PACE IIT & MEDICAL

Advanced Booklet Solution

Units & Dimensions, Errors & Measurement

JEE Main Exercise

Units

1. (C)
Light year is a distance which light travels in one year.

2. (B)
Because magnitude is absolute.

3. (D)
$Watt = Joule/second = Ampere \times volt = Ampere^2 \times Ohm$

4. (C)
Impulse = change in momentum = $F \times t$
So, the unit of momentum will be equal to *Newton-sec.*

5. (C)
Unit of energy will be $kg\text{-}m^2/\text{sec}^2$

6. (C)
$1\ nm = 10^{-9} m = 10^{-7} cm$

7. (D)
$1\ micron = 10^{-6} m = 10^{-4} cm$

8. (C)
$Watt = Joule/sec.$

9. (C)
$$F = \frac{Gm_1m_2}{d^2}; \quad \therefore G = \frac{Fd^2}{m_1m_2} = Nm^2/kg^2$$

10. (A)

11. (C)
$$\text{Angular acceleration} = \frac{\text{Angular velocity}}{\text{Time}} = \frac{\text{rad}}{\text{sec}^2}$$

12. (B)

Kg-m/sec is the unit of linear momentum

13. (D)

ct^2 must have dimensions of L

$\Rightarrow c$ must have dimensions of L/T^2 *i.e.* LT^{-2}.

14. (D)

$\tau = \frac{dL}{dt} \Rightarrow dL = \tau \times dt = r \times F \times dt$

i.e. the unit of angular momentum is *joule-second.*

15. (C)

16. (A)

Volume of cube = a^3

Surface area of cube = $6a^2$

According to problem $a^3 = 6a^2 \Rightarrow a = 6$

$\therefore \quad V = a^3 = 216\,units$.

17. (B)

$6 \times 10^{-5} = 60 \times 10^{-6} = 60\,microns$

18. (D)

19. (D)

Because temperature is a fundamental quantity.

20. (A)

21. (A)

1 C.G.S unit of density = 1000 M.K.S. unit of density $\Rightarrow$ $0.5\,gm/cc = 500\,kg/m^3$

22. (B)

23. (D)

24. (D)

$E = -\frac{dV}{dx}$

25. (D)

26. (D)

Surface tension = $\frac{\text{Force}}{\text{Length}}$ = *Newtons / metre*

27. (B)

$mv = kg\left(\frac{m}{\sec}\right)$

28. (A)

Quantities of similar dimensions can be added or subtracted so unit of *a* will be same as that of velocity.

29. (B)

$1\ MeV = 10^6\ eV$

30. (A)

Energy (E) = $F \times d \Rightarrow F = \frac{E}{d}$

So, *Erg/metre* can be the unit of force.

31. (B)

Potential energy $= mgh = g\left(\frac{cm}{\sec^2}\right)cm = g\left(\frac{cm}{\sec}\right)^2$

32. (B)

$\frac{watt}{ampere} = volt$

33. (B)

Dimensions

34. (B)

Power $= \frac{\text{Work}}{\text{Time}} = \frac{ML^2T^{-2}}{T} = ML^2T^{-3}$

35. (A)

Calorie is the unit of heat *i.e.*, energy.

So dimensions of energy $= ML^2T^{-2}$

36. (B)

Angular momentum = $mvr = MLT^{-1} \times L = ML^2T^{-1}$

37. (C)

$\frac{L}{R}$ = Time constant

38. (C)

Impulse = change in momentum so dimensions of both quantities will be same and equal to MLT^{-1}

39. (B)

$RC = T$

$\because\ [R] = [ML^2T^{-3}I^{-2}]$ and $[C] = [M^{-1}L^{-2}T^4I^2]$

40. (A, D)

[Torque] = [work] = $[ML^2T^{-2}]$

[Light year] = [Wavelength] = $[L]$

41. (A)

$Q = mL \Rightarrow L = \frac{Q}{m}$ (Heat is a form of energy)

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

42. (D)

Volume elasticity = $\frac{\text{Force/Area}}{\text{Volume strain}}$

Strain is dimensionless, so $= \frac{\text{Force}}{\text{Area}} = \frac{MLT^{-2}}{L^2} = [ML^{-1}T^{-2}]$

43. (B)

$F = \frac{Gm_1m_2}{d^2} \Rightarrow G = \frac{Fd^2}{m_1m_2}$

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

44. (A)

Angular velocity = $\frac{\theta}{t},\ [\omega] = \frac{[M^0L^0T^0]}{[T]} = [T^{-1}]$

45. (A)

Power = $\frac{\text{Work done}}{\text{Time}} = \left[\frac{ML^2T^{-2}}{T}\right] = [ML^2T^{-3}]$

46. (A)

Couple = Force $\times$ Arm length $= [MLT^{-2}][L] = [ML^2T^{-2}]$

47. (B)

Angular momentum = mvr

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

48. (B)

Impulse = Force × Time = $[MLT^{-2}][T]=[MLT^{-1}]$

49. (A)

50. (C)

$E=h\nu \Rightarrow [ML^2T^{-2}]=[h][T^{-1}] \Rightarrow [h]=[ML^2T^{-1}]$

51. (B)

Moment of inertia $=mr^2=[M][L^2]$

Moment of Force = Force × Perpendicular distance

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

52. (A)

Momentum = $mv=[MLT^{-1}]$

Impulse = Force × Time = $[MLT^{-2}]\times[T]=[MLT^{-1}]$

53. (B)

Pressure = $\frac{\text{Force}}{\text{Area}}=\frac{\text{Energy}}{\text{Volume}}$ = $ML^{-1}T^{-2}$

54. (A)

$\frac{1}{2}Li^2$ = Stored energy in an inductor = $[ML^2T^{-2}]$

55. (D)

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

Force per unit area = $\frac{[MLT^{-2}]}{[L^2]}=[ML^{-1}T^{-2}]$

Product of voltage and charge per unit volume

$=\frac{V\times Q}{\text{Volume}}=\frac{VIt}{\text{Volume}}=\frac{\text{Power}\times\text{Time}}{\text{Volume}}$

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

Angular momentum per unit mass = $\frac{[ML^2T^{-1}]}{[M]}=[L^2T^{-1}]$

So angular momentum per unit mass has different dimension.

56. (D)

Time constant $\tau=[T]$ and Viscosity $\eta=[ML^{-1}T^{-1}]$

For options (a), (b) and (c) dimensions are not matching with time constant.

