

## Physical World, Units and Measurements

Topic-1: Unit of Physical Quantities

## 1 MCQs with One Correct Answer

1. Given below are two statements :

Statement I : Astronomical unit (Au). Parsec (Pc) and Light year (ly) are units for measuring astronomical distances.
Statement II : Au < Parsec (Pc) < ly [Main April 11, 2023 (I)]
In the light of the above statements choose the most appropriate answer from the options given below:
(a) Both Statement I and Statement II are correct.
(b) Statement I is correct but Statement II is incorrect.
(c) Both Statement I and Statement II are incorrect.
(d) Statement I is incorrect but Statement II is correct.
2. Electric field in a certain region is given by
$\vec{E}=\left(\frac{A}{x^{2}} \hat{i}+\frac{B}{y^{3}} \hat{j}\right)$. The SI unit of $A$ and $B$ are:
[Main Jan. 30, 2023 (I)]
(a) $\mathrm{Nm}^{3} \mathrm{C}^{-1} ; \mathrm{Nm}^{2} \mathrm{C}^{-1}$
(b) $\mathrm{Nm}^{2} \mathrm{C}^{-1} ; \mathrm{Nm}^{3} \mathrm{C}^{-1}$
(c) $\mathrm{Nm}^{3} \mathrm{C} ; \mathrm{Nm}^{2} \mathrm{C}$
(d) $\mathrm{Nm}^{2} \mathrm{C} ; \mathrm{Nm}^{3} \mathrm{C}$
3. Velocity (v) and acceleration (a) in two systems of units 1 and 2 are related as $v_{2}=\frac{n}{m^{2}} v_{1}$ and $a_{2} \xlongequal{\circ} \frac{a_{1}}{m n}$ respectively. Here $m$ and $n$ are constants. The relations for distance and time in two systems respectively are:
(a) $\frac{n^{3}}{m^{3}} L_{1}=L_{2}$ and $\frac{n^{2}}{m} T_{1}=T_{2} \quad$ [MainJune 28, 2022 (III)]
(b) $L_{1}=\frac{n^{4}}{m^{2}} L_{2}$ and $T_{1}=\frac{n^{2}}{m} T_{2}$
(c) $L_{1}=\frac{n^{2}}{m} L_{2}$ and $T_{1}=\frac{n^{4}}{m^{2}}=T_{2}$
(d) $\frac{n^{2}}{m} L_{1}=L_{2}$ and $\frac{n^{4}}{m^{2}} T_{1}=T_{2}$
4. The distance of the Sun from earth is $1.5 \times 10^{11} \mathrm{~m}$ and its angular diameter is (2000) $s$ when observed from the earth. The diameter of the Sun will be : [Main June 27, 2022 (III)]
(a) $2.45 \times 10^{10} \mathrm{~m}$
(b) $1.45 \times 10^{10} \mathrm{~m}$
(c) $1.45 \times 10^{9} \mathrm{~m}$
(d) $0.14 \times 10^{9} \mathrm{~m}$
5. If $E$ and $H$ represents the intensity of electric field and magnetising field respectively, then the unit of $\mathrm{E} / \mathrm{H}$ will be :
[Main Aug. 27, 2021 (I)]
(a) ohm
(b) mho
(c) joule
(d) newton
6. The density of a material in SI unit is $128 \mathrm{~kg} \mathrm{~m}^{-3}$. In certain units in which the unit of length is 25 cm and the unit of mass is 50 g , the numerical value of density of the material is:
[Main 10 Jan. 2019 (I)]
(a) 40
(b) 16
(c) 640
(d) 410
7. A metal sample carrying a current along X-axis with density $\mathrm{J}_{\mathrm{x}}$ is subjected to a magnetic field $\mathrm{B}_{\mathrm{z}}$ (along z -axis). The electric field $\mathrm{E}_{\mathrm{y}}$ developed along Y -axis is directly proportional to $J_{x}$ as well as $B_{z}$. The constant of proportionality has SI unit [Main Online April 25, 2013]
(a) $\frac{m^{2}}{A}$
(b) $\frac{m^{3}}{A s}$
(c) $\frac{m^{2}}{A s}$
(d) $\frac{A s}{m^{3}}$
8. The $S I$ unit of inductance, the henry can be written as
[1998-2 Marks]
(a) weber/ampere
(b) volt-sec/amp
(c) Joule/(ampere) ${ }^{2}$
(d) ohm-second

## 7 Match the Following

9. Match List I with List II
[Main Jan. 25, 2023 (I)]

|  | List - I |  | List - II |
| :--- | :--- | :--- | :--- |
| A | Surface tension | I. | $\mathrm{Kg} \mathrm{m}^{-1} \mathrm{~s}^{-1}$ |
| B | Pressure | II. | $\mathrm{Kg} \mathrm{ms}^{-1}$ |
| C | Viscosity | III. | $\mathrm{Kg} \mathrm{m}^{-1} \mathrm{~s}^{-2}$ |
| D | Impulse | IV. | $\mathrm{Kg} \mathrm{s}^{-2}$ |

Choose the correct answer from the options given below:
(a) A-IV, B-III, C-II, D-I
(b) A-IV, B-III, C-I, D-II
(c) A-III, B-IV, C-I, D-II
(d) A-II, B-I, C-III, D-IV
10. Match List I with List II.
[Main July 29, 2022 (II)]

| List I |  | List II |  |
| :--- | :--- | :--- | :--- |
| A. | Torque | I. | $\mathrm{Nms}^{-1}$ |
| B. | Stress | II. | $\mathrm{J} \mathrm{kg}^{-1}$ |
| C. | Latent Heat | III. | Nm |
| D. | Power | IV. | $\mathrm{Nm}^{-2}$ |

Choose the correct answer from the options given below:
(a) A-III, B-II, C-I, D-IV
(b) A-III, B-IV, C-II, D-I
(c) A-IV, B-I, C-III, D-II
(d) A-II, B-III, C-I, D-IV

## 11. <br> Column I

(A) $G M_{e} M_{s}, G-$ universal gravitational constant,
$M_{e}$ - mass of the earth,
$M_{s}$ - mass of the Sun
(B) $\frac{3 R T}{M}, R$-universal gas constant,
(q) (kilogram) (metre) ${ }^{3}$
(second) $)^{-2}$
$T$ - absolute temperature,
$M$ - molar mass
(C) $\frac{F^{2}}{q^{2} B^{2}}, F$-Force,
(r) $(\text { metre })^{2}(\text { second })^{-2}$
$q$ - charge,
$B$ - magnetic field

Column II
(p) (volt) (coulomb)(metre)
12.
2.
olumn I
(A) Capacitance
(B) Inductance
(C) Magnetic Induction
(s) $($ farad $)(\text { volt })^{2}(\mathrm{~kg})^{-1}$
[2007]
Column II
(i) ohm-second
(ii) coulomb ${ }^{2}$-joule ${ }^{-1}$
(iii) coulomb (volt) ${ }^{-1}$
(iv) newton (amp-metre) $)^{-1}$
(v) volt-second (ampere) ${ }^{-1}$
[1990-3 Marks]

## 10 Subjective Problems

13. Give the MKS units for each of the following quantities.
(A) Young's modulus
[1980]
(B) Magnetic Induction
(C) Power of a lens

