JEE Mains & Advanced Past Years Questions

JEE-MAIN

1. 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*]

(*a*) 92 ± 1.5 s (*b*) 92 ± 5.0 s

(*c*) 92 ± 1.8 s (*d*) 92 ± 3 s

2. A screw gauge with a pitch of 0.5 mm and a circular scale with 50 divisions is used to measure the thickness of 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^{th} 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 25^{th} division coincides with the main scale line? **[*JEE Main-2016*]**

(*a*) 0.75 mm (*b*) 0.80 mm

(*c*) 0.70 mm (*d*) 0.50 mm

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

Diameter of capilary, $D = 1.25 \times 10^{-2}$ m

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

Using $g = 9.80$ m/s^2 and the simplified relation

$T = \frac{rhg}{2} \times 10^3$ N/m , the possible error in surface tension is closest to : **[*JEE Main-2017*]**

(*a*) 2.4% (*b*) 10% (*c*) 0.15% (*d*) 1.5%

4. 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*]

(*a*) 3.5 % (*b*) 4.5 % (*c*) 6 % (*d*) 2.5 %

5. If speed (V), acceleration (*A*) and force (F) are considered as fundamental units, the dimension of Young's modulus will be:

[*JEE Main-2019* (*January*)]

(*a*) $V^{-2}A^2F^{-2}$ (*b*) $V^{-2}A^2F^2$

(*c*) $V^{-4}A^{-2}F$ (*d*) $V^{-4}A^2F$

6. The density of a material in SI units is 128 kg m^{-3}. In certain units in which the unit of length is 25 cm and the unit of mass 50 g, the numerical value of density of the material is:

[*JEE Main-2019* (*January*)]

(*a*) 40 (*b*) 16 (*c*) 640 (*d*) 410

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

[*JEE Main-2019* (*January*)]

(*a*) $\sqrt{\frac{hc^5}{G}}$ (*b*) $\sqrt{\frac{c^3}{Gh}}$ (*c*) $\sqrt{\frac{Gh}{c^5}}$ (*d*) $\sqrt{\frac{Gh}{c^3}}$

8. Let L, R, C and V represent inductance, resistance, capacitance and voltage, respectively. The dimension of $\frac{L}{RCV}$ in SI units will be:

[*JEE Main-2019* (*January*)]

(*a*) $[LA^{-2}]$ (*b*) $[A^{-1}]$ (*c*) [LTA] (*d*) $[LT^2]$

9. In SI units, the dimension of $\sqrt{\frac{\varepsilon_0}{\mu_0}}$ is

[*JEE Main-2019* (*April*)]

(*a*) $A^{-1}TML^3$ (*b*) $A^2T^3M^{-1}L^{-2}$

(*c*) $AT^2M^{-1}L^{-1}$ (*d*) $AT^{-3}ML^{3/2}$

10. 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* (*April*)]

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

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

11. If surface tension (S), Moment of inertia (I) and Planck's constnat (h), were to be taken as the fundamental units, the dimensional formula for linear momentum would be:

[*JEE Main-2019* (*April*)]

(*a*) $S^{3/2}I^{1/2}h^0$ (*b*) $S^{1./2}I^{1/2}h^0$

(*c*) $S^{1/2}I^{1/2}h^{-1}$ (*d*) $S^{1/2}I^{3/2}h^{-1}$

12. Which of the following combination has the dimension of electrical resistance (ε_0 is the permittivity of vacuum and μ_0 is the permeability of vacuum) ?

[*JEE Main-2019* (*April*)]

(*a*) $\sqrt{\frac{\varepsilon_0}{\mu_0}}$ (*b*) $\frac{\mu_0}{\varepsilon_0}$ (*c*) $\sqrt{\frac{\mu_0}{\varepsilon_0}}$ (*d*) $\frac{\varepsilon_0}{\mu_0}$

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* (*January*)]

(*a*) 5.755 mm (*b*) 5.950 mm

(*c*) 5.725 mm (*d*) 5.740 mm

14. 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* (*January*)]

(*a*) $4264 \pm 81\ cm^3$ (*b*) $4264 \pm 81.0\ cm^3$

(*c*) $4260 \pm 80\ cm^3$ (*d*) $4300 \pm 80\ cm^3$

15. 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* (*January*)]

(*a*) 50 (*b*) 200 (*c*) 100 (*d*) 500

16. 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* (*April*)]

(*a*) 37 cm^2 (*b*) 37.0 cm^2

(*c*) 37.03 cm^2 (*d*) 37.030 cm^2

17. 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* (*April*)]