57. (D)

By putting the dimensions of each quantity both the sides we get $[T^{-1}]=[M]^x[MT^{-2}]^y$

Now comparing the dimensions of quantities in both sides we get $x+y=0$ and $2y=1$

$\therefore x=-\frac{1}{2},\ y=\frac{1}{2}$

58. (C)

m = linear density = mass per unit length = $\left[\frac{M}{L}\right]$

A = force $=[MLT^{-2}]$ $\therefore$ $[B]$ = $\frac{[A]}{[m]}=\frac{[MLT^{-2}]}{[ML^{-1}]}=[L^2T^{-2}]$

This is same dimension as that of latent heat.

59. (C)

Let $v^x=kg^y\lambda^z\rho^\delta$.

Now by substituting the dimensions of each quantities and equating the powers of *M*, *L* and *T* we get $\delta=0$ and $x=2, y=1, z=1$.

60. (A)

Farad is the unit of capacitance and $C=\frac{Q}{V}=\frac{[Q]}{[ML^2T^{-2}Q^{-1}]}=M^{-1}L^{-2}T^2Q^2$

61. (A)

$\rho=\frac{RA}{l}$ *i.e.* dimension of resistivity is $[ML^3T^{-1}Q^{-2}]$

62. (B)

From the principle of homogenity $\left(\frac{x}{v}\right)$ has dimensions of *T*.

63. (C)

Stress = $\frac{\text{Force}}{\text{Area}}=\frac{[MLT^{-2}]}{[L^2]}=[ML^{-1}T^{-2}]$

64. (C)

65. (B)

Momentum = mv = $[MLT^{-1}]$

66. (C)

$T = 2\pi\sqrt{l/g} \Rightarrow T^2 = 4\pi^2 l/g \Rightarrow g = \frac{4\pi^2 l}{T^2}$

Here % error in $l = \frac{1mm}{100cm}\times100 = \frac{0.1}{100}\times100 = 0.1\%$ and % error in $T = \frac{0.1}{2\times100}\times100 = 0.05\%$

$\therefore$ % error in g = % error in l + 2(% error in T)

$= 0.1 + 2\times0.05 = 0.2$ %

67. (B)

$\therefore E = \frac{1}{2}mv^2$

$\therefore$ % Error in K.E.

= % error in mass + 2 × % error in velocity

= 2 + 2 × 3 = 8%

68. (B)

69. (B)

Number of significant figures are 3, because 10^3 is decimal multiplier.

70. (B)

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

$\therefore$ % error is volume $= 3\times$% error in radius

$= 3\times1 =$ 3%

71. (C)

Mean time period T = 2.00 *sec*

& Mean absolute error $= \Delta T$ = 0.05 *sec.*

To express maximum estimate of error, the time period should be written as $(2.00 \pm 0.05)\,sec$

72. (B)

Here, $S = (13.8 \pm 0.2)\,m$ and $t = (4.0 \pm 0.3)$ *sec*

Expressing it in percentage error, we have,

$S = 13.8 \pm \frac{0.2}{13.8}\times100\% = 13.8 \pm 1.4\%$ and $t = 4.0 \pm \frac{0.3}{4}\times100\% = 4 \pm 7.5\%$

$\because V = \frac{s}{t} = \frac{13.8 \pm 1.4}{4 \pm 7.5} = (3.45 \pm 0.3)\ m/s.$

73. (C)

% error in velocity = %error in L + %error in t

$= \frac{0.2}{13.8}\times100 + \frac{0.3}{4}\times100$

= 1.44 + 7.5 = 8.94 %

74. (C)

75. (A)

$\frac{1}{20} = 0.05$

$\therefore$ Decimal equivalent upto 3 significant figures is 0.0500

76. (B)

77. (B)

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

$\therefore$ % error in volume

$= 3 \times \%$ error in radius.

$= \frac{3 \times 0.1}{5.3} \times 100$

78. (A)

Since percentage increase in length = 2 %

Hence, percentage increase in area of square sheet

$= 2 \times 2\% = 4\%$

79. (C)

Since for 50.14 *cm*, significant number = 4 and for 0.00025, significant numbers = 2

80. (D)

$a = b^{\alpha} c^{\beta} / d^{\gamma} e^{\delta}$

So maximum error in *a* is given by

$$\left(\frac{\Delta a}{a} \times 100\right)_{\max} = \alpha.\frac{\Delta b}{b} \times 100 + \beta.\frac{\Delta c}{c} \times 100 + \gamma.\frac{\Delta d}{d} \times 100 + \delta.\frac{\Delta e}{e} \times 100$$

$$= \left(\alpha b_1 + \beta c_1 + \gamma d_1 + \delta e_1\right)\%$$

81. (A)

Weight in air $= (5.00 \pm 0.05)\,N$

Weight in water $= (4.00 \pm 0.05)\,N$

Loss of weight in water $= (1.00 \pm 0.1)\,N$

Now relative density $= \frac{\text{weight in air}}{\text{weight loss in water}}$

i.e. $R\,.\,D = \frac{5.00 \pm 0.05}{1.00 \pm 0.1}$

Now relative density with max permissible error

$$= \frac{5.00}{1.00} \pm \left(\frac{0.05}{5.00} + \frac{0.1}{1.00}\right) \times 100 = \frac{5.00}{1.00} \pm \left(\frac{0.05}{5.00} + \frac{0.1}{1.00}\right) \times 100 = 5.0 \pm (1 + 10)\% = 5.0 \pm 11\%$$

82. (B)

$$\therefore \left(\frac{\Delta R}{R}\times 100\right)_{\max} = \frac{\Delta V}{V}\times 100+\frac{\Delta I}{I}\times 100$$

$$=\frac{5}{100}\times 100+\frac{0.2}{10}\times 100=(5+2)\% = 7\%$$

83. (B)

Average value $=\dfrac{2.63+2.56+2.42+2.71+2.80}{5}$

$=2.62\,\text{sec}$

Now $|\Delta T_1|=2.63-2.62=0.01$

$|\Delta T_2|=2.62-2.56=0.06$

$|\Delta T_3|=2.62-2.42=0.20$

$|\Delta T_4|=2.71-2.62=0.09$

$|\Delta T_5|=2.80-2.62=0.18$

Mean absolute error

$$\Delta T=\frac{|\Delta T_1|+|\Delta T_2|+|\Delta T_3|+|\Delta T_4|+|\Delta T_5|}{5}$$

$$=\frac{0.54}{5}=0.108=0.11 sec$$

84. (C)