## Topic-2: Dimensions of Physical Quantities

## 1 MCQs with One Correct Answer

1. Young's modulus of elasticity Y is expressed in terms of three derived quantities, namely, the gravitational constant G, Planck's constant $h$ and the speed of light $c$, as $Y=c^{\alpha} h^{\beta} G^{\gamma}$. Which of the following is the correct option?
[Adv. 2023]
(a) $\alpha=7, \beta=-1, \gamma=-2$
(b) $\alpha=-7, \beta=-1, \gamma=-2$
(c) $\alpha=7, \beta=-1, \gamma=2$
(d) $\alpha=-7, \beta=1, \gamma=-2$
2. The speed of a wave produced in water is given by $v=\lambda^{\mathrm{a}} \mathrm{g}^{\mathrm{b}} \rho^{\mathrm{c}}$. Where, $\lambda$, g and $\rho$ are wayelength of wave, acceleration due to gravity and density of water respectively. The values of $\mathrm{a}, \mathrm{b}$ and c respectively, are:
[Main April 15, 2023 (I)]
(a) $\frac{1}{2}, \frac{1}{2}, 0$
(b) 1, 1, 0
(c) $1,-1,0$
(d) $\frac{1}{2}, 0, \frac{1}{2}$
3. In the equation $\left[X+\frac{a}{Y^{2}}\right][y-b]=R T, X$ is pressure, $Y$ is volume, R is universal gas constant and T is temperature. The physical quantity equivalent to the ratio $\frac{\mathrm{a}}{\mathrm{b}}$ is :
[Main April 13, 2023 (II)]
(a) Energy
(b) Impulse
(c) Pressure gradient
(d) Coefficient of viscosity
4. If force ( F ), velocity $(\mathrm{V})$ and time ( T$)$ are considered as fundamental physical quantity, then dimensional formula of density will be:
[Main April 11, 2023 (III)]
(a) $\mathrm{FV}^{-2} \mathrm{~T}^{2}$
(b) $\mathrm{FV}^{-4} \mathrm{~T}^{-2}$
(c) $\mathrm{FV}^{4} \mathrm{~T}^{-6}$
(d) $\mathrm{F}^{2} \mathrm{~V}^{-2} \mathrm{~T}^{6}$
5. Dimension of $\frac{1}{\mu_{0} \epsilon_{0}}$ should be equal to
[Main April 8, 2023 (I)]
(a) $\frac{\mathrm{T}^{2}}{\mathrm{~L}^{2}}$
(b) $\frac{\mathrm{L}}{\mathrm{T}}$
(c) $\frac{\mathrm{L}^{2}}{\mathrm{~T}^{2}}$
(d) $\frac{\mathrm{T}}{\mathrm{L}}$
6. $\left(P+\frac{a}{\mathrm{~V}^{2}}\right)(V-b)=R T$ represents the equation of state of some gases. Where $P$ is the pressure, $V$ is the volume, $T$ is the temperature and $a, b, R$ are the constants. The physical quantity, which has dimensional formula as that of $\frac{b^{2}}{a}$, will be:
[Main Feb. 1, 2023 (I)]
(a) Bulk modules
(b) Modulus of rigidity
(c) Energy density
(d) Compressibility
7. If the velocity of light c , universal gravitational constant G and Planck's constant h are chosen as fundamental quantities. The dimensions of mass in the new system is:
(a) $\left[\mathrm{h}^{1 / 2} \mathrm{c}^{1 / 2} \mathrm{G}^{-1 / 2}\right]$
[Main Feb. 1, 2023 (III)]
(c) $\left[\mathrm{h}^{1} \mathrm{c}^{1} \mathrm{G}^{-1}\right]$
(b) $\left[\mathrm{h}^{-1 / 2} \mathrm{c}^{1 / 2} \mathrm{G}^{1 / 2}\right]$
8. If R, $X_{L}$. and $X_{C}$ represent resistance, inductive reactance and capacitive reactance. Then which of the following is dimensionless:
[Main Jan. 31, 2023 (I)]
(a) $R X_{L} X_{C}$
(b) $\frac{\mathrm{R}}{\sqrt{\mathrm{X}_{\mathrm{L}} \mathrm{X}_{\mathrm{C}}}}$
(c) $\frac{R}{X_{L} X_{C}}$
(d) $R \frac{X_{L}}{X_{C}}$
9. The equation of a circle is given by $x^{2}+y^{2}=a^{2}$, where $a$ is the radius. If the equation is modified to change the origin other than $(0,0)$, then find out the correct dimensions of A and $B$ in a new equation : $(x-A t)^{2}+\left(y-\frac{t}{B}\right)^{2}=a^{2}$
The dimensions oft is given as $\left[\mathrm{T}^{-1}\right]$. [Main Jan. 29, 2023 (III)]
(a) $\mathrm{A}=\left[\mathrm{L}^{-1} \mathrm{~T}\right], \mathrm{B}=\left[\mathrm{LT}^{-1}\right]$
(b) $\mathrm{A}=[\mathrm{LT}], \mathrm{B}=\left[\mathrm{L}^{-1} \mathrm{~T}^{-1}\right]$
(c) $\mathrm{A}=\left[\mathrm{L}^{-1} \mathrm{~T}^{-1}\right], \mathrm{B}=\left[\mathrm{LT}^{-1}\right]$
(d) $\mathrm{A}=\left[\mathrm{L}^{-1} \mathrm{~T}^{-1}\right], \mathrm{B}=[\mathrm{LT}]$
10. The frequency $(v)$ of an oscillating liquid drop may depend upon radius $(r)$ of the drop, density $(\rho)$ of liquid and the surface tension ( $s$ ) of the liquid as:
$v=r^{a} \rho^{b} s^{c}$. The values of $a, b$ and $c$ respectively are
[Main Jan. 24, 2023 (II)]
(a) $\left(-\frac{3}{2},-\frac{1}{2}, \frac{1}{2}\right)$
(b) $\left(\frac{3}{2},-\frac{1}{2}, \frac{1}{2}\right)$
(c) $\left(\frac{3}{2}, \frac{1}{2},-\frac{1}{2}\right)$
(d) $\left(-\frac{3}{2}, \frac{1}{2}, \frac{1}{2}\right)$
11. Given below are two statements: One is labelled as Assertion (A) and other is labelled as Reason (R).
Assertion (A): Time period of oscillation of a liquid drop depends on surface tension (S), if density of the liquid is $p$ and radius of the drop is $r$, then $T=\sqrt[K]{\frac{\mathrm{pr}^{3}}{\mathrm{~S}^{3 / 2}}}$ is dimensionally correct, where K is dimensionless.
Reason (R): Using dimensional analysis we get R.H.S. having different dimension than that of time period.
In the light of above statements, choose the correct answer from the options given below. [Main July 29, 2022 (I)]
(a) Both (A) and (R) are true and (R) is the correct explanation of (A)
(b) Both (A) and (R) are true but (R) is not the correct explanation of $(\mathrm{A})$
(c) (A) is true but (R) is false
(d) (A) is false but (R) is true
12. The dimensions of $\left(\frac{B^{2}}{\mu_{0}}\right)$ will be : (if $\mu_{0}$ : permeability of free space and B : magnetic field)
[Main Similar Jan 8, 2019 (II), July 28, 2022 (I)]
(a) $\left[\mathrm{M} \mathrm{L}^{2} \mathrm{~T}^{-2}\right]$
(b) $\left[\mathrm{M} \mathrm{L} \mathrm{T}^{-2}\right]$
(c) $\left[\mathrm{M} \mathrm{L}^{-1} \mathrm{~T}^{-2}\right]$
(d) $\left[\mathrm{M} \mathrm{L}^{2} \mathrm{~T}^{-2} \mathrm{~A}^{-1}\right]$
13. Consider the efficiency of carnot's engine is given by $\eta=\frac{\alpha \beta}{\sin \theta} \log e \frac{\beta x}{\mathrm{kT}}$, where $\alpha$ and $\beta$ are constants. If T is temperature, k is Boltzmann constant, $\theta$ is angular displacement and $x$ has the dimensions of length. Then, choose the incorrect option : [Main July 28, 2022 (II)]
(a) Dimensions of $\beta$ is same as that of force.
(b) Dimensions of $\alpha^{-1} x$ is same as that of energy.
(c) Dimensions of $\eta^{-1} \sin \theta$ is same as that of $\alpha \beta$.
(d) Dimensions of $\alpha$ is same as that of $\beta$.
14. An expression of energy density is given by $\mathrm{u}=\frac{\alpha}{\beta} \sin \left(\frac{\alpha \mathrm{x}}{\mathrm{kt}}\right)$. where $\alpha, \beta$ are constants, x is displacement, k is Boltzmann constant and t is the temperature. The dimensions of $\beta$ will be :
[Main July 27, 2022 (III)]
(a) $\left[\mathrm{ML}^{2} \mathrm{~T}^{-2} \theta^{-1}\right]$
(b) $\left[\mathrm{M}^{0} \mathrm{~L}^{2} \mathrm{~T}^{-2}\right]$
(c) $\left[\mathrm{M}^{0} \mathrm{~L}^{0} \mathrm{~T}^{0}\right]$
(d) $\left[\mathrm{M}^{0} \mathrm{~L}^{2} \mathrm{~T}^{0}\right]$
15. If momentum [P], area [A] and time [T] are taken as fundamental quantities, then the dimensional formula for coefficient of viscosity is:
[Main July 25, 2022 (I)]
(a) $\left[\mathrm{P} \mathrm{A}^{-1} \mathrm{~T}^{0}\right]$
(b) $\left[\mathrm{PA} \mathrm{T}^{-1}\right]$
(c) $\left[\mathrm{PA}^{-1} \mathrm{~T}\right]$
(d) $\left[\mathrm{P} \mathrm{A}^{-1} \mathrm{~T}^{-1}\right]$
16. Which of the following physical quantities have the same dimensions?
[Main July 25, 2022 (I)]
(a) Electric displacement $(\overrightarrow{\mathrm{D}})$ and surface charge density
(b) Displacement current and electric field
(c) Current density and surface charge density
(d) Electric potential and energy
17. In Vander Waals equation $\left[P+\frac{a}{V^{2}}\right][V-b]=R T ; P$ is pressure, $V$ is volume, $R$ is universal gas constant and T is temperature. The ratio of constants is $\frac{a}{b}$ dimensionally equal to
[Main June 29, 2022 (I)]
(a) $\frac{P}{V}$
(b) $\frac{V}{P}$
(c) $P V$
(d) $P V^{3}$
18. If $L, C$ and $R$ are the self inductance, capacitance and resistance respectively, which of the following does not have the dimension of time? [Main June 27, 2022 (III)]
(a) RC
(b) $\frac{L}{R}$
(c) $\sqrt{\mathrm{LC}}$
(d) $\frac{\mathrm{L}}{\mathrm{C}}$
19. The SI unit of a physical quantity is pascal-second. The dimensional formula of this quantity will be
[Main June 27, 2022 (III)]
(a) $\left[\mathrm{ML}^{-1} \mathrm{~T}^{-1}\right]$
(b) $\left[\mathrm{ML}^{-1} \mathrm{~T}^{-2}\right]$
(c) $\left[\mathrm{ML}^{2} \mathrm{~T}^{-1}\right]$
(d) $\left[\mathrm{M}^{-1} \mathrm{~L}^{3} \mathrm{~T}^{0}\right]$
20. An expression for a dimensionless quantity $P$ is given by $P=\frac{\alpha}{\beta} \log _{e}\left(\frac{k t}{\beta x}\right)$; where $\alpha$ and $\beta$ are constants, $x$ is distance; $k$ is Boltzmann constant and $t$ is the temperature. Then the dimensions of $\alpha$ will be: [Main June 26, 2022 (I)]
(a) $\left[\mathrm{M}^{0} \mathrm{~L}^{-1} \mathrm{~T}^{0}\right]$
(b) $\left[\mathrm{ML}^{0} \mathrm{~T}^{-2}\right]$
(c) $\left[\mathrm{MLT}^{-2}\right]$
(d) $\left[\mathrm{ML}^{2} \mathrm{~T}^{-2}\right]$
21. The dimension of mutual inductance is :
[Main June 26, 2022 (II)]
(a) $\left[\mathrm{ML}^{2} \mathrm{~T}^{-2} \mathrm{~A}^{-1}\right]$
(b) $\left[\mathrm{ML}^{2} \mathrm{~T}^{-3} \mathrm{~A}^{-1}\right]$
(c) $\left[\mathrm{ML}^{2} \mathrm{~T}^{-2} \mathrm{~A}^{-2}\right]$
(d) $\left[\mathrm{ML}^{2} \mathrm{~T}^{-3} \mathrm{~A}^{-2}\right]$
22. Identify the pair of physical quantities which have different dimensions:
[Main June 24, 2022 (I)]
(a) Wave number and Rydberg's constant
(b) Stress and Coefficient of elasticity
(c) Coercivity and Magnetisation
(d) Specific heat capacity and Latent heat
23. Identify the pair of physical quantities that have same dimensions:
[Main June 24, 2022 (II)]
(a) velocity gradient and decay constant
(b) wien's constant and Stefan constant
(c) angular frequency and angular momentum
(d) wave number and Avogadro number
24. Which of the following equations is dimensionally incorrect? Where $\mathrm{t}=$ time, $\mathrm{h}=$ height, $\mathrm{s}=$ surface tension, $\theta=$ angle, $\rho=$ density, $r=$ radius, $g=$ acceleration due to gravity, $\mathrm{V}=$ volume, $\mathrm{P}=$ pressure, $\mathrm{W}=$ work done, $\in=$ permittivity, $\mathrm{E}=$ electric field, $\mathrm{J}=$ current density, $\mathrm{L}=$ length, $\tau=$ torque
[Main Aug. 31, 2021 (I)]
(a) $\mathrm{v}=\frac{\pi \mathrm{pa}^{4}}{8 \eta \mathrm{~L}}$
(b) $\mathrm{h}=\frac{2 \mathrm{~s} \cos \theta}{\rho \mathrm{rg}}$
(c) $\mathrm{J}=\in \frac{\partial \mathrm{E}}{\partial \mathrm{t}}$
(d) $\mathrm{W}=\tau \theta$
25. Which of the following is not a dimensionless quantity?
[Main Aug. 27, 2021 (I)]
(a) Relative magnetic permeability $\left(\mu_{\mathrm{r}}\right)$
(b) Power factor
(c) Permeability of free space $\left(\mu_{0}\right)$
(d) Quality factor
26. If force $(\mathrm{F})$, length $(\mathrm{L})$ and time $(\mathrm{T})$ are taken as the fundamental quantities. Then what will be the dimension of density: [Main Sep. 02, 2020 (I) (S); Sep. 02, 2020 (III) (S); 11 Jan. 2019 (III) (S);9 Jan. 2019 (I) (S); Online April 15, 2018 (S); Online April 10, 2015 (S); Online May 7, 2012 (S);

