frac{Gm_1m_2}{r^2}$ (Newton's law of gravitation)

$\Rightarrow G=\frac{Fr^2}{m_1m_2} <\Rightarrow G=\frac{Fr^2}{m_1m_2}$

$\Rightarrow [G]=\frac{[M^1L^1T^{-2}][L^2]}{[M^2]}$

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

Hence, option D is correct.

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# Question16

## Match List I with List II.

| | List - I | | List - II |
|---|---|---|---|
| (A) | Coefficient of viscosity | (I) | $\left[ML^0T^{-3}\right]$ |
| (B) | Intensity of wave | (II) | $\left[ML^{-2}T^{-2}\right]$ |
| (C) | Pressure gradient | (III) | $\left[M^{-1}LT^2\right]$ |
| (D) | Compressibility | (IV) | $\left[ML^{-1}T^{-1}\right]$ |



## Choose the correct answer from the options given below:

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**Options:**

A. (A)-(II), (B)-(III), (C)-(IV), (D)-(I)

B. (A)-(IV), (B)-(II), (C)-(I), (D)-(III)

C. (A)-(IV), (B)-(I), (C)-(II), (D)-(III)

D. (A)-(I), (B)-(IV), (C)-(III), (D)-(II)

**Answer: C**

## Solution:

Here are the dimensional formulas:

Coefficient of viscosity, μ

$[\mu] = \frac{\text{pressure} \quad \times\text{time}}{} = \frac{[M L^{-1}T^{-2}] [T]}{} = [M L^{-1}T^{-1}] \quad \longrightarrow$ (IV)

Intensity of a wave, I

$[I] = \frac{\text{power}}{\text{area}} = \frac{[M L^{2}T^{-3}]}{[L^2]} = [M L^{0}T^{-3}] \quad \longrightarrow$ (I)

Pressure gradient, dP/dx

$\left[\frac{dP}{dx}\right] = \frac{[M L^{-1}T^{-2}]}{[L]} = [M L^{-2}T^{-2}] \quad \longrightarrow$ (II)

Compressibility, κ

$[\kappa] = \frac{1}{[\text{pressure} \quad ]} = [M^{-1} L T^{2}] \quad \longrightarrow$ (III)

Matching gives

(A)–(IV), (B)–(I), (C)–(II), (D)–(III), i.e. **Option C**.

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# Question17

## Given a charge q , current I and permeability of vacuum $\mu_{0^*}$. Which of the following quantity has the dimension of momentum ?



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**Options:**

A. $qI/\mu_o$

B. $q^2\mu_o I$

C. $q\mu_0/I$

D. q$\mu_o$I

**Answer: D**

## Solution:

$Q = AT$
$I = A$
$\mu_0 = MLT^{-2}\,A^{-2}$
$P = Q^x \mu_0^y I^z = \left[AT^x\left[MLT^{-2}\,A^{-2}\right]^y[\,A]^z\right.$
$MLT^{-1} = M^y\,L^y\,T^{x-2y}\,A^{-2y+z+x}$
Now; $y = 1$
$x - 2y = -1$
$-2y + z = 0$
$\therefore x = y = z = 1$

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# Question18

## If $\mu_0$ and $\epsilon_0$ are the permeability and permittivity of free space, respectively, then the dimension of $\left(\frac{1}{\mu_0\epsilon_0}\right)$ is :

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**Options:**

A. $T^2/L$



B. $L^2/T^2$

C. $T^2/L^2$

D. $L/T^2$

**Answer: B**

## Solution:

The expression $\frac{1}{\mu_0\epsilon_0}$ is related to the speed of light $c$, given by the equation:

$c = \frac{1}{\sqrt{\mu_0\epsilon_0}}$

Therefore, we have:

$\frac{1}{\mu_0\epsilon_0} = c^2$

The speed of light $c$ has the dimensions of $L\,T^{-1}$, where L is the dimension of length and T is the dimension of time. Thus, when squared, the dimensions become:

$c^2 = (L\,T^{-1})^2 = L^2T^{-2}$

Hence, the dimensions of $\frac{1}{\mu_0 \epsilon_0}$ are $\mathrm{L}^2 \mathrm{T}^{-2}$.

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# Question19

## A person measures mass of 3 different particles as $435.42\ \mathrm{g}$, $226.3\ \mathrm{g}$ and 0.125 g . According to the rules for arithmetic operations with significant figures, the addition of the masses of 3 particles will be.

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**Options:**

A. 661.845 g

B. 661.84 g

C. 662 g

D. 661.8 g



**Answer: D**

## Solution:

To calculate the total mass of the three particles, we perform the following addition:

$m_1 + m_2 + m_3 = 435.42\,\mathrm{g} + 226.3\,\mathrm{g} + 0.125\,\mathrm{g}$

When adding numbers, the result should be reported with the same number of decimal places as the measurement with the fewest decimal places. Here, the second measurement (226.3 g) has only one decimal place, which is the fewest among the given values.