Volume of cylinder $V=\pi r^2 l$

Percentage error in volume

$$\frac{\Delta V}{V}\times 100=\frac{2\Delta r}{r}\times 100+\frac{\Delta l}{l}\times 100$$

$$=\left(2\times\frac{0.01}{2.0}\times 100+\frac{0.1}{5.0}\times 100\right)=(1+2)\% = 3\%$$

85. (C)

$Y=\dfrac{4MgL}{\pi D^2 l}$ so maximum permissible error in Y = $\dfrac{\Delta Y}{Y}\times 100=\left(\dfrac{\Delta M}{M}+\dfrac{\Delta g}{g}+\dfrac{\Delta L}{L}+\dfrac{2\Delta D}{D}+\dfrac{\Delta l}{l}\right)\times 100$

$$=\left(\frac{1}{300}+\frac{1}{981}+\frac{1}{2820}+2\times\frac{1}{41}+\frac{1}{87}\right)\times 100 = 0.065\times 100=6.5\%$$

86. (B)

$H=I^2Rt$

$$\therefore \frac{\Delta H}{H}\times 100=\left(\frac{2\Delta I}{I}+\frac{\Delta R}{R}+\frac{\Delta t}{t}\right)\times 100 = (2\times 3+4+6)\%=16\%$$

87. (D)

Kinetic energy $E = \frac{1}{2}mv^2$

$\therefore \ \frac{\Delta E}{E}\times 100 = \frac{v'^2 - v^2}{v^2}\times 100 \ = [(1.5)^2 - 1]\times 100$

$\therefore \frac{\Delta E}{E}\times 100 = 125\%$

88. (C)

Quantity *C* has maximum power. So it brings maximum error in *P*.

89. (C)

Given, $L = 2.331\,cm$

$= 2.33$ (correct upto two decimal places) and $B = 2.1\,cm = 2.10\,cm$

$\therefore L + B = 2.33 + 2.10 = 4.43\,cm. = 4.4\,cm$

Since minimum significant figure is 2.

90. (D)

The number of significant figures in all of the given number is 4.

91. (C)

92. (A)

Percentage error in $X = a\alpha + b\beta + c\gamma$

93. (D)

Percentage error in $A = \left(2\times 1 + 3\times 3 + 1\times 2 + \frac{1}{2}\times 2\right)\% = 14\%$

PYQ : JEE Main

1. (A)

Torque = Force × Perpendicular distance = $[MLT^{-2}]$ $[L]$ = $[ML^2T^{-2}]$

Work = Force × Displacement = $[MLT^{-2}]$ $[L]$ = $[ML^2T^{-2}]$

2. (B)

$\frac{1}{\sqrt{\mu_0 \in_0}} = \sqrt{L^2T^{-2}} = LT^{-1}$

Speed = LR^{-1}

Stress, Young's modulus $= \frac{MLT^{-2}}{L^2} = ML^{-1}T^{-2}$

Momentum = MLT^{-1}

Torque, work = ML^2T^{-2}

Planck's constant $= \frac{ML^2T^{-2}}{(LT^{-1})}\times L = ML^2T^{-1}$

3. (C)

Vaccum permittivity:

$$F_c = \frac{1}{4\pi\varepsilon_0} \times \frac{q_1 q_2}{r^2}$$

Where ε_0 is permittivity of vaccum.

Dimension will be $[M^{-1}L^{-3}T^4I^2]$

Vaccum permeability:

$$\mu_0 = 4\pi \times 10^{-7} \quad N/A^2$$

Dimensions will be $[MLT^{-2} I^{-2}]$

Dimension for $\frac{1}{\mu_0\varepsilon_0}$ will be $\frac{1}{[M^{-1}L^{-3}T^4I^2] \times [M^1L^1T^{-2}I^{-2}]} = [L^2T^{-2}]$

4. (C)

For calculating coefficient of viscosity we can use the formula, $F = \frac{\eta v A}{S}$

Dimension of coefficient of viscosity will be $= \frac{\text{Dimension of force} \times \text{Distance}}{\text{Velocity} \times \text{Area}}$

$$= \frac{MLT^{-2} \times L}{LT^{-1}L^2}$$

$$= ML^{-1}T^{-1}$$

5. (C)

Moment of Inertia, $I = Mr^2$

$[I] = [ML^2]$

Moment of force, $\vec{\tau} = \vec{r} \times \vec{F}$ -

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

6. (C)

Rad is the unit of absorbed dose of ionizing radiation. One rad is equal approximately to the absorbed dose delivered when soft tissue is exposed to one-roentgen of medium-voltage radiation. Thus this is the bilogical effect of radiation.

7. (B)

Weber = $ML^2T^{-2}I^{-1}$

$= ML^2T^{-2}Q^{-1}T = ML^2T^{-1}Q^{-1}$ $(I = QT^{-1})$

Henry H is SI unit of inductance.

$H = ML^2T^{-2}I^{-2}$; also $I = QT^{-1}$

So, $H = ML^2T^{-2}Q^{-2}T^2 = ML^2Q^{-2}$

8. (A)

Momentum = mv = 3.513 × 5.00 = 17.565 ≈ 17.57

≈ 17.6 kgm/s

(Since 5.00 contains least no. of significant figures i.e. 3)

9. (C)

$$[B] = \frac{F}{il} = \frac{Ft}{ql} = \frac{MLT^{-2}T}{CL} = [MT^{-1}C^{-1}]$$

10. (A)

30 divisions of vernier scale coincide with 29 divisions of main scale.

$$\therefore\ 1\,V.S.D = \frac{29}{30}\,M.S.D$$

Least count = 1 MSD – 1 VSD

$$= 1\,MSD - \frac{29}{30}\,MSD$$

$$= \frac{1}{30}\,MSD = \frac{1}{30} \times 0.5^{o}$$

$$= \frac{1}{30} \times 30\ \text{min} = 1\ \text{min}$$

11. (A)

Zeroes before a digit is not counted as a significant figure. In first number all digits are significant. In number second only 3 is significant all other zeroes are before digit therefore, not counted as a significant figure and numbers in powers are also not counted as a significant number, hence there are only 2 significant digits in the last number. Therefore, option (A).

12. (D)

Angular momentum $= m \times v \times r = ML^{2}T^{-1}$

Latent heat $L = \frac{Q}{m} = \frac{ML^{2}T^{-2}}{M} = L^{2}T^{-2}$

Capacitance $C = \frac{\text{Charge}}{\text{P.d.}} = M^{-1}L^{-2}T^{4}A^{2}$

13. (A)

Given : $E_y \alpha J_x$ and $E_y \alpha B_Z$

$E_y \alpha J_x B_Z$

$\Rightarrow\ E_y - = KJ_x B_Z$ (where K = constant of proportionality)

By Dimensional analysis we have;

$[E_y] = [KJ_x B_Z]$

$$\Rightarrow\ [K] = \frac{[E_y]}{[J_x B_Z]} = \frac{[M^1L^1T^3A^{-1}]}{[L^{-2}A^{A}][M^1T^{-2}A^{-1}]}$$

$$\Rightarrow\ [K] = \frac{[L^3]}{[A^1T^1]} \rightarrow \text{Dimensional formula of K}$$

So, S.I. unit of K will be : $\frac{m^3}{As}$

14. (C)

$[t]=[r]^b[s]^{c/2}[d]^{a/2}$

$T=L^b[MT^{-2c/2}][ML^{-3}]^{a/4}$

So, $\frac{c}{2}+\frac{a}{4}=0, c=-1$ and $b-\frac{3a}{4}=0$

Solving above, we get $b=\frac{3}{2}$

15. (A)

As we know, $F=\frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{R^2} \Rightarrow \varepsilon_0=\frac{q_1 q_2}{4\pi FR^2}$

Hence, $\varepsilon_0=\frac{C^2}{\text{N.m}^2}=\frac{[AT]^2}{[MLT^{-2}][L^2]}=[M^{-1}L^{-3}T^4A^2]$

16. (B)

Here, $T=2\pi\sqrt{\frac{L}{g}}$ or $T^2=4\pi^2\left(\frac{L}{g}\right)$

So, $g=\frac{4\pi^2 T}{T^2}$

Thus, $\frac{\Delta g}{g}=\frac{\Delta L}{L}+2\frac{\Delta T}{T}$

% error in $g=\frac{\Delta g}{g}\times 100$

$$=\left(\frac{\Delta L}{L}+2\frac{\Delta T}{T}\right)\times 100$$

$$=\left(\frac{(1/10)}{20}+2\times\frac{1}{90}\right)\times 100=2.72\%$$

17. (B)

The dimensional formulae of

$e=\left[M^0L^0T^1A^1\right]$

$\varepsilon_0=\left[M^{-1}L^{-3}T^4A^2\right]$

$G=\left[M^{-1}L^3T^{-2}\right]$ and $m_e=\left[M^1L^0T^0\right]$

Now, $\frac{e^2}{2\pi\varepsilon_0 Gm_e^2}=\frac{\left[M^0L^0T^1A^1\right]^2}{2\pi\left[M^{-1}L^{-3}T^4A^2\right]\left[M^{-1}L^3T^{-2}\right]\left[M^1L^0T^0\right]^2}=\frac{1}{2\pi}$

$\because \frac{1}{2\pi}$ is dimensionless thus the combination $\frac{e^2}{2\pi\varepsilon_0 Gm_e^2}$ would have the same value in different systems of units.

18. (D)

The current voltage relation of diode is

$I=\left(e^{1000\,V/T}-1\right)mA$ (given)

When, $I=5mA, e^{1000\,V/T}=6\,mA$

Also, $dI = \left(e^{1000V/T}\right)\times\frac{1000}{T}.dV$

Error = ± 0.01 (By exponential function)

$= \left(6\,mA\right)\times\frac{1000}{300}\times\left(0.01\right) = 0.2$ mA

19. (A)
Measured length of rod = 3.50 cm
For Vernier Scale with 1 Main Scale Division = 1 mm
9 Main Scale Division = 10 Vernier Scale Division,
Least count = 1 MSD – 1 VSD = 0.1 mm

20. (B)
As, $g = 4\pi^2\frac{L}{T^2}$

So, $\frac{\Delta g}{g}\times100 = \frac{\Delta L}{L}\times100 + 2\frac{\Delta T}{T}\times1000$

$= \frac{0.1}{20}\times100 + 2\times\frac{1}{90}\times100 = 2.72 \simeq 3\%$

21. (C)
Dimension of $A \neq$ dimension of (C)
Hence $A - C$ is not possible.

22. (C)
Sum of all observations $= \frac{90+91+95+92}{4} = 368$

Average $= \frac{368}{4} = 92\,\text{sec}$

$\Delta T_1 = 90-90 = 0,\ \Delta T_2 = 91-90 = 1,\ \Delta T_3 = 95-90 = 5, \Delta T_4 = 92-90 = 2$

23. (A)
L.C. $= \frac{0.5}{50} = 0.01\,\text{mm}$

Zero error = (50 – 45) = 5 × 0.01 = 0.05 mm (Negative)
Reading = (0.5 + 25 × 0.01) + 0.05 = 0.80 mm

24. (C)
$\sigma = \frac{ne^2\tau}{m}$

$[\sigma] = \frac{L^{-3}I^2T^2T}{M} = M^{-1}L^{-3}I^2T^3$

25. (A)
$M = \frac{L}{V/r}$

$[M] = \frac{L}{C.Ct} = \frac{[L]}{[C^2]t} = hT^{-1}C^{-2}$

26. (C)

$P = a^{1/2}.b^2.c^3.d^{-4}$

Taking long on both sides

$\log P = \frac{1}{2}\log a + 2\log b + 3\log c - 4\log d$

Now differentiating on both sides

$\frac{dP}{P} = \frac{da}{2a} + 2\frac{bd}{b} + 3\frac{dc}{c} - 4\frac{d(d)}{d}$

or $\frac{\Delta P}{P} = \frac{\Delta a}{2a} \pm 2\frac{\Delta b}{b} \pm 3\frac{\Delta c}{c} \pm 4\frac{\Delta d}{d}$

Now, given $\frac{\Delta a}{a} \times 100 = 2$

$\Rightarrow \frac{\Delta b}{b} \times 100 = 1$, $\Rightarrow \frac{\Delta c}{c} \times 100 = 3$, $\Rightarrow \frac{\Delta d}{d} \times 100 = 5$,

$\Rightarrow \frac{\Delta P}{P} \times 100 = \frac{2}{2} \pm 2\times 1 \pm 3\times 3 \pm 4\times 5$

$\Rightarrow \frac{\Delta P}{P} \times 100 = 32\%$

27. (A)

$T = \frac{rhg}{2} \times 10^3 \text{ N/m} = \frac{Dhg}{4} \times 10^3 \text{ N/m}$ (Since $D = 2r$)

$\Rightarrow \log T = \log D + \log h + \log g - 4 + 3$

$\Rightarrow \frac{\Delta T}{T} = \frac{\Delta D}{D} + \frac{\Delta h}{h}$

$= \frac{0.01}{1.25} + \frac{0.01}{1.45} = 0.015 = 1.5\%$

28. (A)

Pascal second = $\frac{NS}{m^2} = \frac{[MLT^{-2}][T]}{[L^2]} = ML^{-1}T^{-1}$

29. (C)

As $\left[\frac{kt}{\beta x}\right] = 1$ $\quad [\beta] = \left[\frac{kt}{x}\right] = \frac{ML^2T^{-2}}{L} = MLT^{-2}$ $\quad [\because [E] = [k_B T]]$

Now, $[P] = \frac{[\alpha]}{[\beta]}$ $\quad \therefore [\alpha] = [P][\beta] = MLT^{-2}$

30. (C)

Mutual inductance, $M = -\frac{e_2}{\frac{di_1}{dt}}$

$$[M] = \frac{[e_2]}{\left[\frac{di_1}{dt}\right]} = \left[\frac{\frac{W}{q}}{\frac{q}{t^2}}\right] = \frac{ML^2T^{-2}}{\frac{A^2T^2}{T^2}} = ML^2A^{-2}T^{-2}$$

31. (D)

Wave number and Rydberg constant have same unit m^{-1}.

Corecivity and magnetisation have same unit A/m.

Whereas, specific heat capacity, $S = \frac{\Delta Q}{m\Delta T}$ has unit $\frac{\text{J}}{\text{Kg K}}$ and latent heat, $L = \frac{\Delta Q}{m}$ has unit $\frac{\text{J}}{\text{Kg}}$.

32. (A)

Velocity gradient = $\frac{dv}{dx}$

So, its unit will be $\frac{m/s}{m} = s^{-1}$

As $N = N_0 e^{-\lambda t}, \lambda =$ decay constant

As power of *e* is dimensionless

So, $[\lambda t] = 1$ or , $[\lambda] = \left(\frac{1}{t}\right)$

So, unit of λ is s^{-1}

33. (A)

Torque $\tau \rightarrow ML^2T^{-2}$ (III)

Impulse $I \rightarrow MLT^{-1}$ (I)

Tension force $\rightarrow MLT^{-2}$ (IV)

Surface tension $\rightarrow MT^{-2}$ (II)

34. (A)

(i) $\frac{\pi pa^4}{5\eta L} = \frac{dv}{dt} =$ Volumetric flow rate (Poiseuille's law)

(ii) $\because\ h\rho g = \frac{2s}{r}\cos\theta \qquad \therefore\ h = \frac{2s\cos\theta}{\rho rg}$

(iii) $RHS \Rightarrow \varepsilon \times \frac{1}{4\pi\varepsilon_0}\frac{a}{r^2} \times \frac{1}{\varepsilon} = \frac{q}{t} \times \frac{1}{r^2} = \frac{1}{L^2} = IL^{-2}$

LHS $J = \frac{I}{A} = IL^{-2}$

(iv) $W = \tau\theta$

35. (C)

As $B = \frac{\mu_0 i}{2\pi r}$

$$[\mu_0] = \left[\frac{B \times 2\pi r}{I}\right] = \left[\frac{N}{Am} \times \frac{m}{A}\right] = \left[\frac{N}{A^2}\right] = MLT^{-2}A^{-2}$$

Clearly, μ_0 is not a dimensionless quantity.

36. (A)

As, density = $[F]^a\,[L]^b\,[T^c]$

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

$[ML^{-3}] = [M^aL^aT^{-2a}L^bT^c]$

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

On comparing

$a = 1, a + b = -3, 1 + b = -3, b = -4$

$-2a + c = 0 \;\; k \;\; c = 2a$

$c = 2 \quad \therefore$ Density $= \left[F^1 L^{-4} T^2\right]$

37. (D)

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

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

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

$$P = \frac{EL^2}{M^5G^2} \Rightarrow [P] = \frac{\left(ML^2T^{-2}\right)\left(M^2L^4T^{-2}\right)}{M^5\left(M^{-2}L^6T^{-4}\right)} = M^0L^0T^0$$

38. (B)

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

Dimension $= \frac{AB}{D} = \frac{MLT^{-2}T^{-1}}{L^{-1}} = ML^2Th - 3$

39. (D)

$[E] = \frac{hc}{\lambda}$ also $[E] = \frac{e^2}{4\pi\varepsilon_0 r}$

or, $\frac{[E]}{[E]} = \frac{e^2\lambda}{4\pi\varepsilon_0 r \cdot hc}$

or, $\left[M^0L^0T^0\right] = \frac{e^2}{4\pi\varepsilon_0 r}\frac{\lambda}{hc} = \frac{1}{4}\frac{|e|^2}{\pi\varepsilon_0 \hbar c}$ dimensionally.

40. (B)

$W = \alpha^2\beta e^{-\frac{\beta x^2}{kT}}$

As exponents are dimensionless, so, $\frac{\beta x^2}{kT}$ should be dimensionless.

$$[\beta] = \left[\frac{kT}{x^2}\right] = \frac{ML^2T^{-2}}{L^2} = MT^{-2}$$

From the dimensional homogeneity, $\alpha^2\beta$ should have dimension of work.

$$\therefore \quad \left[\alpha^2\beta\right] = ML^2T^{-2} \Rightarrow \left[\alpha^2\right] = \frac{ML^2T^{-2}}{MT^{-2}} \Rightarrow [\alpha] = M^0LT^0$$

41. (A)

We know that

Speed of light, $c = \frac{1}{\sqrt{\mu_0\varepsilon_0}} = x$

Also, $c = \frac{E}{B} = y$

Time constant, $\tau = Rc = t$ $\therefore\ z = \frac{l}{RC} = \frac{l}{t} = \text{Speed}$

Thus, x, y, z will have the same dimension of speed.

42. (D)

From formula, $\frac{dQ}{dt} = kA\frac{dT}{dx}$

$$\Rightarrow\ k = \frac{\left(\frac{dQ}{dt}\right)}{A\frac{dT}{dx}} \Rightarrow [k] = \frac{[ML^2T^{-3}]}{[L^2][KL^{-1}]} = [MLT^{-3}K^{-1}]$$

43. (B)

Solar constant = $\frac{\text{Energy}}{\text{Time Area}}$

Dimension of Energy, $E = ML^2T^{-2}$

Dimension of Time = T

Dimension of Area = L^2

$\therefore$ Dimension of Solar constant $= \frac{M^1L^2T^{-2}}{TL^2} = M^1L^0T^{-3}$

JEE Advanced Exercise

EXERCISE – I

1. (D)

Theoretical

2. (B)

Impulse $= \Delta p$

3. (C)

Theoretical

4. (C)

$\therefore [\eta] = \frac{[F]}{[r][u]} = ML^{-1}T^{-1}$

5. (A)

$T = \frac{F}{L}$

6. (B)

$F = \frac{GM_1M_2}{r^2}$

7. (A)

$$\frac{dQ}{dt}=\frac{KA(\Delta T)}{L}, \text{ [thermal conductivity } K] = \frac{\left[\frac{dQ}{dt}\right][L]}{[A]\left[\frac{DT}{}\right]}$$

$$= MLT^{-3}K^{-1}$$

8. (D)

$$[\sigma]=\frac{[P]}{[T^4]}=Wm^{-2}K^{-4}$$

9. (C)
Theoretical

10. (C)
Theoretical

11. (A)
Theoretical

12. (D)
Theoretical

13. (B)
Theoretical

14. (A)
Theoretical

15. (B)

$$[R]=\frac{[PV]}{[RT]}=ML^2T^{-2}K^{-1}\text{ mol}^{-1}$$

16. (D)
Theoretical

17. (B)

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

18. (A)

$$T \propto m^a\ \ell^b\ g^c$$

$$[T=[m]^a\ [\ell]^b\ [g]^c$$

$$M^0L^0T = M^aL^{b+c}T^{-2c}$$

On comparing powers,
We get

$$a = 0, b = \frac{1}{2}, c = -\frac{1}{2}$$

19. (B)

$V \propto A^{\alpha} u^{\beta} t^{\gamma}$

$[V] \cdot [A]^{\alpha} [u]^{\beta} [t]^{\gamma}$

On comparing powers, we get

$\beta = \gamma, 2\alpha + \beta = 3$

Clearly, $\alpha \neq \beta$ and $\beta = \gamma$

20. (A)
Theoretical

21. (D)
m = mass per unit length

$[m] = ML^{-1}T^{0}$

22. (D)

$[bt] = M^{0}L^{0}T^{0}$

$\therefore \ [b] = T^{-1} =$ frequency

23. (A)

$[bt] = [cx]$

$\therefore \ \left[\frac{b}{c}\right] = \left[\frac{x}{t}\right] = LT^{-1} =$ Velocity

$[P] = \left[\frac{a}{V^{2}}\right]$

$\Rightarrow \ [a] = [PV^{2}]$

$[b] = [V]$ (using principle of Homogeneity)

24. (B)
Theoretical

25. (B)
Theoretical

26. (A)

$nRT = pv$

Energy

27. (D)

$ab = [pv^{2}][v]$

$[M^{1}L^{-1}T^{-2}][L^{6}][L^{3}]$

$= M^{1}L^{8}T^{-2}$

28. (C)

$$y = \frac{F'L}{A\Delta L}$$

$$[y] = \left[FA^2V^{-1}\right]$$

29. (A)

$$F = \frac{q^1q^2}{4\lambda\varepsilon_0 r^2}$$

$$[\varepsilon_0] = \frac{[F]\left[R^2\right]}{\left[q^2\right]}$$

30. (B)

$$\frac{1}{\sqrt{\mu_0\varepsilon_0}} = v$$

31. (A)
Theoretical

32. (C)

$$Q = ms\,\Delta T$$

$$S = \frac{[Q]}{[m][\Delta T]}$$

$$= \frac{M^1L^2T^{-2}}{M\ \ K}$$

$$M^0L^2T^{-2}K^{-1}$$

33. (D)

$$Q = ML$$

$$L = \frac{Q}{M}$$

$$[L] = \left[M^oL^2T^2\right]$$

34. (A)
Theoretical

35. (B)
Theoretical

36. (A)

$$E = \frac{kq}{r^2}$$

37. (D)

Theoretical

38. (A)
Theoretical

39. (B)
Theoretical

40. (D)

$M \propto V^a F^b E^c$

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

$a + b + 2c = 0$

$-a - 2b - 2c = 0$

$b + c = 1$

$2b + 2c = 2$

$-a - 2 = 0$

$-2 + b + 2(1 - b) = 0$

$-2 + b + 2 - 2b = 0$

$b = 0$

$c = 1$

$[M] = V^{-2}F^0E^1$

41. (A)

$F \propto \sqrt{T}$

$Y \propto T$

42. (C)
Theoretical

43. (D)
Theoretical

44. (C)

$[t] = [d]^1 [R]^b [S]^1$

$T = \left[M^1L^3\ L^b\ M^1L^1T^{-2}L^{-1}\right]^{1/2}$

$L\dfrac{3+b}{2} = L^0$

$\dfrac{3+b}{2} = 0$

$b = -3$

45. (C)
Theoretical

46. (B)

$$\left[\frac{dp}{dx}\right] = M^1L^{-2}T^{-2}$$

47. (B)
Theoretical

48. (D)
Theoretical

49. (B)
Theoretical

50. (C)
Theoretical

51. (C)
$$[S] = [E]^a\ [V]^b\ [T]^c$$
$$M^1T^{-2} = \left[M^1L^2T^{-2}\right]^a\ \left[L^1T^{-1}\right]^b\ [T]^c$$
$1 = a$
$0 = 2a + b$
$0 = 2$
$-2 = -2a - b + c$
$-2 = -2 + 2 + c$
$c = -2$

52. (D)
Theoretical

53. (A)
Theoretical

54. (B)
Theoretical

55. (B)
$$\frac{\Delta v}{v} = \frac{3\Delta r}{r}$$
= 3 %

56. (C)
$$\frac{\Delta v}{v} = \frac{3\Delta r}{r}$$
$$\frac{6}{3} = \frac{\Delta r}{r}$$
$$\frac{\Delta r}{r} = 2\%$$
$$\frac{\Delta A}{A} = \frac{2\Delta r}{r} = 4\%$$

57. (B)

$$\frac{dx}{x} = X\frac{\Delta M}{M} + Y\frac{\Delta L}{L} + Z\frac{\Delta T}{T}$$
$$= ax + by + cz$$

58. (C)

$$T = 2z\sqrt{\frac{\ell}{g}}$$
$$T^2 = 4z^2\frac{\ell}{g}$$
$$g = 4z^2\frac{\ell}{T^2}$$
$$\frac{\Delta g}{g} = \frac{\Delta \ell}{\ell} + \frac{2\Delta T}{T}$$
$$= 2 + 2\times 3$$
= 8%

59. (D)
Theoretical

60. (A)
Theoretical

61. (C)

$$M \propto V^x D^y g^z$$
$$[M] = [V]^x [D]^y [g]^z$$
$$ML^0T^0 = \left(LT^{-1}\right)^x \left(ML^{-3}\right)^y \left(LT^{-2}\right)^z$$
$$= M^y L^{x-3y+2} T^{-x-2z}$$
On comparing powers, we get
$$y = 1$$
$$x - 3y + z = 0$$
$$-x - 2z = 0$$
$$\Rightarrow x = 6$$

62. (D)

$$V \propto \lambda^x \rho^y \sigma^z$$
$$\left(LT^{-1}\right) = \left(L^x\right)\left(ML^{-3}\right)\left(ML^{-2}\right)^z$$
Solving, we get
$$x = -\frac{1}{2}$$

63. (C)

$$T \propto r^x M^y G^z$$

Solving we get $x = \frac{3}{2}$

64. (A)

$[M] = E^x P^y F^z$

Solving, we get $x = -1, y = 2, z = 0$

65. (D)

$[T] = C^x G^y h^z$

Solving, we get

$x = -\frac{5}{2}, y = \frac{1}{2}, z = \frac{1}{2}$

66. (A)

$\left[\frac{-at}{m}\right] = M^0 L^0 T^0$

$\Rightarrow [a] = MT^{-1}$

67. (D)

$g = \frac{4\pi^2 L}{T^2}$

$\frac{\Delta g}{g} = \frac{\Delta L}{L} + \frac{2\Delta T}{T}$

68. (B)

$Y = \frac{FL}{A.\ell} = \frac{4F - L}{\pi d^2 \ell}$

$\Delta Y = \frac{2\Delta d}{d} + \frac{\Delta \ell}{\ell}$ (*F* and *L* are exactly known)

$= \frac{2 \times 0.01}{0.4} + \frac{0.05}{0.8}$

$= 0.2 \times 10^{11}\ \text{N/m}^2$

$\therefore\ Y = (2.0 \pm 0.2) \times 10^{11}\ \text{N/m}^2$

69. (C)

LC = 1 MSD – 1 VSD

$= x\ \text{cm} - \left(1 - \frac{1}{n}\right) x\ \text{cm}$

$= \frac{x}{n}$

EXERCISE – II

PASSAGE – I : 1. (A, C, D) 2. (A, B)

PASSAGE – II : 3. (C) 4. (A) 5. (A)

PYQ : JEE Advanced

1. (C)

Least count of screw gauge

$$= \frac{\text{Pitch}}{\text{divisions on circular scale}} = \frac{0.5}{50} = 0.01\,\text{mm} = \Delta r$$

Diameter, $r = M.S.R + (C.S.R.) \times (L.C.)$

Diameter, $r = 2.5\,\text{mm} + 20 \times \frac{0.5}{50} = 2.70\,\text{mm}$

$\frac{\Delta r}{r} = \frac{0.01}{2.70}$ or $\frac{\Delta r}{r} \times 100 = \frac{1}{2.7}$

Now, density, $d = \frac{m}{V} = \frac{m}{\frac{4}{3}\pi\left(\frac{r}{2}\right)^3}$

$\therefore$ Percentage error in density, $\frac{\Delta d}{d} \times 100$

$$= \left\{\frac{\Delta m}{m} + 3\left(\frac{\Delta r}{r}\right)\right\} \times 100 = \frac{\Delta m}{m} \times 100 + 3 \times \left(\frac{\Delta r}{r}\right) \times 100$$

$$= 2\% + 3 \times \frac{1}{2.7} = 3.11\%$$

2. (A)

The maximum possible error in Y due to l and d

$$\frac{\Delta Y}{Y} = \frac{\Delta l}{l} + \frac{2\Delta d}{d}$$

Least count = $\frac{\text{Pitch}}{\text{No. of division on circular scale}}$

$$= \frac{0.5}{100}\,\text{mm} = 0.005\,\text{mm}$$

Here, $\Delta d = \Delta l = 0.005\,\text{mm}$

Error contribution of $l = \frac{\Delta l}{l} = \frac{0.005\,\text{mm}}{0.25\,\text{mm}} = \frac{1}{50}$

Error contribution of $d = \frac{2\Delta d}{d} = \frac{2 \times 0.005\,\text{mm}}{0.5\,\text{mm}} = \frac{1}{50}$

Hence, contribution to the maximum possible error in the measurement of y due to l and d is the same.

3. (B)

In a voltmeter

$V \propto l$

$V = kl$

Now, it is given $E = 1.1$ volt for $l_1 = 440\,\text{cm}$ and $V = 0.5$ volt for $l_2 = 220\,\text{cm}$

Let the error in reading of voltmeter be ΔV then, 1.1 = 400 k and (0.5 – ΔV) = 220 k.

$\Rightarrow \dfrac{1.1}{440} = \dfrac{0.5 - \Delta V}{220}$

$\therefore \ \Delta V = -0.05$ volt

4. (4)

Young's modulus $Y = \dfrac{FL}{A \times l}$

Here, F, A and L are accurately known.

$\therefore$ Percentage error in Young's modulus

$l = (45 - 20) \times \text{L.C.} = 25 \times 10^{-5}$ m

$$\frac{\Delta Y}{Y} \times 100 = \frac{\Delta l}{l} \times 100 = \frac{1.0 \times 10^{-5}}{25 \times 10^{-5}} \times 100 = 4\%$$

5. (BC)

Vernier callipers

1 MSD = $\dfrac{1\text{cm}}{8} = 0.125\,\text{cm}$

5 VSD = 4 MSD $\quad \therefore$ 1 VSD $= \dfrac{4}{5} \times 0.125 = 0.1\,\text{cm}$

L.C. = 1 MSD – 1 VSD

= 0.125 cm – 0.1 cm = 0.025 cm

Screw gauge

If the pitch of screw gauge is twice the L.C. of Vernier calipers then pitch = 2 × L.C. of Vernier caliper = 2 × 0.025 = 0.05 cm.

L.C. of screw gauge $= \dfrac{\text{Pitch}}{\text{Total no. of divisions of circular scale}}$

$$= \frac{0.05}{100}\,\text{cm} = 0.0005\,\text{cm} = 0.005\,\text{mm}$$

Now if the least count of the liner scale of the screw gauge is twice the least count of veriner calipers then L.C. of linear scale of screw gauge = 2 × 0.025 = 0.05 cm.

Then pitch = 2 × 0.05 = 0.1 cm

$\therefore$ L.C. of screw gauge $= \dfrac{0.1}{100}\,\text{cm} = 0.001\,\text{cm} = 0.01\,\text{mm}$.

6. (ACD)

As Planck's constant h, speed of light c and gravitational constant G are used as basic units for length L and Mass M so, $L \propto h^x\, c^y\, G^z$ ….. (i)

and $\quad M \propto h^p\, c^q\, G^r$ ….. (ii)

Dimensions of $[h] = [ML^2T^{-1}], [c] = [LT^{-1}]$

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

Using principle of homogeneity of dimensions

For eqn. (i)

$[M^0LT^0] = [M^xL^{2x}T^{-x}][L^yT^{-y}][M^{-z}L^{3z}\,T^{-2z}]$

$M^0LT^0 = M^{(x-z)}L^{(2x+y+3z)}T^{(-x-y-2z)}$

On comparing powers from both sides, we get

$x - z = 0, 2x + y + 3z = 1, -x - y - 2z = 0$

On solving these eqns., we get

$x = \frac{1}{2},\ y = -\frac{3}{2},\ z = \frac{1}{2}$

$\therefore\ L = K\sqrt{\frac{hG}{c^3}}; K$ is a constant.

In the same way solving eqn. (ii) we get,

$M = K'\sqrt{\frac{hc}{G}}; K'$ is a constant.

7. (AC)

Using, $C = \frac{1}{\sqrt{\mu_0\varepsilon_0}}$ and $R = \sqrt{\frac{\mu_0}{\varepsilon_0}}$

(A) $\mu_0 I = \varepsilon_0 V^2 \Rightarrow \frac{\mu_0}{\varepsilon_0} = \frac{V^2}{I^2} = R^2 = \sqrt{\left(\frac{\mu_0}{\varepsilon_0}\right)^2}$

(B) $\varepsilon_0 I = \mu_0 V \Rightarrow \frac{\mu_0}{\varepsilon_0} = \frac{I}{V} = \frac{1}{R} \quad (\because\ V = RI)$

Dimensionally incorrect.

(C) $I = \varepsilon_0 CV$

$\therefore\ \frac{1}{\varepsilon_0 C}\frac{V}{I} = R \qquad \therefore\ \frac{1}{\varepsilon_0 \frac{1}{\sqrt{\mu_0\varepsilon_0}}} = R$

Dimensionally correct.

(D) $\mu_0 CI = \varepsilon_0 V$

$\therefore\ \frac{\mu_0}{\varepsilon_0} = \frac{V}{IC} = \frac{R}{C} = \sqrt{\frac{\mu_0}{\varepsilon_0}} \times \frac{1}{\frac{1}{\sqrt{\mu_0\varepsilon_0}}} = \mu_0$

8. (BD)

(A) R.H.S. $= \sqrt{\left(\frac{q^2}{\varepsilon}\right)\frac{1}{(k_B T)} \times n}$

$= \sqrt{[U \times r]\frac{1}{[U]} \times n} = \sqrt{[n]\times[r]} = \sqrt{[L^{-3}][L]} = [L^{-1}]$

(B) R.H.S. $= \sqrt{\frac{\varepsilon(k_B T)}{nq^2}} = \sqrt{\frac{(k_B T)}{n(q^2/\varepsilon)}} = \sqrt{\frac{[U]}{[n][U \times r]}}$

$= \sqrt{\frac{1}{[n][r]}} = \sqrt{\frac{1}{[L^{-3}][L]}} = [L]$

(C) R.H.S. $= \sqrt{\left(\frac{q^2}{\varepsilon}\right)\frac{1}{(k_B T)} \times \frac{1}{n^{2/3}}}$

$$= \sqrt{[U \times r]\frac{1}{[U]}\frac{1}{[L^{-2}]}} = [L^{3/2}]$$

(D) R.H.S. $= \sqrt{\left(\frac{q^2}{\varepsilon}\right)\frac{1}{(k_B T)} \times \frac{1}{n^{1/3}}}$

$$= \sqrt{[U \times r]\frac{1}{[U]}\frac{1}{[n^{1/3}]}} = \sqrt{[r] \times \frac{1}{[n^{1/3}]}}$$

$$= \sqrt{[L]\frac{1}{[L^{-1}]}} = [L]$$

9. (D)

Fro C_1 vernier caliper,

L.C. = 1 MSD – 1 VSD

= 1 mm – 0.9 mm

= 0.1 mm = 0.01 cm [$\because$ 10 VSD = 9 MSD = 9 mm]

Reading = MSR + L.C. × VSR = 2.8 + (0.01) × 7 = 2.87 cm

For C_2 vernier caliper,

L.C. = 1 mm – 1.1 mm [$\because$ 10 SD = 11 MSD = 11 mm]

L.C. = –0.1 mm = –0.01 cm

Reading = 2.8 + (10 – 7) × 0.01 = 2.83 cm

10. (ABD)

$$T_{\text{mean}} = \frac{0.52 + 0.56 + 0.57 + 0.54 + 0.59}{6} = 0.556 \approx 0.56\,\text{S}$$

Error in reading $T_{\text{mean}} - T_1; T_{\text{mean}} - T_2; T_{\text{mean}} - T_3; T_{\text{mean}} - T_4; T_{\text{mean}} - T_5$

Mean error $= \frac{0.04 + 0 + 0.01 + 0.02 + 0.03}{6} = 0.016 \approx 0.02\,\text{S}$

$\therefore$ % error in the measurement of 'T'

$$\frac{\Delta T}{T} \times 100 = \frac{0.02}{0.56} \times 100 = 3.57\%$$

% error in the measurement of g

$$\frac{\Delta g}{g} \times 100 = 2\frac{\Delta T}{T} \times 100 + \left(\frac{\Delta R + \Delta r}{R - r}\right) \times 100$$

$$= 2(3.57) + \left(\frac{1+1}{60-10}\right) \times 100 \approx 11\%$$

% error in the measurement of r

$$\frac{\Delta r}{r} \times 100 = \frac{1}{10} \times 100 = 10\%$$