Aug. 27, 2021 (II)]
(a) $\left[\mathrm{FL}^{-4} \mathrm{~T}^{2}\right]$
(b) $\left[\mathrm{FL}^{-3} \mathrm{~T}^{2}\right]$
(c) $\left[\mathrm{FL}^{-5} \mathrm{~T}^{2}\right]$
(d) $\left[\mathrm{FL}^{-3} \mathrm{~T}^{3}\right]$
27. If $\mathrm{E}, \mathrm{L}, \mathrm{M}$ and G denote the quantities as energy, angular momentum, mass and constant of gravitation respectively, then the dimensions of P in the formula $\mathrm{P}=\mathrm{EL}^{2} \mathrm{M}^{-5} \mathrm{G}^{-2}$ are :-
[Main Aug. 26, 2021 (I)]
(a) $\left[\mathrm{M}^{0} \mathrm{~L}^{1} \mathrm{~T}^{0}\right]$
(b) $\left[\mathrm{M}^{-1} \mathrm{~L}^{-1} \mathrm{~T}^{2}\right]$
(c) $\left[\mathrm{M}^{1} \mathrm{~L}^{1} \mathrm{~T}^{-2}\right]$
(d) $\left[\mathrm{M}^{0} \mathrm{~L}^{0} \mathrm{~T}^{0}\right]$
28. The force is given in terms of time $t$ and displacement $x$ by the equation
$\mathrm{F}=\mathrm{A} \cos \mathrm{Bx}+\mathrm{C} \sin \mathrm{Dt}$
[Main July 25, 2021 (II)]
The dimensional formula of $\frac{A D}{B}$ is :
(a) $\left[\mathrm{M}^{0} \mathrm{~L} \mathrm{~T}^{-1}\right]$
(b) $\left[\mathrm{M} \mathrm{L}^{2} \mathrm{~T}^{-3}\right]$
(c) $\left[\mathrm{M}^{1} \mathrm{~L}^{1} \mathrm{~T}^{-2}\right]$
(d) $\left[\mathrm{M}^{2} \mathrm{~L}^{2} \mathrm{~T}^{-3}\right]$
29. If $e$ is the electronic charge, $c$ is the speed of light in free space and h is Planck's constant, the quantity $\frac{1}{4 \pi \varepsilon_{0}} \frac{|\mathrm{e}|^{2}}{\mathrm{hc}}$ has dimensions of:
[Main Feb. 25, 2021 (II)]
(a) $\left[\mathrm{M} \mathrm{L} \mathrm{T}^{-1}\right]$
(b) $\left[\mathrm{M} \mathrm{L} \mathrm{T}^{0}\right]$
(c) $\left[\mathrm{LC}^{-1}\right]$
(d) $\left[\mathrm{M}^{0} \mathrm{~L}^{0} \mathrm{~T}^{0}\right]$
30. In a typical combustion engine the work done by a gas molecule is given by $W=\alpha^{2} \beta e^{-\frac{\beta x^{2}}{k T}}$, where $x$ is the displacement, k is the Boltzmann constant and T is the temperature, If $\alpha$ and $\beta$ are constants, dimensions of $\alpha$ will be
[Main 11 Jan. 2019 (S); Feb. 26, 2021 (I)]
(a) $\left[\mathrm{MLT}^{-1}\right]$
(b) $\left[\mathrm{M}^{0} \mathrm{LT}^{0}\right]$
(c) $\left[\mathrm{MLT}^{-2}\right]$
(d) $\left[\mathrm{M}^{2} \mathrm{LT}^{-2}\right]$
31. The quantities $x=\frac{1}{\sqrt{\mu_{0} \varepsilon_{0}}}, y=\frac{E}{B}$ and $z=\frac{l}{C R}$ are defined where $C$-capacitance, $R$-Resistance, $l$-length, $E$-Electric field, $B$-magnetic field and $\varepsilon_{0}, \mu_{0}$, - free space permittivity and permeability respectively. Then :
[Main Sep. 05, 2020 (II)]
(a) $x, y$ and $z$ have the same dimension.
(b) Only $x$ and $z$ have the same dimension.
(c) Only $x$ and $y$ have the same dimension.
(d) Only $y$ and $z$ have the same dimension.
32. Dimensional formula for thermal conductivity is (here $K$ denotes the temperature : [Main Sep. 04, 2020 (I)]
(a) $\mathrm{MLT}^{-2} \mathrm{~K}$
(b) $\mathrm{MLT}^{-2} \mathrm{~K}^{-2}$
(c) $\mathrm{MLT}^{-3} \mathrm{~K}$
(d) $\mathrm{MLT}^{-3} \mathrm{~K}^{-1}$
33. Amount of solar energy received on the earth's surface per unit area per unit time is defined as solar constant. Dimension of solar constant is: [Main Sep. 03, 2020 (III)]
(a) $\mathrm{ML}^{2} \mathrm{~T}^{-2}$
(b) $\mathrm{ML}^{0} \mathrm{~T}^{-3}$
(c) $\mathrm{M}^{2} \mathrm{~L}^{0} \mathrm{~T}^{-1}$
(d) $\mathrm{MLT}^{-2}$
34. If momentum (P), area (A) and time (T) are taken to be the fundamental quantities then the dimensional formula for energy is :
[Main Sep. 02, 2020 (II)]
(a) $\left[\mathrm{P}^{2} \mathrm{AT}^{-2}\right]$
(b) $\left[\mathrm{PA}^{-1} \mathrm{~T}^{-2}\right]$
(c) $\left[\mathrm{PA}^{1 / 2} \mathrm{~T}^{-1}\right]$
(d) $\left[\mathrm{P}^{1 / 2} \mathrm{AT}^{-1}\right]$
35. Which of the following combinations has the dimension of electrical resistance ( $\epsilon_{0}$ is the permittivity of vacuum and $\mu_{0}$ is the permeability of vacuum)?
[Main Online 11 April 2014, 12 April 2019 (I)]
(a) $\sqrt{\frac{\mu_{0}}{\varepsilon_{0}}}$
(b) $\frac{\mu_{0}}{\varepsilon_{0}}$
(c) $\sqrt{\frac{\varepsilon_{0}}{\mu_{0}}}$
(d) $\frac{\varepsilon_{0}}{\mu_{0}}$
36. In the formula $X=5 \mathrm{YZ}^{2}, \mathrm{X}$ and Z have dimensions of capacitance and magnetic field, respectively. What are the dimensions of Y in SI units ? [Main 10 April 2019 (III)]
(a) $\left[\mathrm{M}^{-3} \mathrm{~L}^{-2} \mathrm{~T}^{8} \mathrm{~A}^{4}\right]$
(b) $\left[\mathrm{M}^{-1} \mathrm{~L}^{-2} \mathrm{~T}^{4} \mathrm{~A}^{2}\right]$
(c) $\left[\mathrm{M}^{-2} \mathrm{~L}^{0} \mathrm{~T}^{-4} \mathrm{~A}^{-2}\right]$
(d) $\left[\mathrm{M}^{-2} \mathrm{~L}^{-2} \mathrm{~T}^{6} \mathrm{~A}^{3}\right]$
37. Let $l, r, c$ and $v$ represent inductance, resistance, capacitance and voltage, respectively. The dimension of $\frac{\ell}{r c v}$ in SI units will be :
[Main 12 Jan. 2019 (II)]
(a) $\left[\mathrm{LA}^{-2}\right]$
(b) $\left[\mathrm{A}^{-1}\right]$
(c) $[\mathrm{LTA}]$
(d) $\left[\mathrm{LT}^{2}\right]$
38. A quantity $f$ is given by $f=\sqrt{\frac{h c^{5}}{G}}$ where c is speed of light, G universal gravitational constant and $h$ is the Planck's constant. Dimension of $f$ is that of: [Main 9 Jan. 2019 (I)]
(a) area
(b) energy
(c) momentum
(d) volume
39. Time (T), velocity (C) and angular momentum (h) are chosen as fundamental quantities instead of mass, length and time. In terms of these, the dimensions of mass would be :
[Main Online April 8, 2017]
(a) $[\mathrm{M}]=\left[\mathrm{T}^{-1} \mathrm{C}^{-2} \mathrm{~h}\right]$
(b) $[\mathrm{M}]=\left[\mathrm{T}^{-1} \mathrm{C}^{2} \mathrm{~h}\right]$
(c) $[\mathrm{M}]=\left[\mathrm{T}^{-1} \mathrm{C}^{-2} \mathrm{~h}^{-1}\right]$
(d) $[\mathrm{M}]=\left[\mathrm{T} \mathrm{C}^{-2} \mathrm{~h}\right]$
40. $\mathrm{A}, \mathrm{B}, \mathrm{C}$ and D are four different physical quantities having different dimensions. None of them is dimensionless. But we know that the equation $\mathrm{AD}=\mathrm{C} \ln (\mathrm{BD})$ holds true. Then which of the combination is not a meaningful quantity?
[Main Online April 10, 2016]
(a) $\frac{\mathrm{C}}{\mathrm{BD}}-\frac{\mathrm{AD}^{2}}{\mathrm{C}}$
(b) $\mathrm{A}^{2}-\mathrm{B}^{2} \mathrm{C}^{2}$
(c) $\frac{\mathrm{A}}{\mathrm{B}}-\mathrm{C}$
(d) $\frac{(\mathrm{A}-\mathrm{C})}{\mathrm{D}}$
41. In the following 'I' refers to current and other symbols have their usual meaning, Choose the option that corresponds to the dimensions of electrical conductivity :
[Main Online April 9, 2016]
(a) $\mathrm{M}^{-1} \mathrm{~L}^{-3} \mathrm{~T}^{3} \mathrm{I}$
(b) $\mathrm{M}^{-1} \mathrm{~L}^{-3} \mathrm{~T}^{3} \mathrm{I}^{2}$
(c) $\mathrm{M}^{-1} \mathrm{~L}^{3} \mathrm{~T}^{3} \mathrm{I}$
(d) $\mathrm{ML}^{-3} \mathrm{~T}^{-3} \mathrm{I}^{2}$
42. If electronic charge e, electron mass $m$, speed of light in vacuum c and Planck's constant $h$ are taken as fundamental quantities, the permeability of vacuum $\mu_{0}$ can be expressed in units of :
[Main Online April 11, 2015]
(a) $\left(\frac{\mathrm{h}}{\mathrm{me}^{2}}\right)$
(b) $\left(\frac{\mathrm{hc}}{\mathrm{me}^{2}}\right)$
(c) $\left(\frac{\mathrm{h}}{\mathrm{ce}^{2}}\right)$
(d) $\left(\frac{\mathrm{mc}^{2}}{\mathrm{he}^{2}}\right)$
43. From the following combinations of physical constants (expressed through their usual symbols) the only combination, that would have the same value in different systems of units, is: [Main Online April 12, 2014]
(a) $\frac{\mathrm{ch}}{2 \pi \varepsilon_{0}^{2}}$
(b) $\frac{\mathrm{e}^{2}}{2 \pi \varepsilon_{0} G m_{\mathrm{e}}^{2}}\left(\mathrm{~m}_{\mathrm{e}}=\right.$ mass of electron)
(c) $\frac{\mu_{0} \varepsilon_{0}}{\mathrm{c}^{2}} \frac{G}{\mathrm{he}^{2}}$
(d) $\frac{2 \pi \sqrt{\mu_{\mathrm{o}} \varepsilon_{\mathrm{o}}}}{\mathrm{ce}^{2}} \frac{\mathrm{~h}}{\mathrm{G}}$
44. Let $\left[\epsilon_{0}\right]$ denote the dimensional formula of the permittivity of vacuum. If $\mathrm{M}=$ mass, $\mathrm{L}=$ length, $\mathrm{T}=$ time and $\mathrm{A}=$ electric current, then:
[2013]
(a) $\in_{0}=\left[\mathrm{M}^{-1} \mathrm{~L}^{-3} \mathrm{~T}^{2} \mathrm{~A}\right]$
(b) $\epsilon_{0}=\left[\mathrm{M}^{-1} \mathrm{~L}^{-3} \mathrm{~T}^{4} \mathrm{~A}^{2}\right]$
(c) $\epsilon_{0}=\left[\mathrm{M}^{1} \mathrm{~L}^{2} \mathrm{~T}^{1} \mathrm{~A}^{2}\right]$
(d) $\epsilon_{0}=\left[\mathrm{M}^{1} \mathrm{~L}^{2} \mathrm{~T}^{1} \mathrm{~A}\right]$
45. If the time period $t$ of the oscillation of a drop of liquid of density $d$, radius $r$, vibrating under surface tension $s$ is given by the formula $t=\sqrt{r^{2 b} s^{c} d^{a / 2}}$. It is observed that the time period is directly proportional to $\sqrt{\frac{d}{s}}$. The value of $b$ should therefore be : [Main Online April 23, 2013]
(a) $\frac{3}{4}$
(b) $\sqrt{3}$
(c) $\frac{3}{2}$
(d) $\frac{2}{3}$
46. The dimensions of angular momentum, latent heat and capacitance are, respectively. [Main Online April 22, 2013]
(a) $\mathrm{ML}^{2} \mathrm{~T}^{1} \mathrm{~A}^{2}, \mathrm{~L}^{2} \mathrm{~T}^{-2}, \mathrm{M}^{-1} \mathrm{~L}^{-2} \mathrm{~T}^{2}$
(b) $\mathrm{ML}^{2} \mathrm{~T}^{-2}, \mathrm{~L}^{2} \mathrm{~T}^{2}, \mathrm{M}^{-1} \mathrm{~L}^{-2} \mathrm{~T}^{4} \mathrm{~A}^{2}$
(c) $\mathrm{ML}^{2} \mathrm{~T}^{-1}, \mathrm{~L}^{2} \mathrm{~T}^{-2}, \mathrm{ML}^{2} \mathrm{TA}^{2}$
(d) $\mathrm{ML}^{2} \mathrm{~T}^{-1}, \mathrm{~L}^{2} \mathrm{~T}^{-2}, \mathrm{M}^{-1} \mathrm{~L}^{-2} \mathrm{~T}^{4} \mathrm{~A}^{2}$
47. Which of the following set have different dimensions?
(a) Pressure, Young's modulus, Stress
[2005S]
(b) EMF, Potential difference, Electric potential
(c) Heat, Work done, Energy
(d) Dipole moment, Electric flux, Electric field
48. Pressure depends on distance as, $P=\frac{\alpha}{\beta} \exp \left(-\frac{\alpha z}{k \theta}\right)$, where $\alpha, \beta$ are constants, $z$ is distance, $k$ is Boltzman's constant and $\theta$ is temperature. The dimension of $\beta$ are
(a) $M^{0} L^{0} T^{0}$
(b) $M^{-1} L^{-1} T^{-1}$
(c) $M^{0} L^{2} T^{0}$
(d) $M^{-1} L^{1} T^{2}$
[2004S]
49. A quantity $X$ is given by $\varepsilon_{0} L \frac{\Delta V}{\Delta t}$ where $\epsilon_{0}$ is the permittivity of the free space, $L$ is a length, $\Delta V$ is a potential difference and $\Delta t$ is a time interval. The dimensional formula for $X$ is the same as that of
[2001S]
(a) resistance
(b) charge
(c) voltage
(d) current
50. The dimension of $\left(\frac{1}{2}\right) \varepsilon_{0} E^{2}$ ( $\varepsilon_{0}$ : permittivity of free space, $E$ electric field)
[2000S]
(a) $M L T^{-1}$
(b) $M L^{2} T^{-2}$
(c) $M L^{-1} T^{-2}$
(d) $M L^{2} T^{-1}$