Thus, according to the rules for significant figures in addition, the sum should be rounded to one decimal place:

Total mass $= 661.8\,\mathrm{g}$

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# Question20

## Match the LIST-I with LIST-II Match the LIST-I with LIST-II

| LIST-I | | LIST-II | |
|---|---|---|---|
| A. | Boltzmann constant Boltzmann constant | I | ML2 T−1 |
| B | Coefficient of viscosity Coefficient of viscosity | II | MLT−3 K−1 |
| C | Planck's constant Planck's constant | III | ML2 T−2 K−1 |
| D | Thermal conductivity Thermal conductivity | IV | ML−1 T−1 |

# Choose the correct answer from the options given below:

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### Options:

A. A - III, B - IV, C - I, D - II

B. A - III, B - IV, C - II, D - I

C. A - III, B - II, C - I, D - IV

D. A - II, B - III, C - IV, D - I



**Answer: A**

# Solution:

### Explanation of Dimensional Analysis

In order to match the quantities from LIST-I with their respective dimensions in LIST-II, we need to analyze their dimensional formulas:

**(A) Boltzmann Constant [k]:**

The equation relating pressure (P), volume (V), number of moles (N), and temperature (T) gives us:

$$[\mathrm{k}] = \frac{\mathrm{PV}}{\mathrm{NT}} = \frac{\mathrm{ML^2\,T^{-2}}}{\mathrm{K}} = \mathrm{ML^2\,T^{-2}\,K^{-1}}$$

This corresponds to option III.

**(B) Coefficient of Viscosity [η]:**

The coefficient of viscosity can be defined using the relation:

$$[\eta] = \frac{\mathrm{F}}{6\pi \mathrm{rv}} = \frac{\mathrm{MLT^{-2}}}{\mathrm{L^2\,T^{-1}}} = \mathrm{ML^{-1}\,T^{-1}}$$

This corresponds to option IV.

**(C) Planck's Constant [h]:**

The relationship between energy (E) and frequency (f) gives the dimensional formula:

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

This corresponds to option I.

**(D) Thermal Conductivity [k]:**

From the heat conduction equation, we get:

$\mathrm{k}=\frac{\left(\mathrm{ML}^2 \mathrm{~T}^{-3}\right) \mathrm{L}}{\mathrm{L}^2 \cdot \mathrm{~K}}=\mathrm{MLT}^{-3} \mathrm{~K}^{-1}$

This corresponds to option II.

To conclude, the correct matches are:

A - III

B - IV

C - I

D - II

This analysis ensures each physical quantity is aligned with its correct dimensional representation.

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# Question21



## In an electromagnetic system, the quantity representing the ratio of electric flux and magnetic flux has dimension of $M^P L^Q T^R A^S$, where value of ' $Q$ ' and ' $R$ ' are

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**Options:**

A. $(3,-5)$

B. $(-2,1)$

C. $(-2,2)$

D. $(1,-1)$

**Answer: D**

# Solution:

To solve this problem, we need to find the dimensions of the electric flux and the magnetic flux, and then take their ratio.

Determine the dimension of electric flux ($\Phi_e$):

Electric flux is defined as

$\Phi_E = \int_S \mathbf{E} \cdot d\mathbf{A}.$

The electric field $\mathbf{E}$ has dimensions:

$[E] = \frac{\text{Force}}{\text{Charge}}.$

Since force has dimensions $MLT^{-2}$, and charge (in SI) has dimensions $AT$, we get:

$[E] = \frac{MLT^{-2}}{AT} = MLT^{-3}A^{-1}.$

The area element $dA$ has dimensions $L^2$.

Thus, the electric flux has dimensions:

$[\Phi_E] = [E][A] = MLT^{-3}A^{-1} \times L^2 = ML^3T^{-3}A^{-1}.$

Determine the dimension of magnetic flux (Φ_B):

Magnetic flux is defined as



$\Phi_B = \int_S \mathbf{B} \cdot d\mathbf{A}.$

The magnetic field $\mathbf{B}$ has dimensions determined via the Lorentz force law (using $F = qvB$), giving:

$[B] = \frac{F}{qv} = \frac{MLT^{-2}}{(AT)(LT^{-1})} = MT^{-2}A^{-1}.$

Again, the area element has dimensions $L^2$.

So the magnetic flux has dimensions:

$[\Phi_B] = [B][A] = (MT^{-2}A^{-1})(L^2) = ML^2T^{-2}A^{-1}.$

Find the ratio of electric flux to magnetic flux:

Taking the ratio:

$\frac{\Phi_E}{\Phi_B} = \frac{ML^3T^{-3}A^{-1}}{ML^2T^{-2}A^{-1}}.$

Canceling like terms:

Mass $(M)$ cancels.

Current $(A^{-1})$ cancels.

For length, $L^{3-2} = L^1$.

For time, $T^{-3-(-2)} = T^{-1}$.

Therefore, the ratio has dimensions:

$L^1 T^{-1}$.

This means in the expression

$M^P L^Q T^R A^S$,

the exponents for length and time are $Q = 1$ and $R = -1$.

Looking at the options provided, this corresponds to Option D: $(1, -1)$.