(*a*) 0.10 kg/m^3 (*b*) 0.31 kg/m^3

(*c*) 0.07 kg/m^3 (*d*) 0.01 kg/m^3

18. The dimensions of $\frac{B^2}{2\mu_0}$, where B is magnetic field and μ_0 is the magnetic permeability of vacuum, is

(*a*) MLT^{-2} (*b*) $ML^{-1}T^{-2}$

(*c*) ML^2T^{-1} (*d*) ML^2T^{-2}

19. 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* (*January*)]

(*a*) volume (*b*) energy

(*c*) momentum (*d*) area

20. 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* (*September*)]**

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

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

21. 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* (*September*)]**

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

(b) FA^2V^{-2} (d) FA^2V^{-3}

22. Amount of solar energy received on the earth's surface per unit area per unit time is defined a solar constant. Dimension of solar constant is **[*JEE Main-2020* (*September*)]**

(a) ML^2T^{-2} (b) MLT^{-2}

(c) $M^2L^0T^{-1}$ (d) ML^0T^{-3}

23. 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* (*September*)]**

(a) Coefficient of viscosity

(b) Force constant

(c) Energy density

(d) Planck's constant

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

(a) $MLT^{-2}K^{-2}$ (b) $MLT^{-3}K^{-1}$

(c) $MLT^{-3}K$ (d) $MLT^{-2}K$

25. The quantities $x = \frac{1}{\sqrt{\mu_0\varepsilon_0}}$, $y = \frac{E}{B}$ and $z = \frac{I}{CR}$ are defined where C-capacitance, R-Resistance, l-length, E-Electric field, B-magnetic field and ε_0, μ_0,- free space permittivity and permeability respectively. Then **[*JEE Main-2020* (*September*)]**

(a) Only x and y have the same dimension

(b) Only x and z have the same dimension

(c) x, y and z have the same dimension

(d) Only y and z have the same dimension

26. 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 stop watch with 1s resolution measures the time taken for 40 oscillations to be 50 s. The accuracy in g is : **[*JEE Main-2020* (*January*)]**

(a) 4.40% (b) 3.40%

(c) 2.40% (d) 5.40%

27. If the screw on a screw–gauge is given six rotations, it moves by 3mm on the main scale. If there are 50 divisions on the circular scale the least count of the screw gauge is: **[*JEE Main-2020* (*January*)]**

(a) 0.01 cm (b) 0.02 mm

(c) 0.001 mm (d) 0.001 cm

28. When the temperature of a metal wire is increased from 0°C to 10°C, its length increases by 0.02%. The percentage change in its mass density will be closest to **[*JEE Main-2020* (*September*)]**

(a) 2.3 (b) 0.06

(c) 0.8 (d) 0.008

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 7^{th} 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 4 VSD coincides with a main scale division. The length of the cylinder is (VSD is vernier scale division) **[*JEE Main-2020* (*September*)]**

(a) 3.21 cm (b) 2.99 cm

(c) 3.07 cm (d) 3.2 cm

30. 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* (*September*)]**

(a) 2.124 cm (b) 2.123 cm

(c) 2.125 cm (d) 2.121 cm

31. When a diode is forward biased, it has a voltage drop of 0.5 V. The safe limit of current through the diode is 10 mA. If a battery of emf 1.5 V is used in the circuit, the value of minimum resistance to be connected in series with the diode so that the current does not exceed the safe limit is **[*JEE Main-2020* (*September*)]**

(a) 50 Ω (b) 200 Ω

(c) 300 Ω (d) 100 Ω

32. A physical quantity z depends on four observables a, b, c and d, as $\frac{a^a b^{\frac{2}{3}}}{\sqrt{c}\, d^3}$. 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

[*JEE Main-2020* (*September*)]

(*a*) 13.5% (*b*) 14.5%

(*c*) 16.5% (*d*) 12.25%

33. 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* (*September*)]**

(*a*) (5.5375 ± 0.0739) mm (*b*) (5.54 ± 0.07) mm

(*c*) (5.538 ± 0.074) mm (*d*) (5.5375 ± 0.0740) mm

34. 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* (*September*)]

35. 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 cm. (least count $= 0.01\,cm$) **[*JEE Main-2021* (*March*)]**

(*a*) $8.58\,cm$ (*b*) $8.54\,cm$

(*c*) $8.56\,cm$ (*d*) $8.36\,cm$

36. 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* (*March*)]