## 2 Integer Value Answer

51. In a particular system of units, a physical quantity can be expressed in terms of the electric charge $e$, electron mass $m_{e}$, Planck's constant $h$, and Coulomb's constant
$k=\frac{1}{4 \pi \epsilon_{0}}$, where $\epsilon_{0}$ is the permittivity of vacuum. In terms of these physical constants, the dimension of the magnetic field is $[B]=[e]^{\alpha}\left[m_{e}\right]^{\beta}[h]^{\gamma}[k]^{\delta}$. The value of $\alpha+$ $\beta+\gamma+\delta$ is $\qquad$ .
[Adv. 2022]
52. To find the distance $d$ over which a signal can be seen clearly in foggy conditions, a railways-engineer uses dimensions and assumes that the distance depends on the mass density $\rho$ of the fog, intensity (power/area) $S$ of the light from the signal and its frequency $f$. The engineer finds that $d$ is proportional to $S^{1 / n}$. The value of $n$ is
[Adv. 2014]

## 4 Fill in the Blanks

53. The dimension of electrical conductivity is $\qquad$ .
[1997-1 Mark]
54. The equation of state for real gas is given by $\left(P+\frac{a}{V^{2}}\right)(V-b)=R T$. The dimensions of the constant $a$ is $\qquad$ -
[1997-2 Marks]
55. In the formula $X=3 Y Z^{2}, X$ and $Z$ have dimensions of capacitance and magnetic induction respectively. The dimensions of $Y$ in $M K S Q$ sytem are $\qquad$ _,
$\qquad$ .
[1988-2 Marks]
56. Planck's constant has dimension $\qquad$ .
[1985-2 Marks]

## 6 MCQs with One or More Than One Correct

57. A physical quantity $\vec{S}$ is defined as $\vec{S}=(\vec{E} \times \vec{B}) / \mu_{0}$, where $\vec{E}$ is electric field, $\vec{B}$ is magnetic field and $\mu_{0}$ is the permeability of free space. The dimensions of $\vec{S}$ are the same as the dimensions of which of the following quantities?
[Adv. 2021]
(a) $\frac{\text { Energy }}{\text { Charge } \times \text { Current }}$
(b) $\frac{\text { Force }}{\text { Length } \times \text { Time }}$
(c) $\frac{\text { Energy }}{\text { Volume }}$
(d) $\frac{\text { Power }}{\text { Area }}$
58. Sometimes it is convenient to construct a system of units so that all quantities can be expressed in terms of only one physical quantity. In one such system, dimensions of different quantities are given in terms of a quantity $X$ as follows:
[position] $=\left[X^{\alpha}\right] ;$ speed $]=\left[X^{\beta}\right] ;$ acceleration $]=\left[X^{p}\right] ;$ $[$ linear momentum $]=\left[X^{q}\right] ;[$ force $]=\left[X^{r}\right]$. Then [Adv. 2020]
(a) $\alpha+p=2 \beta$
(b) $p+q-r=\beta$
(c) $p-q+r=\alpha$
(d) $p+q+r=\beta$
59. Let us consider a system of units in which mass and angular momentum are dimensionless. If length has dimensions of $L$, which of the following statement(s) is/ are correct?
[Adv. 2019]
(a) The dimension of force is $L^{-2}$
(b) The dimension of linear momentum is $L^{-1}$
(c) The dimension of energy is $L^{-2}$
(d) The dimension of power is $L^{-5}$
60. A length-scale $(l)$ depends on the permittivity $(\varepsilon)$ of a dielectric material. Boltzmann constant $\left(\mathrm{k}_{\mathrm{B}}\right)$, the absolute temperature ( T ), the number per unit volume ( n ) of certain charged particles, and the charge ( q ) carried by each of the particles. Which of the following expression(s) for $I$ is(are) dimensionally correct?
[Adv. 2016]
(a) $l=\sqrt{\left(\frac{\mathrm{nq}^{2}}{\varepsilon \mathrm{k}_{\mathrm{B}} \mathrm{T}}\right)}$
(b) $l=\sqrt{\left(\frac{\varepsilon \mathrm{k}_{\mathrm{B}} \mathrm{T}}{\mathrm{nq}^{2}}\right)}$
(c) $l=\sqrt{\left(\frac{\mathrm{q}^{2}}{\varepsilon \mathrm{n}^{2 / 3} \mathrm{k}_{\mathrm{B}} \mathrm{T}}\right)}$
(d) $l=\sqrt{\left(\frac{\mathrm{q}^{2}}{\varepsilon \mathrm{n}^{1 / 3} \mathrm{k}_{\mathrm{B}} \mathrm{T}}\right)}$
61. In terms of potential difference $V$, electric current $I$, permittivity $\varepsilon_{0}$, permeability $\mu_{0}$ and speed of light $c$, the dimensionally correct equation(s) is(are) [Adv. 2015]
(a) $\mu_{0} \mathrm{I}^{2}=\varepsilon_{0} \mathrm{~V}^{2}$
(b) $\varepsilon_{0} \mathrm{I}=\mu_{0} \mathrm{~V}$
(c) $\mathrm{I}=\varepsilon_{0} \mathrm{cV}$
(d) $\mu_{0} \mathrm{cI}=\varepsilon_{0} \mathrm{~V}$
62. Planck's constant $h$, speed of light $c$ and gravitational constant $G$ are used to form a unit of length $L$ and a unit of mass $M$. Then the correct option(s) is(are) [Adv. 2015]
(a) $M \propto \sqrt{c}$
(b) $M \propto \sqrt{G}$
(c) $L \propto \sqrt{h}$
(d) $L \propto \sqrt{G}$
63. Let $\left[\varepsilon_{0}\right]$ denote the dimensional formula of the permittivity of the vacuum, and $\left[\mu_{0}\right.$ ] that of the permeability of the vacuum. If $M=$ mass, $L=$ length, $T=$ time and $I=$ electric current,
[1998-2 Marks]
(a) $\left[\varepsilon_{0}\right]=M^{-1} L^{-3} T^{2} I$
(b) $\left[\varepsilon_{0}\right]=M^{-1} L^{-3} T^{4} I^{2}$
(c) $\left[\mu_{0}\right]=M L T^{-2} I^{-2}$
(d) $\left[\mu_{0}\right]=M L^{2} T^{-1} I$
64. The pairs of physical quantities that have the same dimensions is (are) :
[1995S]
(a) Reynolds number and coefficient of friction
(b) Curie and frequency of a light wave
(c) Latent heat and gravitational potential
(d) Planck's constant and torque
65. The dimensions of the quantities in one (or more) of the following pairs are the same. Identify the pair (s)
(a) Torque and Work
[1986-2 Marks]
(b) Angular momentum and Work
(c) Energy and Young's modulus
(d) Light year and Wavelength

## 7 Match the Following

66. Match List I with List II
[Main April 12, 2023 (I)]

|  | List I |  | List II |
| :---: | :---: | :---: | :---: |
| A. | Spring constant | I. | $\left(\mathrm{T}^{-1}\right)$ |
| B. | Angular speed | II. | $\left(\mathrm{MT}^{-2}\right)$ |
| C. | Angular momentum | III. | $\left(\mathrm{ML}^{2}\right)$ |
| D. | Moment of Inertia | IV. | $\left(\mathrm{ML}^{2} \mathrm{~T}^{-1}\right)$ |

Choose the correct answer from the options given below:
(a) A-II, B-I, C-IV, D-III
(b) A-IV, B-I, C-III, D-II
(c) A-II, B-III, C-I, D-IV
(d) A-I, B-III, C-II, D-IV
67. Match List I with List II List-I
A. Torque
[Main April 8, 2023 (II)] List-II
B. Stress
I. $\mathrm{ML}^{-2} \mathrm{~T}^{-2}$
C. Pressure gradient
II. $\mathrm{ML}^{2} \mathrm{~T}^{-2}$
D. Coefficient of viscosity IV
III. $\mathrm{ML}^{-1} \mathrm{~T}^{-1}$

Choose the correct answer from the options given below:
(a) A-III, B-IV, C-I, D-II
(b) A-IV, B-II, C-III, D-I
(c) A-II, B-IV, C-I, D-III
(d) A-II, B-I, C-IV, D-III
68. Match List-I with List-II.
[Main Jan. 31, 2023 (II)]

|  | List-I |  | List-II |
| :--- | :--- | :--- | :--- | :--- |
| A. | Angular <br> momentum | I. | $\left[\mathrm{ML}^{2} \mathrm{~T}^{-2}\right]$ |
| B. | Torque | II. | $\left[\mathrm{ML}^{-2} \mathrm{~T}^{-2}\right]$ |
| C. | Stress | III. | $\left[\mathrm{ML}^{2} \mathrm{~T}^{-1}\right]$ |
| D. | Pressure gradient | IV. | $\left[\mathrm{ML}^{-1} \mathrm{~T}^{-2}\right]$ |

Choose the correct answer from the options given below:
(a) A-I, B-IV, C-III, D-II
(b) A-III, B-I, C-IV, D-II
(c) A-II, B-III, C-IV, D-I
(d) A-IV, B-II, C-I, D-III]
69. Match List I with List II :
[Main Jan. 29, 2023 (I)]

| List-I |
| :--- |
| (Physical Quantity) |

## List-II

A. Pressure gradient
I. $\quad\left[\mathrm{M}^{0} \mathrm{~L}^{2} \mathrm{~T}^{-2}\right]$
B. Energy density
II. $\quad\left[\mathrm{M}^{1} \mathrm{~L}^{-1} \mathrm{~T}^{-2}\right]$
C. Electric Field
III. $\left[\mathrm{M}^{1} \mathrm{~L}^{-2} \mathrm{~T}^{-2}\right]$
D. Latent heat
IV. $\left[\mathrm{M}^{1} \mathrm{~L}^{1} \mathrm{~T}^{-3} \mathrm{~A}^{-1}\right]$

Choose the correct answer from the options given below:
(a) A-III, B-II, C-I, D-IV
(b) A-II, B-III, C-IV, D-I
(c) A-III, B-II, C-IV, D-I
(d) A-II, B-III, C-I, D-IV
70. Match List I with List II
[Main Jan. 25, 2023 (II)]

|  | List |  | List II |
| :--- | :--- | :--- | :--- |
| A. | Young's Modulus (Y) | I. | $\left[\mathrm{M} \mathrm{L}^{-1} \mathrm{~T}^{-1}\right]$ |
| B. | Co-efficient of | II. | $\left[\mathrm{M} \mathrm{L}^{2} \mathrm{~T}^{-1}\right]$ |
|  | Viscosity $(\eta)$ |  |  |
| C. | Planck's Constant $(\mathrm{h})$ | III. | $\left[\mathrm{M} \mathrm{L}^{-1} \mathrm{~T}^{-2}\right]$ |
| D. | Work Function $(\phi)$ | IV. | $\left[\mathrm{M} \mathrm{L}^{2} \mathrm{~T}^{-2}\right]$ |

Choose the correct answer from the options given below:
(a) A-II, B-III, C-IV, D-I
(b) A-III, B-I, C-II, D-IV
(c) A-I, B-III, C-IV, D-II
(d) A-I, B-II, C-III, D-IV
71. Match List I with List II
[Main Jan. 24, 2023 (I)]

| LIST I |  | LIST II |  |
| :--- | :--- | :--- | :--- |
| A. | Planck's Constant (h) | I. | $\left[\mathrm{M}^{1} \mathrm{~L}^{2} \mathrm{~T}^{-2}\right]$ |
| B. | Stopping Potential (Vs) | II. | $\left[\mathrm{M}^{1} \mathrm{~L}^{1} \mathrm{~T}^{-1}\right]$ |
| C. | Work function $(\phi)$ | III. | $\left[\mathrm{M}^{1} \mathrm{~L}^{2} \mathrm{~T}^{-1}\right]$ |
| D. | Momentum (p) | IV. | $\left[\mathrm{M}^{1} \mathrm{~L}^{2} \mathrm{~T}^{-3} \mathrm{~A}^{-1}\right]$ |

(a) A-III, B-I, C-II, D-IV
(b) A-III, B-IV, C-I, D-II
(c) A-II, B-IV, C-III, D-I
(d) A-I, B-III, C-IV, D-II
72. Match List-I with List-II.

## List-I

(A) Torque
(B) Impulse
(C) Tension
(D) Surface Tension
[Main Aug. 31, 2021 (I)]

## List-II

(i) $\mathrm{MLT}^{-1}$
(ii) $\mathrm{MT}^{-2}$
(iii) $\mathrm{ML}^{2} \mathrm{~T}^{-2}$
(iv) $\mathrm{MLT}^{-2}$

Choose the most appropriate answer from the option given below :
(a) (A)-(iii), (B)-(i), (C)-(iv), (D)-(ii)
(b) (A)-(ii), (B)-(i), (C)-(iv), (D)-(iii)
(c) (A)-(i), (B)-(iii), (C)-(iv), (D)-(ii)
(d) (A)-(iii), (B)-(iv), (C)-(i), (D)-(ii)
73. Match List I with List II and select the correct answer using the codes given below the lists:
[Adv. 2013]

## List I

P. Boltzmann constant
Q. Coefficient of viscosity
R. Planck constant
S. Thermal conductivity

Codes:

| Codes: |  |  |  |  |
| :--- | :--- | :--- | :--- | :--- |
|  | P | Q | R | S |
| (a) | 3 | 1 | 2 | 4 |
| (b) | 3 | 2 | 1 | 4 |
| (c) | 4 | 2 | 1 | 3 |
| (d) | 4 | 1 | 2 | 3 |

74. Match the physical quantities given in column I with dimensions expressed in terms of mass $(M)$, length $(L)$, time $(T)$, and charge $(Q)$ given in column II and write the correct answer against the matched quantity in a tabular form in your answer book.
[1983-6 Marks]

| Column I | Column III |
| :--- | :--- |
| Angular momentum | $M L^{2} T^{-2}$ |
| Latent heat | $M L^{2} Q^{-2}$ |
| Torque | $M L^{2} T^{-1}$ |
| Capacitance | $M L^{3} T^{-1} Q^{-2}$ |
| Inductance | $M^{-1} L^{-2} T^{2} Q^{2}$ |
| Resistivity | $L^{2} T^{-2}$ |

## 8 Comprehension/Passage Based Questions

## Passage

In electromagnetic theory, the electric and magnetic phenomena are related to each other. Therefore, the dimensions of electric and magnetic quantities must also be related to each other. In the questions below, $[E]$ and $[B]$ stand for dimensions of electric and magnetic fields respectively, while $\left[\varepsilon_{0}\right]$ and $\left[\mu_{0}\right]$ stand for dimensions of the permittivity and permeability of free space respectively. $[L]$ and $[T]$ are dimensions of length and time respectively. All the quantities are given in SI units.
[Adv. 2018]
75. The relation between $[E]$ and $[B]$ is
(a) $[E]=[B][L][T]$
(b) $[E]=[B][L]^{-1}[T]$
(c) $[E]=[B][L][T]^{-1}$
(d) $[E]=[B][L]^{-1}[T]^{-1}$
76. The relation between $\left[\varepsilon_{0}\right]$ and $\left[\mu_{0}\right]$ is
(a) $\left[\mu_{0}\right]=\left[\varepsilon_{0}\right][L]^{2}[T]^{-2}$
(b) $\left[\mu_{0}\right]=\left[\varepsilon_{0}\right][L]^{-2}[T]^{2}$
(c) $\left[\mu_{0}\right]=\left[\varepsilon_{0}\right]^{-1}[L]^{2}[T]^{-2}$
(d) $\left[\mu_{0}\right]=\left[\varepsilon_{0}\right]^{-1}[L]^{-2}[T]^{2}$

## 10 Subjective Problems

77. Write the dimensions of the following in terms of mass, time, length and charge
[1982-2 Marks]
(i) magnetic flux
(ii) rigidity modulus
78. A gas bubble, from an explosion under water, oscillates with a period $T$ proportional to $p^{a} d^{b} E^{c}$. Where ' $P$ ' is the static pressure, ' $d$ ' is the density of water and ' $E$ ' is the total energy of the explosion. Find the values of $a, b$ and $c$.
[1981-3 Marks]

## Topic-3: Errors in Measurements \& Experimental Physics

## 1 MCQs with One Correct Answer

1. A body of mass $(5 \pm 0.5) \mathrm{kg}$ is moving with a velocity of $(20 \pm$ $0.4) \mathrm{m} / \mathrm{s}$. Its kinetic energy will be [Main Aprill 13, 2023 (I)]
(a) $(1000 \pm 140) \mathrm{J}$
(b) $(1000 \pm 0.14) \mathrm{J}$
(c) $(500 \pm 0.14) \mathrm{J}$
(d) $(500 \pm 140) \mathrm{J}$
2. In an experiment with Vernier callipers of least count 0.1 mm , when two jaws are joined together the zero of Vernier scale lies right to the zero of the main scale and $6^{\text {th }}$ division of Vernier scale coincides with the main scale division. While measuring the diameter of a spherical bob, the zero of vernier scale lies in between 3.2 cm and 3.3 cm marks, and $4^{\text {th }}$ division of vernier scale coincides with the main scale division. The diameter of bob is measured as :
[Main April 8, 2023 (I), April 10, 2023 (II)]
(a) 3.18 cm
(b) 3.25 cm
(c) 3.26 cm
(d) 3.22 cm
3. A cylindrical wire of mass $(0.4 \pm 0.01) \mathrm{g}$ has length ( $8 \pm 0.04$ ) cm and radius ( $6 \pm 0.03$ ) mm.
[Similar Main June 27, 2022 (I)] The maximum error in its density will be
(a) $1 \%$
(b) $3.5 \%$
(c) $4 \%$
(d) $5 \%$
4. Two resistances are given as $\mathrm{R}_{1}=(10 \pm 0.5) \Omega$ and $\mathrm{R}_{2}$ $=(15 \pm 0.5) \Omega$. The percentage error in the measurement of equivalent resistance when they are connected in parallel is
[Main April 6, 2023 (I)]
(a) 6.33
(b) 2.33
(c) 4.33
(d) 5.33
5. Area of the cross-section of a wire is measured using a screw gauge. The pitch of the main scale is 0.5 mm . The circular scale has 100 divisions and for one full rotation of the circular scale, the main scale shifts by two divisions. The measured readings are listed below. [Adv. 2022]

| Meas urement <br> condition | Main scale <br> reading | Circular scale <br> reading |
| :--- | :---: | :---: |
| Two arms of <br> gauge touching <br> each other <br> without wire | 0 division | 4 divisions |
| Attempt-1: W ith <br> wire | 4 divisions | 20 divisions |
| Attempt-2: W ith <br> wire | 4 divisions | 16 divisions |

What are the diameter and cross-sectional area of the wire measured using the screw gauge?
(a) $2.22 \pm 0.02 \mathrm{~mm}, \pi(1.23 \pm 0.02) \mathrm{mm}^{2}$
(b) $2.22 \pm 0.01 \mathrm{~mm}, \pi(1.23 \pm 0.01) \mathrm{mm}^{2}$
(c) $2.14 \pm 0.02 \mathrm{~mm}, \pi(1.14 \pm 0.02) \mathrm{mm}^{2}$
(d) $2.14 \pm 0.01 \mathrm{~mm}, \pi(1.14 \pm 0.01) \mathrm{mm}^{2}$
6. A travelling microscope has 20 divisions per cm on the main scale while its Vernier scale has total 50 divisions and 25 Vernier scale divisions are equal to 24 main scale divisions, what is the least count of the travelling microscope?
[Main July 29, 2022 (I)]
(a) 0.001 cm
(b) 0.002 mm
(c) 0.002 cm
(d) 0.005 cm
7. In an experiment to find out the diameter of wire using screw gauge, the following observation were noted :
(a) Screwmoves 0.5 mm on main scale in one complete rotation.
(b) Total divisions on circular scale $=50$
(c) Main scale reading is 2.5 mm
(d) $45^{\text {th }}$ division of circular scale is in the pitch line
(e) Instrument has 0.03 mm negative error

Then the diameter of wire is : [Main July 29, 2022 (I)]
(a) 2.92 mm
(b) 2.54 mm
(c) 2.98 mm (d) 3.45 mm
8. A torque meter is calibrated to reference standards of mass, length and time each with $5 \%$ accuracy. After calibration, the measured torque with this torque meter will have net accuracy of :
[Main July 27, 2022 (I)]
(a) $15 \%$
(b) $25 \%$
(c) $75 \%$
(d) $5 \%$
9. A screw gauge of pitch 0.5 mm is used to measure the diameter of uniform wire of length 6.8 cm , the main scale reading is 1.5 mm and circular scale reading is 7 . The calculated curved surface area of wire to appropriate significant figures is :
[Main July 26, 2022 (I)] [Screw gauge has 50 divisions on its circular scale]
(a) $6.8 \mathrm{~cm}^{2}$
(b) $3.4 \mathrm{~cm}^{2}$
(c) $3.9 \mathrm{~cm}^{2}$
(d) $2.4 \mathrm{~cm}^{2}$
10. The maximum error in the measurement iof resistance, current and time for which current flows in an electrical circuit are $1 \%, 2 \%$ and $3 \%$ respectively. The maximum percentage error in the detection of the dissipated heat will be:
[Main July 25, 2022 (III)]
(a) 2
(b) 4
(c) 6
(d) 8
11. If n main scale divisions coincide with $(\mathrm{n}+1)$ vernier scale divisions. The least count of vernier callipers, when each centimetre on the main scale is divided into five equal parts, will be.
[Main July 30, 2022(I)]
(a) $\frac{2 \mathrm{n}}{\mathrm{n}+1} \mathrm{~mm}$
(b) $\frac{5}{\mathrm{n}+1} \mathrm{~mm}$
(c) $\frac{1}{2 \mathrm{n}} \mathrm{mm}$
(d) $\frac{1}{5 \mathrm{n}} \mathrm{mm}$
12. A silver wire has mass $(0.6 \pm 0.006) \mathrm{g}$, radius $(0.5 \pm 0.005)$ mm and length $(4 \pm 0.04) \mathrm{cm}$. The maximum percentage error in the measurement of its density will be :
[Main June 27, 2022 (I)]
(a) $4 \%$
(b) $3 \%$
(c) $6 \%$
(d) $7 \%$
13. The smallest division on the main scale of a Vernier calipers is 0.1 cm . Ten divisions of the Vernier scale correspond to nine divisions of the main scale. The figure below on the left shows the reading of this calipers with no gap between its two jaws. The figure on the right shows the reading with a solid sphere held between the jaws. The correct diameter of the sphere is
[Adv. 2021]

(a) 3.07 cm
(b) 3.11 cm
(c) 3.15 cm
(d) 3.17 cm
14. A student determined Young's Modulus of elasticity using the formula $\mathrm{Y}=\frac{\mathrm{MgL}^{3}}{4 \mathrm{bd}^{3} \delta}$. The value of g is taken to be 9.8 $\mathrm{m} / \mathrm{s}^{2}$, without any significant error, his observation are as following.

|  | Least count of <br> the Equipment <br> used for <br> meas urement | Oalue |
| :--- | :--- | :--- |
| vas |  |  |