Thus, the answer is Option D.

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# Question22

## For the determination of refractive index of glass slab, a travelling microscope is used whose main scale contains 300 equal divisions equals to 15 cm . The vernier scale attached to the microscope has 25 divisions equals to 24 divisions of main scale. The least count (LC) of the travelling microscope is (in cm ) :



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**Options:**

A. 0.002

B. 0.0025

C. 0.0005

D. 0.001

**Answer: A**

## Solution:

**Determine one main scale division (msd):**

$300 \, \text{msd} = 15 \, \text{cm}$

Therefore,

$1 \, \text{msd} = \frac{15}{300} \, \text{cm} = 0.05 \, \text{cm}$

**Determine one vernier scale division (vsd):**

$25 \, \text{vsd} = 24 \, \text{msd}$

Therefore,

$1 \, \text{vsd} = \frac{24}{25} \, \text{msd}$

**Calculate the least count (LC):**

The least count is given by the difference between one main scale division and one vernier scale division:

$\text{LC} = 1 \, \text{msd} - 1 \, \text{vsd}$

Substitute the expression for 1 vsd:

$\text{LC} = 1 \, \text{msd} - \frac{24}{25} \times 1 \, \text{msd}$

This simplifies to:

$\text{LC} = \frac{1}{25} \times 1 \, \text{msd}$

**Calculate the LC in cm:**

Substituting the value of 1 msd:

$\text{LC} = \frac{1}{25} \times 0.05 \, \text{cm} = 0.002 \, \text{cm}$

Hence, the least count of the traveling microscope is 0.002 cm.



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# Question23

## In an electromagnetic system, a quantity defined as the ratio of electric dipole moment and magnetic dipole moment has dimension of $\left[\mathrm{M}^{\mathrm{P}} \mathrm{L}^{\mathrm{Q}} \mathrm{T}^{R} A^{\mathrm{S}}\right]$. The value of P and Q are :

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**Options:**

A. $-1, 0$

B. $0, -1$

C. $-1, 1$

D. $1, -1$

**Answer: B**

## Solution:

Electric dipole moment $(\overrightarrow{P}) = q \times 2\ell$

Magnetic dipole moment $(\overrightarrow{M}) = IA$

$\left[\frac{P}{M}\right] = \left[\frac{LTA}{L^2 A}\right] = L^{-1} T = M^0 L^{-1} T^1 A^0$

After compering values of $P \& Q$ are $0, -1$

Correct Answer : Option 4

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# Question24

## Match List - I with List - II.

| List - I | List - II |
|---|---|
| (A) Mass density | (I) $[ML^2T^{-3}]$ |
| (B) Impulse | (II) $[MLT^{-1}]$ |
| (C) Power | (III) $[ML^2T^0]$ |
| (D) Moment of inertia | (IV) $[ML^{-3}T^0]$ |



## Choose the correct answer from the options given below :

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**Options:**

A.

(A)-(IV), (B)-(II), (C)-(III), (D)-(I)

B.

(A)-(II), (B)-(III), (C)-(IV), (D)-(I)

C.

(A)-(IV), (B)-(III), (C)-(I), (D)-(II)

D.

(A)-(IV), (B)-(II), (C)-(I), (D)-(III)

**Answer: D**

## Solution:

**(A) Mass density:**

Mass density is defined as mass per unit volume.

The dimension of mass is $[M]$.

The dimension of volume is $[L^3]$.

Therefore, the dimension of mass density is $\frac{[M]}{[L^3]} = [ML^{-3}T^0]$.

Matches with (IV).

**(B) Impulse:**

Impulse is defined as the change in momentum, or force multiplied by time.

Impulse = Force x Time

The dimension of force is $[MLT^{-2}]$.



The dimension of time is $[T]$.

Therefore, the dimension of impulse is $[MLT^{-2}] \cdot [T] = [MLT^{-1}]$.

Matches with (II).

**(C) Power:**

Power is defined as the rate of doing work or energy per unit time.

Power = Work / Time

The dimension of work (or energy) is $[ML^2T^{-2}]$.

The dimension of time is $[T]$.

Therefore, the dimension of power is $\frac{[ML^2T^{-2}]}{[T]} = [ML^2T^{-3}]$.

Matches with (I).

**(D) Moment of inertia:**

Moment of inertia is defined as $I = mr^2$, where m is mass and r is the distance from the axis of rotation.

The dimension of mass is $[M]$.

The dimension of distance squared is $[L^2]$.

Therefore, the dimension of moment of inertia is $[ML^2T^0]$.

Matches with (III).

So, the correct matches are:

(A) - (IV)

(B) - (II)

(C) - (I)

(D) - (III)

Therefore, the correct option is **D**.

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# Question25

## The dimension of $\sqrt{\frac{\mu_0}{\epsilon_0}}$ is equal to that of:

## ($\mu_0$ = Vacuum permeability and $\epsilon_0$ = Vacuum permittivity)

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**Options:**

A.

Voltage

B.

Inductance

C.

Resistance

D.

Capacitance

**Answer: C**

## Solution: