Chapter 29

Units and Measurement

1. In an experiment the angles are required to be measured using an instrument. 29 divisions of the main scale exactly coincide with the 30 divisions of the vernier scale. If the smallest division of the main scale is half-a-degree (= 0.5°), then the least count of the instrument is **[AIEEE-2009]**

   (1) Half minute (2) One degree

   (3) Half degree (4) One minute

2. The respective number of significant figures for the numbers 23.023, 0.0003 and 2.1×10^{-3} are **[AIEEE-2010]**

   (1) 4, 4, 2 (2) 5, 1, 2

   (3) 5, 1, 5 (4) 5, 5, 2

3. A spectrometer gives the following reading when used to measure the angle of a prism.

   Main scale reading : 58.5 degree

   Vernier scale reading : 09 divisions

   Given that 1 division on main scale corresponds to 0.5 degree. Total divisions on the vernier scale is 30 and match with 29 divisions of the main scale. The angle of the prism from the above data **[AIEEE-2012]**

   (1) 58.77 degree (2) 58.65 degree

   (3) 59 degree (4) 58.59 degree

4. Resistance of a given wire is obtained by measuring the current flowing in it and the voltage difference applied across it. If the percentage errors in the measurement of the current and the voltage difference are 3% each, then error in the value of resistance of the wire is **[AIEEE-2012]**

   (1) Zero (2) 1%

   (3) 3% (4) 6%

5. Let $[\varepsilon_0]$ denote the dimensional formula of the permittivity of vacuum. If M = mass, L = length, T = time and A = electric current, then **[JEE (Main)-2013]**

   (1) $[\varepsilon_0] = M^{-1} L^{-3} T^2 A]$

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

   (3) $[\varepsilon_0] = M^{-1} L^2 T^{-1} A^{-2}]$

   (4) $[\varepsilon_0] = M^{-1} L^2 T^{-1} A]$

6. The current voltage relation of diode is given by $I = (e^{1000V/T} - 1)$ mA, where the applied V is in volts and the temperature T is in degree kelvin. If a student makes an error measuring ± 0.01 V while measuring the current of 5 mA at 300 K, what will be the error in the value of current in mA? **[JEE (Main)-2014]**

   (1) 0.2 mA (2) 0.02 mA

   (3) 0.5 mA (4) 0.05 mA

7. A student measured the length of a rod and wrote it as 3.50 cm. Which instrument did he use to measure it? **[JEE (Main)-2014]**

   (1) A meter scale

   (2) 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

   (3) A screw gauge having 100 divisions in the circular scale and pitch as 1 mm

   (4) A screw gauge having 50 divisions in the circular scale and pitch as 1 mm

8. The period of oscillation of a simple pendulum is $T = 2\pi\sqrt{\frac{L}{g}}$. 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 **[JEE (Main)-2015]**

   (1) 2% (2) 3%

   (3) 1% (4) 5%

9. A student measures the time period of 100 oscillations of a simple pendulum four times. The data set is 90 s, 91 s, 95 s and 92 s. If the minimum division in the measuring clock is 1 s, then the reported mean time should be: **[JEE (Main)-2016]**

   (1) 92 ± 5.0 s (2) 92 ± 1.8 s

   (3) 92 ± 3 s (4) 92 ± 2 s

10. 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, its is found that when the two jaws of the screw gauge are brought in contact, the 45th division coincides with the main scale line and that 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 deivision coincides with the main scale line?

[JEE (Main)-2016]

(1) 0.80 mm (2) 0.70 mm

(3) 0.50 mm (4) 0.75 mm

11. The following observations were taken for determining surface tension T of water by capillary method:

diameter of capillary, $D = 1.25 \times 10^{-2}$ m

rise of water, $h = 1.45 \times 10^{-2}$ m.

Using $g = 9.80$ m/s^2 and the simplified relation $T = \frac{rhg}{2} \times 10^3 \text{N/m}$, the possible error in surface tension is closest to **[JEE (Main)-2017]**

(1) 0.15% (2) 1.5%

(3) 2.4% (4) 10%

12. 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 **[JEE (Main)-2018]**

(1) 2.5% (2) 3.5%

(3) 4.5% (4) 6%

13. 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 divisions 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 this sheet is

[JEE (Main)-2019]

(1) 5.725 mm (2) 5.740 mm

(3) 5.755 mm (4) 5.950 mm

14. Expression for time in terms of G(universal gravitational constant), h (Planck constant) and c (speed of light) is proportional to

[JEE (Main)-2019]

(1) $\sqrt{\frac{Gh}{c^5}}$ (2) $\sqrt{\frac{c^3}{Gh}}$

(3) $\sqrt{\frac{Gh}{c^3}}$ (4) $\sqrt{\frac{hc^5}{G}}$

15. The density of a material is SI units is 128 kg 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

[JEE (Main)-2019]

(1) 640 (2) 410

(3) 40 (4) 16

16. The diameter and height of a cylinder are measured by a meter scale to be 12.6 ± 0.1 cm and 34.2 ± 0.1 cm, respectively. What will be the value of its volume in appropriate significant figures?

[JEE (Main)-2019]

(1) 4264 ± 81 cm^3 (2) 4300 ± 80 cm^3

(3) 4260 ± 80 cm^3 (4) 4264.4 ± 81.0 cm^3

17. The force of interaction between two atoms is given by $F = \alpha\beta \exp\left(-\frac{x^2}{\alpha kt}\right)$; where x is the distance, k is the Boltzmann constant and T is temperature and α and β are two constants. The dimension of β is **[JEE (Main)-2019]**

(1) $M^0L^2T^{-4}$ (2) M^2LT^{-4}

(3) MLT^{-2} (4) $M^2L^2T^{-2}$

18. If speed (V), acceleration (A) and force (F) are considered as fundamental units, the dimension of Young's modulus will be **[JEE (Main)-2019]**

(1) $V^{-2}A^2F^{-2}$ (2) $V^{-2}A^2F^2$

(3) $V^{-4}A^2F$ (4) $V^{-4}A^{-2}F$

19. The least count of the main scale of a screw gauge is 1 mm. The minimum number of divisions on its circular scale required to measure 5 μm diameter of a wire is **[JEE (Main)-2019]**

(1) 200 (2) 50

(3) 100 (4) 500

20. If Surface tension (S), Moment of Inertia (I) and Planck's constant (h), were to be taken as the fundamental units, the dimensional formula for linear momentum would be: **[JEE (Main)-2019]**

(1) $S^{1/2}I^{3/2}h^{-1}$ (2) $S^{3/2}I^{1/2}h^0$

(3) $S^{1/2}I^{1/2}h^{-1}$ (4) $S^{1/2}I^{1/2}h^0$

21. In a simple pendulum experiment for determination of acceleration due to gravity (g), time taken for 20 oscillations is measured by using a watch of 1 second least count. The mean value of time taken comes out to be 30 s. The length of pendulum is measured by using a meter scale of least count 1 mm and the value obtained is 55.0 cm. The percentage error in the determination of g is close to: **[JEE (Main)-2019]**

(1) 6.8% (2) 0.2%

(3) 3.5% (4) 0.7%

22. In the density measurement of a cube, the mass and edge length are measured as (10.00 ± 0.10) kg and (0.10 ± 0.01) m, respectively. The error in the measurement of density is **[JEE (Main)-2019]**

(1) 0.31 kg/m^3

(2) 1000 kg/m^3

(3) 0.10 kg/m^3

(4) 3100 kg/m^3

23. The area of a square is 5.29 cm^2. The area of 7 such squares taking into account the significant figures is **[JEE (Main)-2019]**

(1) 37.03 cm^2 (2) 37.0 cm^2

(3) 37.030 cm^2 (4) 37 cm^2

24. In the formula $X = 5YZ^2$, X and Z have dimensions of capacitance and magnetic field, respectively. What are the dimensions of Y in SI units ? **[JEE (Main)-2019]**

(1) $[M^{-2}L^{-2}T^6A^3]$ (2) $[M^{-1}L^{-2}T^4A^2]$

(3) $[M^{-2}L^0T^{-4}A^{-2}]$ (4) $[M^{-3}L^{-2}T^8A^4]$

25. A simple pendulum is being used to determine the value of gravitational acceleration g at a certain place. The length of the pendulum is 25.0 cm and a stopwatch with 1 s resolution measures the time taken for 40 oscillation to be 50 s. The accuracy in g is **[JEE (Main)-2020]**

(1) 3.40% (2) 2.40%

(3) 5.40% (4) 4.40%

26. 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 **[JEE (Main)-2020]**

(1) 0.01 cm (2) 0.001 mm

(3) 0.001 cm (4) 0.02 mm

27. A quantity f is given by $f = \sqrt{\frac{hc^5}{G}}$ where c is speed of light, G universal gravitational constant and h is the Planck's constant. Dimension of f is that of **[JEE (Main)-2020]**

(1) Energy

(2) Area

(3) Volume

(4) Momentum

28. For the four sets of three measured physical quantities as given below. Which of the following options is correct? **[JEE (Main)-2020]**

(i) $A_1 = 24.36$, $B_1 = 0.0724$, $C_1 = 256.2$

(ii) $A_2 = 24.44$, $B_2 = 16.082$, $C_2 = 240.2$

(iii) $A_3 = 25.2$, $B_3 = 19.2812$, $C_3 = 236.183$

(iv) $A_4 = 25$, $B_4 = 236.191$, $C_4 = 19.5$

(1) $A_1 + B_1 + C_1 = A_2 + B_2 + C_2 = A_3 + B_3 + C_3 = A_4 + B_4 + C_4$

(2) $A_1 + B_1 + C_1 < A_3 + B_3 + C_3 < A_2 + B_2 + C_2 < A_4 + B_4 + C_4$

(3) $A_1 + B_1 + C_1 < A_2 + B_2 + C_2 = A_3 + B_3 + C_3 < A_4 + B_4 + C_4$

(4) $A_4 + B_4 + C_4 < A_1 + B_1 + C_1 < A_3 + B_3 + C_3 < A_2 + B_2 + C_2$

29. The least count of the main scale of a vernier callipers is 1 mm. Its vernier scale is divided into 10 divisions and coincide with 9 divisions of the main scale. When jaws are touching each other, the 7th division of vernier scale coincides with a division of main scale and the zero of vernier scale is lying right side of the zero of main scale. When this vernier is used to measure length of a cylinder the zero of the vernier scale between 3.1 cm and 3.2 cm and 4th VSD coincides with a main scale division. The length of the cylinder is (VSD is vernier scale division) **[JEE (Main)-2020]**

(1) 3.21 cm

(2) 2.99 cm

(3) 3.07 cm

(4) 3.2 cm

30. If speed V, area A and force F are chosen as fundamental units, then the dimension of Young's modulus will be **[JEE (Main)-2020]**

(1) $FA^{-1}V^0$ (2) FA^2V^{-1}

(3) FA^2V^{-2} (4) FA^2V^{-3}

31. If momentum (P), area (A) and time (T) are taken to be the fundamental quantities then the dimensional formula for energy is **[JEE (Main)-2020]**

(1) $\left[P^{\frac{1}{2}}AT^{-1}\right]$ (2) $[P^2AT^{-2}]$

(3) $\left[PA^{\frac{1}{2}}T^{-1}\right]$ (4) $[PA^{-1}T^{-2}]$

32. 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 **[JEE (Main)-2020]**

(1) 2.124 cm (2) 2.123 cm

(3) 2.125 cm (4) 2.121 cm

33. Dimensional formula for thermal conductivity is (here K deontes the temperature) **[JEE (Main)-2020]**

(1) $MLT^{-2}\,K^{-2}$ (2) $MLT^{-3}\,K^{-1}$

(3) $MLT^{-3}\,K$ (4) $MLT^{-2}\,K$

34. A quantity x is given by (IFv^2/WL^4) in terms of moment of inertia I, force F, velocity v, work W and length L. The dimensional formula for x is same as that of **[JEE (Main)-2020]**

(1) Coefficient of viscosity

(2) Force constant

(3) Energy density

(4) Planck's constant

35. A physical quantity z depends on four observables a, b, c and d, as $z = \frac{a^2b^{\frac{2}{3}}}{\sqrt{c}\,d^3}$. 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 **[JEE (Main)-2020]**

(1) 13.5% (2) 14.5%

(3) 16.5% (4) 12.25%

36. 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. **[JEE (Main)-2020]**

(1) Positive, 0.1 mm (2) Positive, 10 μm

(3) Negative, 2 μm (4) Positive, 0.1 μm

37. 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 mm, 5.55 mm, 5.45 mm; 5.65 mm. The average of these four readings 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 **[JEE (Main)-2020]**

(1) (5.5375 ± 0.0739) mm

(2) (5.54 ± 0.07) mm

(3) (5.538 ± 0.074) mm

(4) (5.5375 ± 0.0740) mm

38. 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 _____. **[JEE (Main)-2020]**

39. The work done by a gas molecule in an isolated system is given by, $W = \alpha\beta^2 e^{-\frac{x^2}{\alpha kT}}$, where x is the displacement, k is the Boltzmann constant and T is the temperature. α and β are constants. Then the dimensions of β will be : **[JEE (Main)-2021]**

(1) $\left[M^2LT^2\right]$

(2) $\left[ML^2T^{-2}\right]$

(3) $\left[MLT^{-2}\right]$

(4) $\left[M^0LT^0\right]$

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

[JEE (Main)-2021]

(1) 1.30% (2) 1.33%

(3) 1.13% (4) 1.03%

41. Match List-I with List-II: **[JEE (Main)-2021]**

List-I	List-II
(a) h (Planck's constant)	(i) $[ML T^{-1}]$
(b) E (kinetic energy)	(ii) $[ML^2T^{-1}]$
(c) V (electric potential)	(iii) $[ML^2T^{-2}]$
(d) P (linear momentum)	(iv) $[ML^2I^{-1}T^{-3}]$

Choose the correct answer from the options given below :

(1) (a) → (i), (b) → (ii), (c) → (iv), (d) → (iii)

(2) (a) → (ii), (b) → (iii), (c) → (iv), (d) → (i)

(3) (a) → (iii), (b) → (ii), (c) → (iv), (d) → (i)

(4) (a) → (iii), (b) → (iv), (c) → (ii), (d) → (i)

42. If the time period of a two meter long simple pendulum is 2 s, the acceleration due to gravity at the place where pendulum is executing S.H.M. is:

[JEE (Main)-2021]

(1) 9.8 ms^{-2}

(2) π^2 ms^{-2}

(3) 16 m/s^2

(4) $2\pi^2$ ms^{-2}

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

[JEE (Main)-2021]

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

(2) $[M L T^0]$

(3) $[L C^{-1}]$

(4) $[M^0 L^0 T^0]$

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

[JEE (Main)-2021]

(1) $[MLT^{-1}]$ (2) $[M^0LT^0]$

(3) $[MLT^{-2}]$ (4) $[M^2LT^{-2}]$

45. 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:

[JEE (Main)-2021]

(1) $(4 \pm 0.4)\ \Omega$ (2) $(2 \pm 0.4)\ \Omega$

(3) $(2 \pm 0.3)\ \Omega$ (4) $(4 \pm 0.3)\ \Omega$

46. If 'C' and 'V' represent capacity and voltage respectively then what are the dimensions of λ where $C/V = \lambda$? **[JEE (Main)-2021]**

(1) $[M^{-1} L^{-3} I^{-2} T^{-7}]$ (2) $[M^{-2} L^{-4} I^3 T^7]$

(3) $[M^{-2} L^{-3} I^2 T^6]$ (4) $[M^{-3} L^{-4} I^3 T^7]$

47. A wire of 1 W has a length of 1 m. It is stretched till its length increases by 25%. The percentage change in resistance to the nearest integer is

[JEE (Main)-2021]

(1) 76% (2) 56%

(3) 12.5% (4) 25%

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

[JEE (Main)-2021]

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

[JEE (Main)-2021]

(1) 1.4%

(2) 0.14%

(3) 9%

(4) 0.9%

50. Suppose you have taken a dilute solution of oleic acid in such a way that its concentration becomes 0.01 cm^3 of oleic acid per cm^3 of the solution. Then you make a thin film of this solution (monomolecular thickness) of area 4 cm^2 by considering 100 spherical drops of radius $\left(\frac{3}{40\pi}\right)^{\frac{1}{3}} \times 10^{-3}$ cm. Then the thickness of oleic acid layer will be x × 10^{-14} m. Where x is _____. **[JEE (Main)-2021]**

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

[JEE (Main)-2021]

(1) 3% (2) 5%

(3) 2% (4) 4%

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

[JEE (Main)-2021]

(1) 3.0

(2) 3.9

(3) 7.5

(4) 8.4

53. The radius of a sphere is measured to be (7.50 ± 0.85) cm. Suppose the percentage error in its volume is x.

The value of x, to the nearest x, is _____.

[JEE (Main)-2021]

54. The entropy of any system is given by

$$S = \alpha^2\beta \ln\left[\frac{\mu k R}{J\beta^2} + 3\right]$$

where α and β are the constants, μ, J, *k* and R are no. of moles, mechanical equivalent of heat, Boltzmann constant and gas constant respectively.

[Take $S = \frac{dQ}{T}$]

Choose the **incorrect option** from the following

[JEE (Main)-2021]

(1) S, β, *k* and μR have the same dimensions

(2) α and *k* have the same dimensions

(3) α and J have the same dimensions

(4) S and α have different dimensions

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

[JEE (Main)-2021]

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

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

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

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

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

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

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

[JEE (Main)-2021]

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

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

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

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

57. **Assertion A :** If in five complete rotations of the circular scale, the distance travelled on main scale of the screw gauge is 5 mm and there are 50 total divisions on circular scale, then least count is 0.001 cm.

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

In the light of the above statements, choose the most appropriate answer from the options given below : **[JEE (Main)-2021]**

(1) Both A and R are correct and R is the correct explanation of A.

(2) A is not correct but R is correct.

(3) Both A and R are correct and R is not the correct explanation of A

(4) A is correct but R is not correct

58. Match **List I** with **List II**. **[JEE (Main)-2021]**

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

Choose the correct answer from the options given below

(1) (a) → (iii), (b) → (iv), (c) → (ii), (d) → (i)

(2) (a) → (iii), (b) → (ii), (c) → (iv), (d) → (i)

(3) (a) → (iv), (b) → (ii), (c) → (iii), (d) → (i)

(4) (a) → (iv), (b) → (iii), (c) → (ii), (d) → (i)

59. A physical quantity '*y*' is represented by the formula $y = m^2 r^{-4} g^x l^{-\frac{3}{2}}$. If the percentage errors found in *y*, *m*, *r*, *l* and *g* are 18, 1, 0.5, 4 and *p* respectively, then find the value of *x* and *p*. **[JEE (Main)-2021]**

(1) $\frac{16}{3}$ and $\pm \frac{3}{2}$ (2) 8 and $\pm$ 2

(3) 4 and $\pm$ 3 (4) 5 and $\pm$ 2

60. If E, L, M and G denote the quantities as energy, angular momentum, mass and constant of gravitation respectively, then the dimensions of P in the formula $P = EL^2M^{-5}G^{-2}$ are: **[JEE (Main)-2021]**

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

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

(3) $[M^0L^1T^0]$

(4) $[M^0L^0T^0]$

61. If the length of the pendulum in pendulum clock increases by 0.1%, then the error in time per day is: **[JEE (Main)-2021]**

(1) 43.2 s

(2) 4.32 s

(3) 86.4 s

(4) 8.64 s

62. Match **list-I** with **list-II**: **[JEE (Main)-2021]**

List-I	List-II
(a) Magnetic Induction	(i) $ML^2T^{-2}A^{-1}$
(b) Magnetic Flux	(ii) $M^0L^{-1}A$
(c) Magnetic Permeability	(iii) $MT^{-2}A^{-1}$
(d) Magnetization	(iv) $MLT^{-2}A^{-2}$

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

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

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

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

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

63. The acceleration due to gravity is found upto an accuracy of 4% on a planet. The energy supplied to a simple pendulum of known mass 'm' to undertake oscillations of time period T is being estimated. If time period is measured to an accuracy of 3%, the accuracy to which E is known as ___ %. **[JEE (Main)-2021]**

64. A huge circular arc of length 4.4 ly subtends an angle '4s' at the centre of the circle. How long it would take for a body to complete 4 revolution if its speed is 8 AU per second? **[JEE (Main)-2021]**

Given: 1 ly = 9.46×10^{15} m

1 AU = 1.5×10^{11} m

(1) 3.5×10^6 s

(2) 4.5×10^{10} s

(3) 4.1×10^8 s

(4) 7.2×10^8 s

65. Which of the following is not a dimensionless quantity? **[JEE (Main)-2021]**

(1) Quality factor

(2) Power factor

(3) Permeability of free space(μ_0)

(4) Relative magnetic permeability(μ_r)

66. If E and H represents the intensity of electric field and magnetising field the unit of E/H will be respectively, then **[JEE (Main)-2021]**

(1) joule

(2) ohm

(3) newton

(4) mho

67. Match List-I with List-II. **[JEE (Main)-2021]**

List-I		List-II	
(a)	R_H(Rydberg constant)	(i)	kg $m^{-1}s^{-1}$
(b)	h(Planck's constant)	(ii)	kg m^2s^{-1}
(c)	μ_B(Magnetic field energy density)	(iii)	m^{-1}
(d)	η(coefficient of viscocity)	(iv)	kg $m^{-1}s^{-2}$

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

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

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

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

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

68. If force (F), length (L) and time (T) are taken as the fundamental quantities. Then what will be dimension of density: **[JEE (Main)-2021]**

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

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

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

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

69. Match **List-I** with **List-II.** **[JEE (Main)-2021]**

List-I		List-II	
(a)	Torque	(i)	MLT^{-1}
(b)	Impulse	(ii)	MT^{-2}
(c)	Tension	(iii)	ML^2T^{-2}
(d)	Surface tension	(iv)	MLT^{-2}

Choose the **most appropriat**e answer from the otpion given below:

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

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

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

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

70. Which of the following equations is dimensionally incorrect? **[JEE (Main)-2021]**

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

(1) $h = \frac{2s\cos\theta}{prg}$ (2) $W = \tau\theta$

(3) $v = \frac{\pi pa^4}{8\eta L}$ (4) $J = \varepsilon\frac{\partial E}{\partial t}$

71. If velocity [V], time [T] and force [F] are chosen as the base quantities, the dimensions of the mass will be: **[JEE (Main)-2021]**

(1) $[FT^{-1}V^{-1}]$ (2) $[FVT^{-1}]$

(3) $[FT^2V]$ (4) $[FTV^{-1}]$

72. A student determined Young's Modulus of elasticity using the formula $Y = \frac{MgL^3}{4bd^3\delta}$. The value of g is taken to be 9.8 m/s^2, without any significant error, his observation are as following.

Physical Quantity	Least count of the Equipment used for measurement	Observed Value
Mass (M)	1 g	2 kg
Length of bar (L)	1 mm	1 m
Breadth of bar (b)	0.1 mm	4 cm
Thickness of bar (d)	0.01 mm	0.4 cm
Depression (δ)	0.01 mm	5 mm

Then the fractional error in the measurement of Y is : **[JEE (Main)-2021]**

(1) 0.155 (2) 0.0083

(3) 0.0155 (4) 0.083

73. Identify the pair of physical quantities which have different dimensions. **[JEE (Main)-2022]**

(1) Wave number and Rydberg's constant

(2) Stress and Coefficient of elasticity

(3) Coercivity and Magnetisation

(4) Specific heat capacity and Latent heat

74. Identify the pair of physical quantities that have same dimensions : **[JEE (Main)-2022]**

(1) Velocity gradient and decay constant

(2) Wien's constant and Stefan constant

(3) Angular frequency and angular momentum

(4) Wave number and Avogadro number

75. If $Z = \frac{A^2B^3}{C^4}$, then the relative error in Z will be **[JEE (Main)-2022]**

(1) $\frac{\Delta A}{A} + \frac{\Delta B}{B} + \frac{\Delta C}{C}$ (2) $\frac{2\Delta A}{A} + \frac{3\Delta B}{B} - \frac{4\Delta C}{C}$

(3) $\frac{2\Delta A}{A} + \frac{3\Delta B}{B} + \frac{4\Delta C}{C}$ (4) $\frac{\Delta A}{A} + \frac{\Delta B}{B} - \frac{\Delta C}{C}$

76. For $z = a^2x^3y^{\frac{1}{2}}$, where '$a$' is a constant. If percentage error in measurement of 'x' and 'y' are 4% and 12%, respectively, then the percentage error for 'z' will be _____ %. **[JEE (Main)-2022]**

77. An expression for a dimensionless quantity P is given by $P = \frac{\alpha}{\beta}\log_e\left(\frac{kt}{\beta x}\right)$; where α and β are constants, x is distance; k is Boltzmann constant and t is the temperature. Then the dimensions of α will be **[JEE (Main)-2022]**

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

(3) $[MLT^{-2}]$ (4) $[ML^2T^{-2}]$

78. The dimension of mutual inductance is : **[JEE (Main)-2022]**

(1) $[ML^2T^{-2}A^{-1}]$ (2) $[ML^2T^{-3}A^{-1}]$

(3) $[ML^2T^{-2}A^{-2}]$ (4) $[ML^2T^{-3}A^{-2}]$

79. A silver wire has a mass (0.6 ± 0.006) g, radius (0.5 ± 0.005) mm and length (4 ± 0.04) cm. The maximum percentage error in the measurement of its density will be **[JEE (Main)-2022]**

(1) 4%

(2) 3%

(3) 6%

(4) 7%

80. The SI unit of a physical quantity is pascal-second. The dimensional formula of this quantity will be : **[JEE (Main)-2022]**

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

(2) $[ML^{-1}T^{-2}]$

(3) $[ML^2T^{-1}]$

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

81. If L, C and R are the self-inductance, capacitance and resistance respectively, which of the following does not have the dimension of time? **[JEE (Main)-2022]**

(1) RC (2) $\frac{L}{R}$

(3) $\sqrt{LC}$ (4) $\frac{L}{C}$

82. Given below are two statements : One is labelled as **Assertion A** and the other is labelled as **Reason R**.

Assertion A : Product of Pressure (P) and time (t) has the same dimension as that of coefficient of viscosity.

Reason R : Coefficient of viscosity $= \frac{\text{Force}}{\text{Velocity gradient}}$

Choose the correct answer from the options given below. **[JEE (Main)-2022]**

(1) Both **A** and **R** are true, and **R** is correct explanation of **A**.

(2) Both **A** and **R** are true but **R** is NOT the correct explanation of **A**.

(3) **A** is true but **R** is false.

(4) **A** is false but **R** is true.

83. 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 $a_2 = \frac{a_1}{mn}$ respectively. Here m and n are constants. The relations for distance and time in two systems respectively are : **[JEE (Main)-2022]**

(1) $\frac{n^3}{m^3}L_1 = L_2$ and $\frac{n^2}{m}T_1 = T_2$

(2) $L_1 = \frac{n^4}{m^2}L_2$ and $T_1 = \frac{n^2}{m}T_2$

(3) $L_1 = \frac{n^2}{m}L_2$ and $T_1 = \frac{n^4}{m^2}T_2$

(4) $\frac{n^2}{m}L_1 = L_2$ and $\frac{n^4}{m^2}T_1 = T_2$

84. A student in the laboratory measures thickness of a wire using screw gauge. The readings are 1.22 mm, 1.23 mm, 1.19 mm and 1.20 mm. The percentage error is $\frac{x}{121}\%$. The value of x is _____.

[JEE (Main)-2022]

85. In van der Wall equation $\left[P+\frac{a}{V^2}\right][V-b]=RT; P$ is pressure, V is volume, R is universal gas constant and T is temperature. The ratio of constants $\frac{a}{b}$ is dimensionally equal to:

[JEE (Main)-2022]

(1) $\frac{P}{V}$ (2) $\frac{V}{P}$

(3) PV (4) PV^3

86. If momentum [P], area [A] and time [T] are taken as fundamental quantities, then the dimensional formula for coefficient of viscosity is

[JEE (Main)-2022]

(1) $[PA^{-1}T^0]$

(2) $[PAT^{-1}]$

(3) $[PA^{-1}T]$

(4) $[PA^{-1}T^{-1}]$

87. Which of the following physical quantities have the same dimensions? **[JEE (Main)-2022]**

(1) Electric displacement $(\vec{D})$ and surface charge density

(2) Displacement current and electric field

(3) Current density and surface charge density

(4) Electric potential and energy

88. 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

[JEE (Main)-2022]

(1) 15%

(2) 25%

(3) 75%

(4) 5%

89. An expression of energy density is given by $u=\frac{\alpha}{\beta}\sin\left(\frac{\alpha x}{kt}\right)$, where α, β are constants, x is displacement, k is Boltzmann constant and t is the temperature. The dimensions of β will be

[JEE (Main)-2022]

(1) $[ML^2T^{-2}\theta^{-1}]$

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

(3) $[M^0L^0T^0]$

(4) $[M^0L^2T^0]$

90. The dimensions of $\left(\frac{B^2}{\mu_0}\right)$ will be

(if μ_0 : permeability of free space and B : magnetic field) **[JEE (Main)-2022]**

(1) $[ML^2T^{-2}]$ (2) $[MLT^{-2}]$

(3) $[ML^{-1}T^{-2}]$ (4) $[ML^2T^{-2}A^{-1}]$

91. If the radius of earth shrinks by 2% while its mass remains same. The acceleration due to gravity on the earth's surface will approximately

[JEE (Main)-2022]

(1) Decrease by 2%

(2) Decrease by 4%

(3) Increase by 2%

(4) Increase by 4%

92. Consider the efficiency of carnot's engine is given by $\eta=\frac{\alpha\beta}{\sin\theta}\log e\frac{\beta x}{kT}$, where α and β are constants. If T is temperature, k is Boltzmann constant, θ is angular displacement and x has the dimensions of length. Then, choose the incorrect option **[JEE (Main)-2022]**

(1) Dimensions of β is same as that of force.

(2) Dimensions of $\alpha^{-1}x$ is same as that of energy.

(3) Dimensions of $\eta^{-1}\sin\theta$ is same as that of $\alpha\beta$.

(4) Dimensions of α is same as that of β.

93. 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 oscillations 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 _____

[JEE (Main)-2022]

94. 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 ρ and radius of the drop is r, then $T = K\sqrt{\frac{\rho r^3}{S^{3/2}}}$ 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.

[JEE (Main)-2022]

(1) Both (A) and (R) are true and (R) is the correct explanation of (A)

(2) Both (A) and (R) are true but (R) is not the correct explanation of (A)

(3) (A) is true but (R) is false

(4) (A) is false but (R) is true

95. The length of a given cylindrical wire is increased to double of its original length. The percentage increase in the resistance of the wire will be _____%.

[JEE (Main)-2022]

96. An aluminium wire is stretched to make its length, 0.4% larger. The percentage change in resistance is:

[JEE (Main)-2022]

(1) 0.4%

(2) 0.2%

(3) 0.8%

(4) 0.6%

97. The maximum error in the measurement of 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 **[JEE (Main)-2022]**

(1) 2

(2) 4

(3) 6

(4) 8

Chapter 29

Units and Measurement

1. Answer (4)

29 Div of M.S = 30 Div of V.S

1 Div of V.S = $\frac{29}{30}$ Div of M.S

Least count = 1 Div of M.S – 1 Div V.S

$= \frac{1}{30}$ Div. of M.S

$= \frac{1}{30} \times \frac{1}{2} = \frac{1}{60^\circ} = 1\,\text{minute}$

2. Answer (2)

$23.023 \rightarrow 5$

$0.0003 \rightarrow 1$

$2.1 \times 10^{-3} \rightarrow 2$

3. Answer (2)

4. Answer (4)

5. Answer (2)

$\varepsilon_0 = 8.85 \times 10^{-12}\ C^2N^{-1}m^{-2}$

$[\varepsilon_0] = L^{-2}A^2T^2\ (MLT^{-2})^{-1}$

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

6. Answer (1)

$I = (e^{1000\ V/T} - 1)\text{mA}$

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

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

$= (6\ \text{mA}) \times \frac{1000}{300} \times (0.01)$

= 0.2 mA

7. Answer (2)

As measured value is 3.50 cm, the least count must be 0.01 cm = 0.1 mm

For vernier scale with 1 MSD = 1 mm and 9 MSD = 10 VSD,

Least count = 1 MSD – 1 VSD

= 0.1 mm

8. Answer (2)

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

$\Rightarrow \frac{\Delta g}{g} \times 100 = \frac{\Delta l}{l} \times 100 + 2\frac{\Delta T}{T} \times 100$

$= \frac{\Delta l}{l} \times 100 + 2.\frac{\Delta t}{t} \times 100$

$= \frac{0.1}{20.0} \times 100 + 2 \times \frac{1}{90} \times 100$

$= \frac{100}{200} + \frac{200}{90} = \frac{1}{2} + \frac{20}{9} \cong 3\%$

9. Answer (4)

$T = \frac{T_1 + T_2 + T_3 + T_4}{4}$

$\Delta T = \frac{|T_1 - T| + |T_2 - T| + |T_3 - T| + |T_4 - T|}{4}$

= 1.5 s $\approx$ 2 s (Since least count is 1 s)

Final answer is 92 ± 2 s

10. Answer (1)

Zero error = –5 division of circular scale

1 division of circular scale

$= \frac{0.5}{50} = 10^{-2}$ mm = 0.01 mm

$\therefore$ Zero error = -5×10^{-2} = –0.05 mm

Zero correction = + 0.05 mm

Reading = 0.5 + 25 × 0.01 + 0.05 = 0.80 mm

11. Answer (2)

$\frac{\Delta T}{T} \times 100 = \frac{\Delta D}{D} \times 100 + \frac{\Delta h}{h} \times 100$

$= \frac{0.01}{1.25} \times 100 + \frac{0.01}{1.45} \times 100$

$= \frac{100}{125} + \frac{100}{145}$

= 0.8 + 0.689

= 1.489

$\simeq$ 1.5%

12. Answer (3)

$$\rho = \frac{m}{l^3}$$

$$\frac{d\rho}{\rho} = \frac{dm}{m} + 3\frac{dl}{l}$$

$= (1.5 + 3 \times 1)$

$= 4.5\%$

13. Answer (1)

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

Zero error, $e = 3 \times 0.005 = 0.015$ mm

Thickness $= (5.5 + 48 \times 0.005 - 0.015)$ mm

$= 5.725$ mm

14. Answer (1)

$[T] = [G]^a . [h]^b . [c]^c$

$= [M^{-1}L^3T^{-2}]^a [ML^2T^{-1}]^b [LT^{-1}]^c$

$-a + b = 0$

$3a + 2b + c = 0 \quad \Rightarrow 5a + c = 0$

$-2a - b - c = 1 \quad \Rightarrow 3a + c = -1$

$$\Rightarrow a = \frac{1}{2}$$

$$b = \frac{1}{2}$$

$$c = \frac{-5}{2}$$

$$\Rightarrow [T] = \sqrt{\frac{Gh}{c^5}}$$

15. Answer (3)

$$\rho = \frac{128\,\text{kg}}{\text{m}^3} = \frac{128}{\left(\frac{100}{25}\right)^3}\frac{1000}{50} = \frac{128}{4^3} \times 20 = 40$$

16. Answer (3)

$$V = \frac{\pi D^2 h}{4} = \frac{\pi}{4} \times 34.2 \times (12.6)^2 = 4264.39 \text{ cm}^3$$

$$\therefore \quad \frac{\Delta V}{V} = \frac{2\Delta D}{D} + \frac{\Delta h}{h} = \frac{2 \times 0.1}{12.6} + \frac{0.1}{34.2}$$

$\Rightarrow \Delta V = 80.157$

Reducing the answers to proper significant digit then we should write it as

$V = 4260 \pm 80$ cm^3

17. Answer (2)

$[x^2] = [\alpha KT]$

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

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

$[\alpha \cdot \beta] = MLT^{-2}$

$M^{-1}T^{+2}[\beta] = MLT^{-2}$

$[\beta] = M^2LT^{-4}$

18. Answer (3)

$V = L^1T^{-1}$

$A = L^1T^{-2}$

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

$$Y = \frac{\text{Force}}{\text{Area}}$$

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

$[M^1L^{-1}T^{-2}] = [F]^\alpha [A]^\beta [V]^\gamma$

$\alpha = 1, \beta = 2, \gamma = -4$

19. Answer (1)

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

$$\Rightarrow \quad 5 \times 10^{-6} = \frac{10^{-3}}{N}$$

$\Rightarrow N = 200$

20. Answer (4)

$[p] = MLT^{-1} = [I^x h^y S^z]$

$= M^xL^{2x} (ML^2T^{-1})^y (MT^{-2})^z$

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

$x + y + z = 1$

$$2(x + y) = 1 \quad \Rightarrow \quad x + y = \frac{1}{2} \quad \Rightarrow \quad z = \frac{1}{2}$$

$$y + 2z = 1 \quad \Rightarrow \quad y = 0 \quad \Rightarrow \quad x = \frac{1}{2}$$

$$[p] = \sqrt{IS}$$

21. Answer (1)

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

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

$$= \left(\frac{0.1}{55} + \frac{2 \times 1}{30}\right) \times 100$$

$\approx 6.8\%$

22. Answer (4)

$$\rho = M/V = \frac{10}{(0.1)^3} = 10{,}000 \text{ kg/m}^3$$

$$\frac{d\rho}{\rho} = \left[\frac{dM}{M} + \frac{dV}{V}\right]$$

$$\frac{d\rho}{10,000} = \frac{0.1}{10} + \frac{0.03}{0.1}$$

$d\rho = 3100 \text{ kg/m}^3$

23. Answer (2)

$5.29 \times 7 = 37.0 \text{ cm}^2$

Answer should be in 3 significant digits.

24. Answer (4)

$X = 5YZ^2$

$$Y \propto \frac{X}{Z^2}$$

$$X = C = \frac{Q^2}{E} = \frac{[A^2 T^2]}{[ML^2 T^{-2}]}$$

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

$$Z = B = \frac{F}{IL}$$

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

$$Y = \frac{[M^{-1} L^{-2} T^4 A^2]}{[MT^{-2} A^{-1}]^2}$$

$$Y = [M^{-3} L^{-2} T^8 A^4]$$

25. Answer (4)

$l = 25.0$ cm

Time of 40 oscillation is 50 sec

$$\therefore \quad g = \frac{4\pi^2 l}{T^2} \quad \Rightarrow \quad \frac{\Delta g}{g} = \frac{\Delta l}{l} + \frac{2\Delta T}{T}$$

$$\Rightarrow \quad \frac{\Delta g}{g} = \left(\frac{0.1}{25.0}\right) + 2\left(\frac{1}{50}\right)$$

$$\Rightarrow \quad \left(\frac{\Delta g}{g} \times 100\right) = 4.4\%$$

26. Answer (3)

$$\text{Pitch} = \frac{3 \text{ mm}}{6} = 0.5 \text{ mm}$$

$$\Rightarrow \text{ L.C.} = \frac{0.5}{50} \text{mm}$$

$$= \frac{1}{100} \text{mm}$$

$$= 10^{-3} \text{ cm}$$

27. Answer (1)

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

$[c] = [LT^{-1}]$

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

$$\begin{cases} F = \dfrac{Gm_1m_2}{r^2} \\ \Rightarrow G = \dfrac{Fr^2}{m_1m_2} \end{cases}$$

$$\Rightarrow \quad \left[\sqrt{\frac{hc^5}{G}}\right] = [ML^2T^{-2}] = \text{Energy}$$

28. Answer (3)

$A_1 + B_1 + C_1 = 280.6$

$A_2 + B_2 + C_2 = 280.7$

$A_3 + B_3 + C_3 = 280.7$

$A_4 + B_4 + C_4 = 281$

29. Answer (3)

$$\text{Least count of V.C} = \left(1 - \frac{9}{10}\right) \times 1 \text{ mm}$$

$= 0.1$ mm

$\therefore$ Zero error $= 7 \times 0.1 = 0.7$ mm positive error

Measured value $= (31 + 4 \times 0.1)$ mm

$= 31.4$ mm

$\therefore$ Length of cylinder $= 31.4 - 0.7$

$= 30.7$ mm

$= 3.07$ cm

30. Answer (1)

$$\because \quad [\text{Young's modulus}] = \left[\frac{\text{Force}}{\text{Area}}\right]$$

$\Rightarrow$ [Young's modulus] $= FA^{-1}$

$\Rightarrow$ [Young's modulus] $= FA^{-1}V^0$

31. Answer (3)

Energy = Force × Distance

$$\Rightarrow \quad [\text{Energy}] = \frac{P}{T} \times \sqrt{A}$$

$$= PT^{-1}A^{1/2}$$

32. Answer (1)

$$\text{Least count} = \frac{0.1}{50} \text{ cm}$$

$$= 0.002 \text{ cm}$$

Thickness of object = Main scale Reading + Circular scale reading × least count

33. Answer (2)

$$\frac{dQ}{dt} = \frac{KA(\Delta T)}{x}$$

$$\Rightarrow [K] = \frac{ML^2T^{-2} \times L}{T \times L^2 \times K}$$

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

34. Answer (3)

$$x = \frac{IFv^2}{WL^4}$$

$$\therefore [x] = \frac{(ML^2) \times (MLT^{-2}) \times (LT^{-1})^2}{(ML^2T^{-2}) \times L^4}$$

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

= [Energy density]

35. Answer (2)

$$\frac{\Delta z}{z} = 2\frac{\Delta A}{A} + \frac{2}{3}\frac{\Delta b}{b} + \frac{1}{2}\frac{\Delta c}{c} + 3\frac{\Delta d}{d}$$

$$= 2 \times 2 + \frac{2}{3} \times 1.5 + \frac{1}{2} \times 4 + 3 \times 2.5$$

= 14.5%

36. Answer (2)

$$\text{: L.C.} = \frac{0.5 \text{ mm}}{50}$$

$= 10^{-2}$ mm

$= 10^{-5}$ m

$= 10\ \mu m$

37. Answer (2)

d_{av} = 5.5375 mm

Δd = 0.07395 mm

$\because$ Measured data are up to two digits after decimal

$\therefore$ d = (5.54 ± 0.07) mm

38. Answer (1050.00)

$$\rho = \frac{m}{\frac{4}{3}\pi\left(\frac{d}{2}\right)^3}$$

$$\therefore \% \frac{\Delta\rho}{\rho} = \frac{\Delta m}{m} + 3.\left(\frac{\Delta d}{d}\right)$$

= 6 + 3 × 1.5

= 10.5%

$$= \left(\frac{1050}{100}\right)\%$$

39. Answer (3)

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

$$\left[\frac{x^2}{\alpha kT}\right] = \text{dimensionless}$$

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

and $[\alpha\beta^2] = ML^2T^{-2}$

$$[\beta^2] = \frac{ML^2T^{-2}}{M^{-1}T^2} = M^2L^2T^{-4}$$

$$\Rightarrow [\beta] = MLT^{-2}$$

40. Answer (3)

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

$$\frac{dg}{g} = \frac{d\ell}{\ell} + \frac{2dT}{T}$$

$$\frac{dg}{g} = \frac{1}{1000} + \frac{2 \times 0.01}{1.95} = \frac{1.13}{100}$$

41. Answer (2)

$$h = [ET] = ML^2T^{-2} \times T$$

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

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

$$[V] = \left[\frac{U}{q}\right] = \frac{ML^2T^{-2}}{IT} = ML^2T^{-3}I^{-1}$$

$$[P] = M \times LT^{-1} = MLT^{-1}$$

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

42. Answer (4)

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

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

$g = 2\pi^2$ m/s^2

43. Answer (4)

$$[E] = \frac{hc}{\lambda}$$

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

$$[M^0L^0T^0] = \frac{e^2}{4\pi\varepsilon_0 r}\frac{\lambda}{hc}$$

44. Answer (2)

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

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

$$\left[\alpha^2\beta\right] = ML^2T^{-2}$$

$$\Rightarrow \left[\alpha^2\right] = \frac{ML^2T^{-2}}{MT^{-2}}$$

$$\Rightarrow [\alpha] = M^0LT^0$$

45. Answer (3)

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} \qquad \ldots(1)$$

$$-\frac{dR}{R^2} = -\frac{dR_1}{R_1^2} - \frac{dR_2}{R_2^2} \qquad \ldots(2)$$

From (1) $R = 2\ \Omega$

$$+\frac{dR}{4} = \frac{0.8}{16} + \frac{0.4}{16}$$

$$dR = \frac{4.8}{16} = 0.3$$

46. Answer (2)

$$U = \frac{1}{2}CV^2$$

$$\Rightarrow \quad \frac{C}{V} = \frac{U}{V^3} = \frac{F \times L}{V^3}$$

$$V = \frac{F \times L}{IT}$$

$$\Rightarrow \quad \frac{C}{V} = \frac{F \times L \times I^3T^3}{F^3 \times L^3}$$

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

47. Answer (2)

$$R = \frac{\rho\ell}{A} = \frac{\rho\ell^2}{(\text{Vol.})}$$

$$R_1 = \left(\frac{\rho}{V}\right)(\ell)^2$$

$$R_2 = \left(\frac{\rho}{V}\right)\left(\frac{5\ell}{4}\right)^2$$

$$\frac{\Delta R}{R_1} \times 100 = \frac{9}{16} \times 100 \simeq 56\%$$

48. Answer (5)

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

$$\Rightarrow \frac{\Delta R}{R} \times 100 = \frac{\Delta V}{V} \times 100 + \frac{\Delta I}{I} \times 100$$

$$= \frac{2}{50} \times 100 + \frac{0.2}{20} \times 100 = 5\%$$

49. Answer (1)

$$\because \quad Y = \frac{F\ /\ A}{\Delta l\ /\ l}$$

$$= \frac{mg \times l}{\left(\pi r^2\right) \times \Delta l}$$

$$\therefore \quad \frac{\Delta Y}{Y} \times 100 = \left(\frac{1}{1000} + \frac{1}{1000} + 2 \times \frac{0.001}{0.2} + \frac{0.001}{0.5}\right) \times 100$$

$$= 1.4\%$$

50. Answer (25)

$$\text{Volume of oleic acid} = 100 \times \frac{4}{3}\pi r^3 \times \frac{1}{100}$$

$$\frac{4}{3}\pi r^3 = A \times t$$

$$t = 25 \times 10^{-14}\ m$$

$$x = 25$$

51. Answer (1)

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

$$\text{or} \quad g = \frac{l(2\pi)^2}{T^2}$$

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

$$\Rightarrow \quad x = \frac{10^{-3}}{10 \times 10^{-2}} \times 100 + 2 \times \frac{1}{100} \times 100$$

$x = (1 + 2)\%$

$x = 3\%$

52. Answer (2)

$$V = I \times \rho \frac{\ell}{A}$$

$$\Rightarrow \quad \rho = \frac{VA}{I\ell} = \frac{\pi}{4}\frac{Vd^2}{I\ell}$$

$$\frac{\Delta\rho}{\rho} = \frac{2\Delta d}{d} + \frac{\Delta V}{V} + \frac{\Delta I}{I} + \frac{\Delta \ell}{\ell}$$

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

$$\frac{\Delta\rho}{\rho} = 0.039 \ = 3.9\%$$

53. Answer (34)

$$v = \frac{4}{3}\pi R^3$$

$$\Rightarrow \quad \frac{\Delta v}{v} \times 100 \ = \ (3)\frac{\Delta R}{R} \times 100$$

$$= \ (3) \times \frac{0.85}{7.5} \times 100$$

$$= 34$$

54. Answer (2)

$$[\mu R] = \left[\frac{\text{Energy}}{\text{Temperature}}\right] = [k] = [S]$$

$$\Rightarrow \quad [\beta] = [k] = [\mu R] = [S] = \frac{ML^2T^{-2}}{k}$$

55. Answer (2)

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

$M = I^{\alpha}t^{\beta}v^{\gamma}$

$M = [M^1L^2T^{-1}]^{\alpha}\ [T]^{\beta}\ [L^1T^{-1}]^{\gamma}$

$\alpha = 1$

$-\alpha + \beta - \gamma = 0$

$2\alpha + \gamma = 0$

$\gamma = -2$

$\beta = -1$

56. Answer (4)

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

$$\therefore \quad \left[\frac{AD}{B}\right] = \frac{MLT^{-2} \times T^{-1}}{L^{-1}}$$

$= [ML^2T^{-3}]$

57. Answer (2)

$$\text{Pitch} \ = \frac{5\,\text{mm}}{5} = 1\,\text{mm}$$

$$\text{So least count} \ = \frac{\text{Pitch}}{\text{Total division on circular scale}}$$

$$= \frac{1\,\text{mm}}{50}$$

$= 0.02$ mm

$= 0.002$ cm

So A is not correct but R is correct.

58. Answer (2)

(a) $U = \dfrac{Q^2}{2C}$

$$\Rightarrow [C] = \frac{I^2t^2}{U} = \frac{A^2T^2}{[ML^2T^{-2}]} = [M^{-1}L^{-2}T^4A^2]$$

(b) $[\varepsilon_0] \rightarrow [M^{-1}L^{-3}T^4A^2]$

(c) $[\mu_0] \rightarrow [MLT^{-2}A^{-2}]$

(d) $W = qE \times d \Rightarrow E = \dfrac{[ML^2T^{-2}]}{[AT][L]}$

59. Answer (1)

$$\frac{\Delta y}{y} = \frac{2\Delta m}{m} + \frac{4\Delta r}{r} + \frac{x\Delta g}{g} + \frac{3}{2}\frac{\Delta l}{l}$$

$$18 = 2 \times 1 + 4 \times 0.5 + \frac{3}{2} \times 4 + px$$

$8 = px$

As per given option, option 1 is correct match

60. Answer (4)

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

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

61. Answer (1)

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

$$\Rightarrow \quad \frac{\Delta T}{T} = \frac{1}{2}\frac{\Delta l}{l}$$

$\Rightarrow$ Time lost in 1 day.

$$\Delta t = \frac{1}{2}\left(\frac{\Delta l}{l}\right) \times t$$

$$= \frac{1}{2} \times \frac{0.1}{100} \times 86400$$

$$= 43.2 \text{ s}$$

62. Answer (4)

[Magnetic flux] $\rightarrow [M^1L^2T^{-2}I^{-1}]$,

$$[B] \rightarrow \frac{F}{IL} = \frac{MLT^{-2}}{AL} = \left[MT^{-2}A^{-1}\right]$$

$[\mu] \rightarrow [MLT^{-2}A^{-2}]$

[Magnetization] $\rightarrow [M^0L^{-1}A]$

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

63. Answer (14)

$$E = \frac{1}{2}mv^2 = \frac{1}{2}m\omega^2\ell^2\theta_0^2$$

$$E = CT^2g^2$$

$$\frac{\Delta E}{E}\% = 2 \times (4+3) = 14$$

64. Answer (2)

$l = r\theta$

and $T = \frac{2\pi r}{V} = \frac{2\pi}{V} \times \frac{l}{\theta}$

$$\therefore\ t = 4T = \frac{8\pi \times l}{V\theta}$$

$$= \frac{8\pi \times 4.4 \times 9.46 \times 10^{15}}{8 \times 1.5 \times 10^{11} \times 4 \times \frac{1}{3600} \times \frac{\pi}{180}}$$

$= 4.5 \times 10^{10}$ s

65. Answer (3)

Permeability of free space is not a dimensionless quantity.

66. Answer (2)

Unit of $E = \frac{V}{m}$

Unit of $H = \frac{A}{m}$

$$\frac{E}{H} = \frac{V}{A} = \Omega$$

67. Answer (1)

Unit of $R_h = m^{-1}$

Unit of h = ET = kg m^2s^{-1}

Unit of μ_B = kg $m^{-1}s^{-2}$

Unit of η = kg $m^{-1}s^{-1}$

68. Answer (3)

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

$\rho = M^1L^{-3}$

$\rho = [F]^a[L]^b[T]^c$

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

$\Rightarrow$ a = 1, b = –4, c = 2

$\rho = F^1L^{-4}T^2$

69. Answer (3)

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

Impulse = $F \times$ time

$= MLT^{-1}$

Tension = MLT^{-2}

$$\text{Surface tension} = \frac{\text{force}}{\text{length}} = MT^{-2}$$

So, (3) is correct option.

70. Answer (3)

Option (3) is dimensionally incorrect as dimension of $\frac{\pi Pa^4}{8\eta l}$ is L^3T^{-1} by Poiseuille formula.

71. Answer (4)

Mass, $M = [V]^a\ [T]^b\ [F]^c$

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

$\Rightarrow c = 1$

$\Rightarrow a + c = 0 \Rightarrow a = -c = -1$

$\Rightarrow$ –a + b – 2c = 0

$\Rightarrow b = a + 2c = -1 + 2 \times 1 = 1$

$M = [FTV^{-1}]$

72. Answer (3)

$$Y = \frac{MgL^3}{4bd^3\delta}$$

$$\frac{dY}{Y} = \frac{dM}{M} + \frac{3dL}{L} + \frac{db}{b} + \frac{3dd}{d} + \frac{d\delta}{\delta}$$

$$= \frac{1}{2000} + \frac{3}{1000} + \frac{1}{400} + \frac{0.003}{0.4} + \frac{1}{500}$$

$$= \frac{1+6+5.0+15+4}{2000}$$

$$= \frac{31}{2000} = 0.0155$$

73. Answer (4)

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

and, $[L] = \frac{[Q]}{[m]}$

$\Rightarrow$ They have different dimensions

74. Answer (1)

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

$\Rightarrow$ Dimensions are $\frac{[LT^{-1}]}{[L]} = [T^{-1}]$

Decay constant λ has dimensions of $[T^{-1}]$ because of the relation $\frac{dN}{dt} = -\lambda N$

$\Rightarrow$ Velocity gradient and decay constant have same dimensions.

75. Answer (3)

$$Z = \frac{A^2B^3}{C^4}$$

$$\therefore \quad \frac{\Delta Z}{Z} = \frac{2\Delta A}{A} + 3 \times \frac{\Delta B}{B} + \frac{4\Delta C}{C}$$

76. Answer (18)

$$\% \text{ error in } z = 3 \times 4 + \frac{1}{2} \times 12$$

$$= 12 + 6 = 18\%$$

77. Answer (3)

$$[\alpha] = [\beta] = \left[\frac{kt}{x}\right]$$

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

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

78. Answer (3)

$$\because \quad U = \frac{1}{2}Mi^2$$

$$\Rightarrow \quad [M] = \frac{[U]}{[i^2]} = \frac{ML^2T^{-2}}{A^2}$$

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

79. Answer (1)

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

$\therefore$ % error in

$$\rho = \left(\frac{0.006}{0.6} + 2 \times \frac{0.005}{0.5} + \frac{0.04}{4}\right) \times 100 = 4\%$$

80. Answer (1)

$$[\text{pascal-second}] = \frac{MLT^{-2}}{L^2} \times T$$

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

81. Answer (4)

$$U = \frac{1}{2}Li^2 = \frac{1}{2}CV^2$$

So, $\left[\frac{L}{C}\right] = \frac{V^2}{i^2} = R^2$ is not the dimension of time.

82. Answer (3)

$$[\text{Pressure}][\text{Time}] = \left[\frac{\text{Force}}{\text{Area}}\right]\left[\frac{\text{Distance}}{\text{Velocity}}\right]$$

$$[\text{Coefficient of viscosity}] = \left[\frac{\text{Force}}{\text{Area}}\right]\left[\frac{\text{Distance}}{\text{Velocity}}\right]$$

Statement 'A' is true

But statement R is false because coefficient of viscosity

$$= \frac{\text{Force}}{\text{Area} \times \text{Velocity gradient}}$$

83. Answer (1)

$$[L] = \frac{[v^2]}{[a]}$$

$$\text{so } \frac{[v_2]^2}{[a_2]} = \frac{\left[\frac{n}{m^2}v_1\right]^2}{\left[\frac{a_1}{mn}\right]}$$

$$\frac{[v_2]^2}{[a_2]} = \frac{n^3}{m^3}\frac{[v_1]^2}{[a_1]}$$

$$\text{or } [L_2] = \frac{n^3}{m^3}[L_1]$$

Similarly

$$[T] = \frac{[v]}{[a]}$$

$$\text{So, } [T_2] = \frac{n^2}{m}[T_1]$$

84. Answer (150)

$$I_{mean} = \frac{1.22+1.23+1.19+1.20}{4} = 1.21$$

$$\Delta I_{mean} = \frac{0.01+0.02+0.02+0.01}{4} = 0.015$$

So % $I = \frac{\Delta I_{mean}}{I_{mean}} \times 100 = \frac{0.015}{1.21} \times 100$

$$= \frac{150}{121}\%$$

$x = 150$

85. Answer (3)

From the equation

$[a] \equiv [PV^2]$

$[b] \equiv [V]$

$\Rightarrow \left[\frac{a}{b}\right] \equiv [PV]$

86. Answer (1)

$[\eta] = [ML^{-1}T^{-1}]$

Now if $[\eta] = [P]^a[A]^b[T]^c$

$\Rightarrow [ML^{-1}T^{-1}] = [ML^1T^{-1}]^a[L^2]^b[T]^c$

$\Rightarrow a = 1, a + 2b = -1, -a + c = -1$

$\Rightarrow a = 1, b = -1, c = 0$

$\Rightarrow [\eta] = [P][A]^{-1}[T]^0$

$= [PA^{-1}T^0]$

87. Answer (1)

Electric displacement $(\vec{D}) = \varepsilon_0\vec{E}$

$\Rightarrow [\vec{D}] = [\varepsilon_0][\vec{E}]$

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

$[\vec{D}] = [L^{-2}T^1A^1]$

$$[\text{Surface charge density}] = \frac{[Q]}{[A]}$$

$[\sigma] = [ATL^{-2}]$

$\Rightarrow \vec{D}$ and $[\sigma]$ have same dimensions

88. Answer (2)

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

$\Rightarrow \frac{\Delta\tau}{\tau} = \frac{\Delta M}{M} + 2\frac{\Delta L}{L} + 2\frac{\Delta T}{T}$

$= 5 \times 5\% = 25\%$

89. Answer (4)

$u = \frac{\alpha}{\beta}\sin\left(\frac{\alpha x}{kt}\right)$

$[\alpha] = \left[\frac{kt}{x}\right] = \frac{[\text{Energy}]}{[\text{Distance}]}$

$[\beta] = \frac{[\alpha]}{[u]}$

$= \frac{[\text{Energy}]/[\text{Distance}]}{[\text{Energy}]/[\text{Volume}]}$

$= [L^2]$

90. Answer (3)

$\left[\frac{B^2}{\mu_0}\right] = [\text{Energy density}]$

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

91. Answer (4)

$g = \frac{GM}{R^2}$

$\frac{\Delta R}{R} \times 100 = -2$

$\frac{\Delta g}{g} = -\frac{2\Delta R}{R} = 4\%$

Increase by 4%

92. Answer (4)

(1) $[\beta] = \left[\frac{kT}{x}\right] = \left[\frac{E}{x}\right] = [MLT^{-2}]$

$= [F]$

(2) $[\alpha\beta] = [M^0L^0T^0]$

$[\alpha]^{-1} = [\beta] = \left[\frac{kT}{x}\right]$

So $[\alpha]^{-1}[x] = [kT] = [ML^2T^{-2}]$

(3) $\eta\sin\theta = \alpha\beta$

So $[\eta\sin\theta] = [\alpha\beta]$

$[\eta] = [M^0L^0T^0]$ it is dimensionless quantity

(4) $[\alpha] \neq [\beta]$

93. Answer (5)

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

$$\frac{dg}{g}\times 100 = \frac{2dT}{T}\times 100 + \frac{d\ell}{\ell}\times 100$$

$$= 2\times\frac{1}{50}\times 100 + \frac{1}{100}\times 100 = 5\%$$

94. Answer (4)

$$\left[\frac{\rho r^3}{T^{3/2}}\right] = \frac{[ML^{-3}][L^3]}{[ML^0T^{-2}]^{3/2}} \neq [T]$$

As the equation for first statement is wrong dimensionally.

$\Rightarrow$ A is false and R is true

95. Answer (300)

Volume is constant so on length doubled

Area is halfed so

$$R = \rho\frac{l}{A} \text{ and } R' = \rho\frac{2l}{\frac{A}{2}} = 4\rho\frac{l}{A} = 4R$$

So percentage increase will be

$$R\% = \frac{4R - R}{R}\times 100 = 300\%$$

96. Answer (3)

When the wire is stretched, volume remains constant. If length is increased by 0.4% area will decrease by 0.4% so

From $R = \rho\frac{l}{A}$

$$\frac{dR}{R}\times 100 = \frac{dl}{l}\times 100 + \frac{dA}{A}\times 100$$

$\%R = 0.4 + 0.4 = 0.8\%$

97. Answer (D)

$\because H = i^2Rt$

$\because$ % error in $H = 2 \times 2\% + 1\% + 3\%$

$= 8\%$

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