Then the fractional error in the measurement of Y is :
[Main Sep. 1, 2021 (II)]
(a) 0.0083
(b) 0.0155
(c) 0.155
(d) 0.083
15. Two resistors $R_{1}=(4 \pm 0.8) \Omega$ and $R_{2}=(4 \pm 0.4) \Omega$ are connected in parallel. The equivalent resistance of their parallel combination will be: [Main Sep. 1, 2021 (III)]
(a) $(4 \pm 0.4) \Omega$
(b) $(2 \pm 0.4) \Omega$
(c) $(2 \pm 0.3) \Omega$
(d) $(4 \pm 0.3) \Omega$
16. 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 $20^{\text {th }}$ division of the circular scale coincides with reference line. Calculate the true reading. [Main Aug. 26, 2021 (I)]
(a) 5.00 mm
(b) 5.25 mm (c) 5.15 mm
(d) 5.20 mm
17. If the length of the pendulum in pendulum clock increases by $0.1 \%$, then the error in time per day is:
[Main Aug. 26, 2021 (II)]
(a) 86.4 s
(b) 4.32 s
(c) 43.2 s
(d) 8.64 s
18. 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 $\qquad$ cm . (least count $=0.01 \mathrm{~cm}$ )
[Main March 17, 2021 (I)]
(a) 8.54 cm
(b) 8.36 cm
(c) 8.56 cm
(d) 8.58 cm
19. A screw gauge has 50 divisions on its circular scale. The circular scale is 4 units ahead of the pitch scale marking, prior to use. Upon one complete rotation of the circular scale, a displacement of 0.5 mm is noticed on the pitch scale. The nature of zero error involved, and the least count of the screw gauge, are respectively :
[Main Sep. 06, 2020 (I)]
(a) Negative, $2 \mu \mathrm{~m}$
(b) Positive, $10 \mu \mathrm{~m}$
(c) Positive, 0.1 mm
(d) Positive, $0.1 \mu \mathrm{~m}$
20. A student measuring the diameter of a pencil of circular cross-section with the help of a vernier scale records the following four readings $5.50 \mathrm{~mm}, 5.55 \mathrm{~mm}, 5.45 \mathrm{~mm}$, 5.65 mm , The average of these four reading is 5.5375 mm and the standard deviation of the data is 0.07395 mm . The average diameter of the pencil should therefore be recorded as :
[Main Sep. 06, 2020 (II)]
(a) $(5.5375 \pm 0.0739) \mathrm{mm}$
(b) $(5.5375 \pm 0.0740) \mathrm{mm}$
(c) $(5.538 \pm 0.074) \mathrm{mm}$
(d) $(5.54 \pm 0.07) \mathrm{mm}$
21. A physical quantity $z$ depends on four observables $a, b, c$ and $d$, as $z=\frac{a^{2} b^{\frac{2}{3}}}{\sqrt{c} d^{3}}$. The percentages of error in the measurement of $a, b, c$ and $d$ are $2 \%, 1.5 \%, 4 \%$ and $2.5 \%$ respectively. The percentage of error in $z$ is: [Main 2017 (S); Online April 9 (S), 2017 (S) Sep. 05, 2020 (I)]
(a) $12.25 \%$ (b) $16.5 \%$
(c) $13.5 \%$
(d) $14.5 \%$
22. Using screw gauge of pitch 0.1 cm and 50 divisions on its circular scale, the thickness of an object is measured. It should correctly be recorded as: [Main Sep. 03, 2020 (I)]
(a) 2.121 cm
(b) 2.124 cm
(c) 2.125 cm
(d) 2.123 cm
23. If the screw on a screw-gauge is given six rotations, it moves by 3 mm on the main scale. If there are 50 divisions on the circular scale the least count of the screw gauge is: [Main 9 Jan. 2020 I]
(a) 0.001 cm
(b) 0.02 mm
(c) 0.01 cm
(d) 0.001 mm
24. In the density measurement of a cube, the mass and edge length are measured as $(10.00 \pm 0.10) \mathrm{kg}$ and $(0.10 \pm 0.01)$ m , respectively. The error in the measurement of density is:
[Main 9 April 2019 I]
(a) $0.01 \mathrm{~kg} / \mathrm{m}^{3}$
(b) $0.10 \mathrm{~kg} / \mathrm{m}^{3}$
(c) $0.013 \mathrm{~kg} / \mathrm{m}^{3}$
(d) $0.07 \mathrm{~kg} / \mathrm{m}^{3}$
25. The area of a square is $5.29 \mathrm{~cm}^{2}$. The area of 7 such squares taking into account the significant figures is:
[Main 9 April 2019 II]
(a) $37 \mathrm{~cm}^{2}$
(b) $37.030 \mathrm{~cm}^{2}$
(c) $37.03 \mathrm{~cm}^{2}$
(d) $37.0 \mathrm{~cm}^{2}$
26. The pitch and the number of divisions, on the circular scale for a given screw gauge are 0.5 mm and 100 respectively. When the screw gauge is fully tightened without any object, the zero of its circular scale lies 3 division below the mean line.
The readings of the main scale and the circular scale, for a thin sheet, are 5.5 mm and 48 respectively, the thickness of the sheet is: [Main 9 Jan. 2019 II]
(a) 5.755 mm
(b) 5.950 mm
(c) 5.725 mm
(d) 5.740 mm
27. The density of a material in the shape of a cube is determined by measuring three sides of the cube and its mass. If the relative errors in measuring the mass and length are respectively $1.5 \%$ and $1 \%$, the maximum error in determining the density is:
[2018]
(a) $2.5 \%$
(b) $3.5 \%$
(c) $4.5 \%$
(d) $6 \%$
28. The relative uncertainty in the period of a satellite orbiting around the earth is $10^{-2}$. If the relative uncertainty in the radius of the orbit is negligible, the relative uncertainty in the mass of the earth is [Main Online April 16, 2018]
(a) $3 \times 10^{-2}$
(b) $10^{-2}$
(c) $2 \times 10^{-2}$
(d) $6 \times 10^{-2}$
29. The relative error in the determination of the surface area of a sphere is $\alpha$. Then the relative error in the determination of its volume is
[Main Online April 15, 2018]
(a) $\frac{2}{3} \alpha$
(b) $\frac{2}{3} \alpha$
(c) $\frac{3}{2} \alpha$
(d) $\alpha$
30. In a screw gauge, 5 complete rotations of the screw cause it to move a linear distance of 0.25 cm . There are 100 circular scale divisions. The thickness of a wire measured by this screw gauge gives a reading of 4 main scale divisions and 30 circular scale divisions. Assuming negligible zero error, the thickness of the wire is: [Main Online April 15, 2018]
(a) 0.0430 cm
(b) 0.3150 cm
(c) 0.4300 cm
(d) 0.2150 cm
31. A person measures the depth of a well by measuring the time interval between dropping a stone and receiving the sound of impact with the bottom of the well. The error in his measurement of time is $\delta \mathrm{T}=0.01$ seconds and he measures the depth of the well to be $\mathrm{L}=20$ meters. Take the acceleration due to gravity $g=10 \mathrm{~ms}^{-2}$ and the velocity of sound is $300 \mathrm{~ms}^{-1}$. Then the fractional error in the measurement, $\delta \mathrm{L} / \mathrm{L}$, is closest to
[Adv. 2017]
(a) $0.2 \%$
(b) $1 \%$
(c) $3 \%$
(d) $5 \%$
32. There are two Vernier calipers both of which have 1 cm divided into 10 equal divisions on the main scale. The Vernier scale of one of the calipers $\left(\mathrm{C}_{1}\right)$ has 10 equal divisions that correspond to 9 main scale divisions. The Vernier scale of the other caliper $\left(\mathrm{C}_{2}\right)$ has 10 equal divisions that correspond to 11 main scale divisions. The readings of the two calipers are shown in the figure. The measured values (in cm ) by calipers $\mathrm{C}_{1}$ and $\mathrm{C}_{2}$, respectively, are
[Adv. 2016]

(a) 2.85 and 2.82
(b) 2.87 and 2.83
(c) 2.87 and 2.86
(d) 2.87 and 2.87
33. A screw gauge with a pitch of 0.5 mm and a circular scale with 50 divisions is used to measure the thickness of a thin sheet of Aluminium. Before starting the measurement, it is found that when the two jaws of the screw gauge are brought in contact, the $45^{\text {th }}$ division coincides with the main scale line and the zero of the main scale is barely visible. What is the thickness of the sheet if the main scale reading is 0.5 mm and the 25th division coincides with the main scale line?
(a) 0.70 mm (b) 0.50 mm
(c) 0.75 mm
[2016]
34. A student measures the time period of 100 oscillations of a simple pendulum four times. The data set is $90 \mathrm{~s}, 91 \mathrm{~s}, 95$ s , and 92 s . If the minimum division in the measuring clock is 1 s , then the reported mean time should be: [2016]
(a) $92 \pm 1.8 \mathrm{~s}$
(b) $92 \pm 3 \mathrm{~s}$
(c) $92 \pm 2 \mathrm{~s}$
(d) $92 \pm 5.0 \mathrm{~s}$
35. The period of oscillation of a simple pendulum is $\mathrm{T}=2 \pi \sqrt{\frac{\mathrm{~L}}{\mathrm{~g}}}$. Measured value of L is 20.0 cm known to 1 mm accuracy and time for 100 oscillations of the pendulum is found to be 90 s using a wrist watch of 1 s resolution. The accuracy in the determination of $g$ is :
[2015]
(a) $1 \%$
(b) $5 \%$
(c) $2 \%$
(d) $3 \%$
36. Diameter of a steel ball is measured using a Vernier callipers which has divisions of 0.1 cm on its main scale (MS) and 10 divisions of its vernier scale (VS) match 9 divisions on the main scale. Three such measurements for a ball are given as:
[Main Online April 10, 2015]

| S.No. | MS(cm) | VS divisions |
| :---: | :---: | :---: |
| 1. | 0.5 | 8 |
| 2. | 0.5 | 4 |
| 3. | 0.5 | 6 |

If the zero error is -0.03 cm , then mean corrected diameter is: (a) 0.52 cm (b) 0.59 cm (c) 0.56 cm (d) 0.53 cm
37. The current voltage relation of a diode is given by $I=\left(e^{1000 \mathrm{~V} / \mathrm{T}}-1\right) \mathrm{mA}$, where the applied voltage V is in volts and the temperature T is in degree kelvin. If a student makes an error measuring $\pm 0.01 \mathrm{~V}$ while measuring the current of 5 mA at 300 K , what will be the error in the value of current in mA?
[2014]
(a) 0.2 mA (b) 0.02 mA
(c) 0.5 mA
(d) 0.05 mA
38. A student measured the length of a rod and wrote it as 3.50 cm . Which instrument did he use to measure it?
[2014]
(a) A meter scale.
(b) A vernier calliper where the 10 divisions in vernier scale matches with 9 division in main scale and main scale has 10 divisions in 1 cm .
(c) A screw gauge having 100 divisions in the circular scale and pitch as 1 mm .
(d) A screw gauge having 50 divisions in the circular scale and pitch as 1 mm .
39. Match List-I (Event) with List-II (Order of the time interval for happening of the event) and select the correct option from the options given below the lists:
[Main Online April 19, 2014]

| List - I |  | List - II |  |
| :---: | :--- | :---: | :--- |
| (1) | Rotation period of earth | (i) | $10^{5} \mathrm{~s}$ |
| $(2)$ | Revolution period of earth | (ii) | $10^{7} \mathrm{~s}$ |
| (3) | Period of light wave | (iii) | $10^{-15} \mathrm{~s}$ |
| (4) | Period of sound wave | (iv) | $10^{-3} \mathrm{~s}$ |

(a) (1)-(i), (2)-(ii), (3)-(iii), (4)-(iv)
(b) (1)-(ii), (2)-(i), (3)-(iv), (4)-(iii)
(c) (1)-(i), (2)-(ii), (3)-(iv), (4)-(iii)
(d) (1)-(ii), (2)-(i), (3)-(iii), (4)-(iv)
40. In the experiment of calibration of voltmeter, a standard cell of e.m.f. 1.1 volt is balanced against 440 cm of potentiometer wire. The potential difference across the ends of resistance is found to balance against 220 cm of the wire. The corresponding reading of voltmeter is 0.5 volt. The error in the reading of volmeter will be:
[Main Online April 12, 2014]
(a) -0.15 volt
(b) 0.15 volt
(c) 0.5 volt
(d) -0.05 volt
41. The diameter of a cylinder is measured using a Vernier callipers with no zero error. It is found that the zero of the Vernier scale lies between 5.10 cm and 5.15 cm of the main scale. The Vernier scale has 50 divisions equivalent to 2.45 cm . The $24^{\text {th }}$ division of the Vernier scale exactly coincides with one of the main scale divisions. The diameter of the cylinder is
[Adv. 2013]
(a) 5.112 cm
(b) 5.124 cm
(c) 5.136 cm
(d) 5.148 cm
42. In the determination of Young's modulus $\left(Y=\frac{4 M L g}{\pi l d^{2}}\right)$ by using Searle's method, a wire of length $L=2 \mathrm{~m}$ and diameter $d=0.5 \mathrm{~mm}$ is used. For a load $M=2.5 \mathrm{~kg}$, an extension $l=0.25 \mathrm{~mm}$ in the length of the wire is observed. Quantities $d$ and $l$ are measured using a screw gauge and a micrometer, respectively. They have the same pitch of 0.5 mm . The number of divisions on their circular scale is 100. The contributions to the maximum probable error of the $Y$ measurement
[2012]
(a) due to the errors in the measurements of $d$ and $l$ are the same.
(b) due to the error in the measurement of $d$ is twice that due to the error in the measurement of $l$.
(c) due to the error in the measurement of $l$ is twice that due to the error in the measurement of $d$.
(d) due to the error in the measurement of $d$ is four times that due to the error in the measurement of $l$.
43. The density of a solid ball is to be determined in an experiment. The diameter of the ball is measured with a screw gauge, whose pitch is 0.5 mm and there are 50 divisions on the circular scale. The reading on the main
scale is 2.5 mm and that on the circular scale is 20 divisions. If the measured mass of the ball has a relative error of $2 \%$, the relative percentage error in the density is [2011]
(a) $0.9 \%$
(b) $2.4 \%$
(c) $3.1 \%$
(d) $4.2 \%$
44. A vernier calipers has 1 mm marks on the main scale. It has 20 equal divisions on the Vernier scale which match with 16 main scale divisions. For this Vernier calipers, the least count is
[2010]
(a) 0.02 mm
(b) 0.05 mm
(c) 0.1 mm
(d) 0.2 mm
45. Students I, II and III perform an experiment for measuring the acceleration due to gravity $(g)$ using a simple pendulum. They use different lengths of the pendulum and /or record time for different number of oscillations. The observations are shown in the table. [Main 2008, July 22, 2021 (III)] Least count for length $=0.1 \mathrm{~cm}$
Least count for time $=0.1 \mathrm{~s}$

| Student | Length of the <br> pendulum <br> $(\mathrm{cm})$ | No. of <br> oscillations <br> $(\mathrm{n})$ | Total time <br> for (n) <br> oscillations <br> $(\mathrm{s})$ | Time <br> period <br> $(\mathrm{s})$ |
| :---: | :---: | :---: | :---: | :---: |
| I | 64.0 | 8 | 128.0 | 16.0 |
| II | 64.0 | 4 | 64.0 | 16.0 |
| III | 20.0 | 4 | 36.0 | 9.0 |

If $E_{I}, E_{I I}$ and $E_{I I I}$ are the percentage errors in $g$, i.e., $\left(\frac{\Delta g}{g} \times 100\right)$ for students I, II and III, respectively, then
(a) $E_{I}=0$
(b) $E_{I}$ is minimum
(c) $E_{I}=E_{I I}$
(d) $E_{I I}$ is maximum
46. Astudent performs an experiment to determine the Young's modulus of a wire, exactly 2 m long, by Searle's method. In a particular reading, the student measures the extension in the length of the wire to be 0.8 mm with an uncertainty of $\pm 0.05 \mathrm{~mm}$ at a load of exactly 1.0 kg . The student also measures the diameter of the wire to be 0.4 mm with an uncertainty of $\pm 0.01 \mathrm{~mm}$. Take $g=9.8 \mathrm{~m} / \mathrm{s}^{2}$ (exact). The Young's modulus obtained from the reading is [2007]
(a) $(2.0 \pm 0.3) \times 10^{11} \mathrm{~N} / \mathrm{m}^{2}$
(b) $(2.0 \pm 0.2) \times 10^{11} \mathrm{~N} / \mathrm{m}^{2}$
(c) $(2.0 \pm 0.1) \times 10^{11} \mathrm{~N} / \mathrm{m}^{2}$
(d) $(2.0 \pm 0.05) \times 10^{11} \mathrm{~N} / \mathrm{m}^{2}$
47. A student performs an experiment for determination of $g\left(=\frac{4 \pi^{2} \ell}{T^{2}}\right)$. The error in length $\ell$ is $\Delta \ell$ and in time $T$ is $\Delta T$ and $n$ is number of times the reading is taken. The measurement of $g$ is most accurate for [2006-3M,-1]

|  | $\Delta \ell$ | $\Delta T$ |
| :--- | :--- | :--- |
| (a) | 5 mm | 0.2 sec |
| (b) | 5 mm | 0.2 sec |
| (c) 5 mm | 0.10 |  |
| (d) | 1 mm | 0.1 sec |
|  | 20 |  |
| ( |  | 10 |
|  |  |  |

48. In a screw gauge, the zero of mainscale coincides with fifth division of circular scale in figure (i). The circular division of screw gauge are 50. It moves 0.5 mm on main scale in one rotation. The diameter of the ball in figure (ii) is
[2006-3M,-1]


Figure (i)


Figure (ii)
(a) 2.25 mm
(b) 2.20 mm
(c) 1.20 mm
(d) 1.25 mm
49. A wire of length $\ell=6 \pm 0.06 \mathrm{~cm}$ and radius $r=0.5 \pm 0.005 \mathrm{~cm}$ and mass $m=0.3 \pm 0.003 \mathrm{gm}$. Maximum percentage error in density is
[2004S]
(a) 4
(b) 2
(c) 1
(d) 6.8
50. A cube has a side of length $1.2 \times 10^{-2} \mathrm{~m}$. Calculate its volume.
(a) $1.7 \times 10^{-6} \mathrm{~m}^{3}$
(b) $1.73 \times 10^{-6} \mathrm{~m}^{3}$
(c) $1.70 \times 10^{-6} \mathrm{~m}^{3}$
(d) $1.732 \times 10^{-6} \mathrm{~m}^{3}$

## 2 Integer Value Answer

51. In an experiment for determination of the focal length of a thin convex lens, the distance of the object from the lens is $10 \pm 0.1 \mathrm{~cm}$ and the distance of its real image from the lens is $20 \pm 0.2 \mathrm{~cm}$. The error in the determination of focal length of the lens is $n \%$. The value of $n$ is $\qquad$ .
[Adv. 2023]
52. The energy of a system as a function of time $t$ is given as $E(t)=A^{2} \exp (-\alpha t$,$) where \alpha=0.2 \mathrm{~s}^{-1}$. The measurement of $A$ has an error of $1.25 \%$. If the error in the measurement of time is $1.50 \%$, the percentage error in the value of $E(t)$ at $t=5 \mathrm{~s}$ is
[Adv. 2015]
53. During Searle's experiment, zero of the Vernier scale lies between $3.20 \times 10^{-2} \mathrm{~m}$ and $3.25 \times 10^{-2} \mathrm{~m}$ of the main scale. The $20^{\text {th }}$ division of the Vernier scale exactly coincides with one of the main scale divisions. When an additional load of 2 kg is applied to the wire, the zero of the Vernier scale still lies between $3.20 \times 10^{-2} \mathrm{~m}$ and $3.25 \times 10^{-2} \mathrm{~m}$ of the main scale but now the $45^{\text {th }}$ division of Vernier scale coincides with one of the main scale divisions. The length of the thin metallic wire is 2 m and its cross-sectional area is $8 \times 10^{-7} \mathrm{~m}^{2}$. The least count of the Vernier scale is $1.0 \times$ $10^{-5} \mathrm{~m}$. The maximum percentage error in the Young's modulus of the wire is
[Adv. 2014]

## 3 Numeric Answer

54. In a screw gauge, there are 100 divisions on the circular scale and the main scale moves by 0.5 mm on a complete rotation of the circular scale. The zero of circular scale lies 6 divisions below the line of graduation when two studs are brought in contact with each other. When a wire is placed between the studs, 4 linear scale divisions are clearly visible while $46^{\text {th }}$ division the circular scale coincide with the reference line. The diameter of the wire is $\times 10^{-2} \mathrm{~mm}$.
[Main Jan. 30, $2 \overline{023 \text { (I)] }}$
55. In an experiment of measuring the refractive index of a glass slab using travelling microscope in physics lab, a student measures real thickness of the glass slab as 5.25 mm and apparent thickness of the glass slab at 5.00 mm . Travelling microscope has 20 divisions in one cm on main
scale and 50 divisions on Vernier scale is equal to 49 divisions on main scale. The estimated uncertainty in the measurement of refractive index of the slab is $\frac{x}{10} \times 10^{-3}$, where x is
[Main Jan. 29, 2023 (II)]
56. In an experiment to find acceleration due to gravity (g) using simple pendulum, time period of 0.5 s is measured from time of 100 oscillation with a watch of 1 s resolution. If measured value of length is 10 cm known to 1 mm accuracy. The accuracy in the determination of $g$ is found to be $x \%$. The value of $x$ is
[Main July 28, 2022 (II)]
57. The one division of main scale of vernier callipers reads 1 mm and 10 divisions of Vernier scale is equal to the 9 divisions on main scale. When the two jaws of the instrument touch each other the zero of the Vernier lies to the right of zero of the main scale and its fourth division coincides with a main scale division. When a spherical bob is tightly placed between the two jaws, the zero of the Vernier scale lies in between 4.1 cm and 4.2 cm and 6th Vernier division coincides with a main scale division. The diameter of the bob will be _ $10^{-2} \mathrm{~cm}$
[Main July 27, 2022 (I)]
58. The vernier constant of Vernier callipers is 0.1 mm and it has zero error of $(-0.05) \mathrm{cm}$. While measuring diameter of a sphere, the main scale reading is 1.7 cm and coinciding vernier division is 5 . The corrected diameter will be $\times 10^{-2} \mathrm{~cm}$.
[Main June 29, $202 \overline{2(I I)]}$
59. A student in the laboratory measures thickness of a wire using screw gauge. The readings are $1.22 \mathrm{~mm}, 1.23 \mathrm{~mm}$,
1.19 mm and 1.20 mm . The percentage error is $\frac{x}{121} \%$. The value of $x$ is $\qquad$ [Main June 28, 2022 (II)]
60. In a vernier callipers, each cm on the main scale is divided into 20 equal parts. If tenth vernier scale division coincides with nineth main scale division. Then the value of vernier constant will be. $\qquad$ $\times 10^{-2} \mathrm{~mm}$.
[Main June 26, 2022 (I)]
61. For $z=a^{2} x^{3} y^{1 / 2}$, where ' $a$ ' is à constant. If percentage error in measurement of ' $x$ ' and ' $y$ ' are $4 \%$ and $12 \%$, respectively, then the percentage error for ' $z$ ' will be $\%$.
[Main June 25, 2022 (II)]
62. The diameter of a spherical bob is measured using a vernier callipers. 9 divisions of the main scale, in the vernier callipers, are equal to 10 divisions of vernier scale. One main scale division is 1 mm . The main scale reading is 10 mm and $8^{\text {th }}$ division of vernier scale was found to coincide exactly with one of the main scale division. If the given vernier callipers has positive zero error of 0.04 cm , then the radius of the bob is $\qquad$ $\times 10^{-2} \mathrm{~cm}$.
[Main Aug. 31, 2021 (II)]
63. 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 $\qquad$ _.
[Figure shows position of reference ' O ' when jaws of screw gauge are closed]
Given pitch $=0.1 \mathrm{~cm}$.
[Main July 25, 2021 (I); June 25, 2022 (I)]

64. The radius of a sphere is measured to be $(7.50+0.85) \mathrm{cm}$. Suppose the percentage error in its volume is x .
The value of $x$, to the nearest $x$, is $\qquad$ .
[Main March 18, 2021 (II)]
65. The resistance $R=\frac{V}{I}$, where $V=(50 \pm 2) V$ and $\mathrm{I}=(20 \pm 0.2) \mathrm{A}$. The percentage error in R is ' $\mathrm{x} \%$. The value of ' $x$ ' to the nearest integer is $\qquad$ .
[Main March 16, 2021 (I)]
66. Two capacitors with capacitance values $C_{1}=2000 \pm 10 \mathrm{pF}$ and $C_{2}=3000 \pm 15 \mathrm{pF}$ are connected in series. The voltage applied across this combination is $V=5.00 \pm 0.02 \mathrm{~V}$. The percentage error in the calculation of the energy stored in this combination of capacitors is $\qquad$ . [Adv. 2020]
67. The density of a solid metal sphere is determined by measuring its mass and its diameter. The maximum error in the density of the sphere is $\left(\frac{x}{100}\right) \%$. If the relative errors in measuring the mass and the diameter are $6.0 \%$ and $1.5 \%$ respectively, the value of $x$ is $\qquad$ . [Main Sep. 06, 2020 (I)] An optical bench has 1.5 m long scale having four equal divisions in each cm . While measuring the focal length of a convex lens, the lens is kept at 75 cm mark of the scale and the object pin is kept at 45 cm mark. The image of the object pin on the other side of the lens overlaps with image pin that is kept at 135 cm mark. In this experiment, the percentage error in the measurement of the focal length of the lens is $\qquad$ [Adv. 2019]
68. A steel wire of diameter 0.5 mm and Young's modulus $2 \times 10^{11} \mathrm{~N} \mathrm{~m}^{-2}$ carries a load of mass $M$. The length of the wire with the load is 1.0 m . A vernier scale with 10 divisions is attached to the end of this wire. Next to the steel wire is a reference wire to which a main scale, of least count 1.0 mm , is attached. The 10 divisions of the vernier scale correspond to 9 divisions of the main scale. Initially, the zero of vernier scale coincides with the zero of main scale. If the load on the steel wire is increased by 1.2 kg , the vernier scale division which coincides with a main scale division is Take $\mathrm{g}=10 \mathrm{~ms}^{-2}$ and $\pi=3.2$.
[Adv. 2018]
69. The side of a cube is measured by vernier callipers ( 10 divisions of a vernier scale coincide with 9 divisions of main scale, where 1 division of main scale is 1 mm ). The main scale reads 10 mm and first division of vernier scale coincides with the main scale. Mass of the cube is 2.736 g . Find the density of the cube in appropriate significant figures.
[2005-2 Marks]
70. In Searle's experiment, which is used to find Young's Modulus of elasticity, the diameter of experimental wire is $D=0.05 \mathrm{~cm}$ (measured by a scale of least count 0.001 cm ) and length is $L=110 \mathrm{~cm}$ (measured by a scale of least count 0.1 cm ). A weight of 50 N causes an extension of $X$ $=0.125 \mathrm{~cm}$ (measured by a micrometer of least count 0.001 cm ). Find maximum possible error in the values of Young's modulus. Screw gauge and meter scale are free from error.
[2004-2 Marks]
71. A screw gauge having 100 equal divisions and a pitch of length 1 mm is used to measure the diameter of a wire of length 5.6 cm . The main scale reading is 1 mm and $47^{\text {th }}$ circular division coincides with the main scale. Find the curved surface area of wire in $\mathrm{cm}^{2}$ to appropriate significant figure. (use $\pi=\frac{22}{7}$ ).
[2004-2 Marks]

## 6 MCQs with One or More than One Correct Answer

73. In an experiment to determine the acceleration due to gravity $g$, the formula used for the time period of a periodic motion is $T=2 \pi \sqrt{\frac{7(\mathrm{R}-\mathrm{r})}{5 \mathrm{~g}}}$. The values of R and r are measured to be $(60 \pm 1) \mathrm{mm}$ and $(10 \pm 1) \mathrm{mm}$, respectively. In five successive measurements, the time period is found to be $0.52 \mathrm{~s}, 0.56 \mathrm{~s}, 0.57 \mathrm{~s}, 0.54 \mathrm{~s}$ and 0.59 s . The least count of the watch used for the measurement of time period is 0.01 s . Which of the following statement(s) is (are) true?
[Adv. 2016]
(a) The error in the measurement of $r$ is $10 \%$
(b) The error in the measurement of T is $3.75 \%$
(c) The error in the measurement of T is $2 \%$
(d) The error in the determined value of $g$ is $11 \%$
74. Consider a Vernier callipers in which each 1 cm on the main scale is divided into 8 equal divisions and a screw gauge with 100 divisions on its circular scale. In the Vernier callipers, 5 divisions of the Vernier scale coincide with 4 divisions on the main scale and in the screw gauge, one complete rotation of the circular scale moves it by two divisions on the linear scale. Then :
[Adv. 2015]
(a) If the pitch of the screw gauge is twice the least count of the Vernier callipers, the least count of the screw gauge is 0.01 mm
(b) If the pitch of the screw gauge is twice the least count of the Vernier callipers, the least count of the screw gauge is 0.005 mm
(c) If the least count of the linear scale of the screw gauge is twice the least count of the Vernier callipers, the least count of the screw gauge is 0.01 mm
(d) If the least count of the linear scale of the screw gauge is twice the least count of the Vernier callipers, the least count of the screw gauge is 0.005 mm
75. Using the expression $2 \mathrm{~d} \sin \theta=\lambda$, one calculates the values of $d$ by measuring the corresponding angles $\theta$ in the range 0 to $90^{\circ}$. The wavelength $\lambda$ is exactly known and the error in $\theta$ is constant for all values of $\theta$. As $\theta$ increases from $0^{\circ}$
[Adv. 2013]
(a) The absolute error in $d$ remains constant
(b) The absolute error in $d$ increases
(c) The fractional error in $d$ remains constant
(d) The fractional error in $d$ decreases
76. A student uses a simple pendulum of exactly 1 m length to determine $g$, the acceleration due to gravity. He uses a stop watch with the least count of 1 sec for this and records 40 seconds for 20 oscillations. For this observation, which of the following statement(s) is (are) true?
[2010]
(a) Error $\Delta T$ in measuring $T$, the time period, is 0.05 seconds
(b) Error $\Delta T$ in measuring $T$, the time period, is 1 second
(c) Percentage error in the determination of $g$ is $5 \%$
(d) Percentage error in the determination of $g$ is $2.5 \%$

## 8 Comprehension/Passage Based Questions

## Passage

If the measurement errors in all the independent quantities are known, then it is possible to determine the error in any dependent quantity. This is done by the use of series expansion and truncating the expansion at the first power of the error. For example, consider the relation $z=x / y$. If the errors in $x, y$ and $z$ are $\Delta x, \Delta y$ and $\Delta z$, respectively, then

$$
z \pm \Delta z=\frac{x \pm \Delta x}{y \pm \Delta y}=\frac{x}{y}\left(1 \pm \frac{\Delta x}{x}\right)\left(1 \pm \frac{\Delta y}{y}\right)^{-1} .
$$

The series expansion for $\left(1 \pm \frac{\Delta y}{y}\right)^{-1}$, to first power in $\Delta y / y$, is
$1 \mp(\Delta y / y)$. The relative errors in independent variables are always added. So the error in $z$ will be

$$
\Delta z=z\left(\frac{\Delta x}{x}+\frac{\Delta y}{y}\right) .
$$

The above derivation makes the assumption that $\Delta x / x \ll 1$, $\Delta y / y \ll 1$. Therefore, the higher powers of these quantities are neglected.
[Adv. 2018]
77. Consider the ratio $r=\frac{(1-a)}{(1+a)}$ to be determined by measuring a dimensionless quantity $a$. If the error in the measurement of $a$ is $\Delta a(\Delta a / a \ll 1$, then what is the error $\Delta r$ in determining $r$ ?
(a) $\frac{\Delta a}{(1+a)^{2}}$
(b) $\frac{2 \Delta a}{(1+a)^{2}}$
(c) $\frac{2 \Delta a}{\left(1-a^{2}\right)}$
(d) $\frac{2 a \Delta a}{\left(1-a^{2}\right)}$
78. In an experiment the initial number of radioactive nuclei is 3000 . It is found that $1000 \pm 40$ nuclei decayed in the
first 1.0 s . For $|x| \ll 1, \ln (1+x)=x$ up to first power in $x$. The error $\Delta \lambda$, in the determination of the decay constant $\lambda$, in $s^{-1}$, is
(a) 0.04
(b) 0.03
(c) 0.02
(d) 0.01

## 10 Subjective Problems

79. If $n^{\text {th }}$ division of main scale coincides with $(n+1)^{\text {th }}$ divisions of vernier scale. Given one main scale division is equal to ' $a$ ' units. Find the least count of the vernier.
[2003-2 Marks]

## Topic-4: Miscellaneous (Mixed Concepts) Problems

## 8 Comprehension/Passage Based Questions <br> Passage

A dense collection of equal number of electrons and positive ions is called neutral plasma. Certain solids containing fixed positive ions surrounded by free electrons can be treated as neutral plasma. Let ' $N$ ' be the number density of free electrons, each of mass ' $m$ '. When the electrons are subjected to an electric field, they are displaced relatively away from the heavy positive ions. If the electric field becomes zero, the electrons begin to oscillate about the positive ions with a natural angular frequency ' $\omega_{\mathrm{p}}$ ' which is called the plasma frequency. To sustain the oscillations, a time varying electric field needs to be applied that has an angular frequency $\omega$, where a part of the energy is absorbed and a part of

## Answer Key

it is reflected. As $\omega$ approaches $\omega_{\mathrm{p}}$ all the free electrons are set to resonance together and all the energy is reflected. This is the explanation of high reflectivity of metals.
[2011]

1. Taking the electronic charge as 'e' and the permittivity as ' $\varepsilon_{0}$ '. Use dimensional analysis to determine the correct expression for $\omega_{\mathrm{p}}$.
(a) $\sqrt{\frac{N e}{m \varepsilon_{0}}}$
(b) $\sqrt{\frac{m \varepsilon_{0}}{N e}}$
(c) $\sqrt{\frac{N e^{2}}{m \varepsilon_{0}}}$
(d) $\sqrt{\frac{N e^{2}}{m \varepsilon_{0}}}$
2. Estimate the wavelength at which plasma reflection will occur for a metal having the density of electrons $\mathrm{N} \approx 4 \times 10^{27} \mathrm{~m}^{-3}$. Taking $\varepsilon_{0}=10^{-11}$ and mass $\mathrm{m} \approx 10^{-30}$, where these quantities are in proper SI units.
(a) 800 nm
(b) 600 nm
(c) 300 nm
(d) 200 nm

## Topic-1 : Unit of Physical Quantities

1. (b)
2. (b)
3. (a)
4. (c)
5. (a)
6. (a)
7. (b)
8. (a, b, c, d)
9. (b)
10. (b) 11. ( $A \rightarrow p, q ; B \rightarrow r, s ; C \rightarrow r, s ; D \rightarrow r, s)$

Topic-2 : Dimensions of Physical Quantities
 Topic-3 : Errors in Measurements \& Experimental Physics

1. (a)
2. (a)
3. (c)
4. (c)
5. (c)
6. (c)
7. (c)
8. (b)
9. (b)
10. (d)
11. (a)
12. (a)
13. (c)
14. (b)
15. (c)
16. (c)
17. (c)
18. (a)
19. (b)
20. (d)
21. (d)
22. (b)
23. (a)
24. (None
25. (d)
26. (c)
27. (c)
28. (c)
29. (c)
30. (d)
31. (b)
32. (b)
33. (d)
34. (c)
35. (d)
36. (b)
37. (a)
38. (b)
39. (a)
40. (d)
41. (b)
42. (a)
43. (c)
44. (d)
45. (b)
46. (b)
47. (d)
48. (c)
49. (a)
50. (a)
51. (1)
52. (4)
53. (4)
54. (22)
55. (41)
56. (5)
57. (412)
58. (180)
59. (150)
60. (5)
61. (18)
62. (52)
63. (13)
64. (34)
65. (5)
66. (1.30)
67. (1050)
68. (1.39)
69. (3.00)
70. $\left(1.09 \times 10^{10} \mathrm{~N} / \mathrm{m}^{2}\right)$
71. $\left(2.6 \mathrm{~cm}^{2}\right)$
72. $(a, b, d) 74$. $(b, c)$
73. (d)
74. $(\mathrm{a}, \mathrm{c})$
75. (b)
76. (c)

Topic-4 : Miscellaneous (Mixed Concepts) Problems

1. (c)
2. (b)