(*a*) 0.14% (*b*) 9%

(*c*) 1.4% (*d*) 0.9%

37. One main scale division of a vernier callipers is 'a' cm and n^{th} division of the vernier scale coincide with $(n-1)^{th}$ division of the main scale. The least count of the callipers in mm is: **[*JEE Main-2021* (*March*)]**

(*a*) $\frac{10a}{R}$ (*b*) $\frac{10ra}{(r-1)}$

(*c*) $\left(\frac{R-1}{10R}\right)a$ (*d*) $\frac{10a}{(r-1)}$

JEE-ADVANCED

1. In the determination of Young's modulus $\left(Y = \frac{4MLg}{\pi l d^2}\right)$ by using Searle's method, a wire of length L = 2 m and diameter d = 0.5 mm is used. For a load M = 2.5 kg, an extension $\ell = 0.25$ 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 **[*IIT JEE-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 time that due to the error in the measurement of ℓ.

2. Match List-I with List-II and select the correct answer using the codes given below the lists :

[*JEE Advanced-2013*]

List-I	**List-II**
P. Boltzmann constant	1. $[ML^2T^{-1}]$
Q. Coefficient of viscosity	2. $[ML^{-1}T^{-1}]$
R. Planck constant	3. $[MLT^{-3}K^{-1}]$
S. Thermal conductivity	4. $[ML^2T^{-2}K^{-1}]$

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

3. The diameter of a c ylinder 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 division equivalent to 2.45 cm. The 24th division of the vernier scale exactly coincides with one of the main scale divisions. The diameter of the cylinder is :

[*JEE Advanced-2013*]

(*a*) 5.112 cm (*b*) 5.124 cm
(*c*) 5.136 cm (*d*) 5.148 cm

4. In an experiment to determine the acceleration due to gravity g, the formula used for the time period of a periodic motion is $T = 2\pi\sqrt{\frac{7(R-r)}{5g}}$. The values of R and R are measured to be (60 ± 1) mm and (10 ± 1) mm, respectively. In five successive measurements, the time period is found to be 0.52 s, 0.56s, 0.57s, 0.54s 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? **[*JEE Advanced-2013*]**

(*a*) The error in the measurement of *r* is 10%
(*b*) The error in the measurement of *T* is 3.57%
(*c*) The error in the measurement of *T* is 2%
(*d*) The error in the determined value of g is 11%

5. Using the expression 2d sin θ = λ, one calculates the values of d by measuring the corresponding angles θ in the range 0 to 90º. The wavelength λ is exactly knowns and the error in θ is constant for all values of As θ increases from 0º : **[*JEE Advanced-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.

6. To find the distance d over which a signal can be seen clearly in foggy conditions, a railways engineer uses dimensional analysis and assumes that the distance depends on the mass density ρ of the fog, intensity (power/area) S of the light from the signal and its frequency f. The engineer find that d is proportional to $S^{1/n}$. The value of n is:

[*JEE Advanced-2014*]

7. A length –scale (*l*) depends on the permittivity (ε) of a dielectric material, Boltzmann constant(k_B), 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 *l* is (are) dimensionally correct?

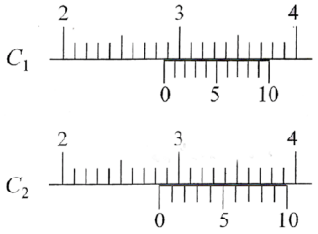
[*JEE Advanced-2016*]

(*a*) $l=\sqrt{\left(\frac{nq^2}{\varepsilon k_B T}\right)}$ (*b*) $l=\sqrt{\left(\frac{\varepsilon k_B T}{nq^2}\right)}$

(*c*) $l=\sqrt{\left(\frac{q^2}{\varepsilon n^{2/3} k_B T}\right)}$ (*d*) $l=\sqrt{\left(\frac{q^2}{\varepsilon n^{1/3} k_B T}\right)}$

8. 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 (C_1) has 10 equal divisions that correspond to 9 main scale divisions. The Vernier scale of the other caliper (C_2) has 10 equal divisions that correspond to 11 main scale division. The readings of the two calipers are shown in the figure. The measured values (in cm) by calipers C_1 and C_2, respectively, are

[*JEE Advanced-2016*]



(*a*) 2.87 and 2.86 (*b*) 2.85 and 2.82
(*c*) 2.87 and 2.87 (*d*) 2.87 and 2.83

Comprehension – 1 (No. 9 and 10)

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 [$\in_0$] and [μ] 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.

[*JEE Advanced - 2018*]

9. 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*) $[E] = [B] [L]^{-1} [T]^{-1}$

10. The relation between [$\in_0$] and [μ_0] is -

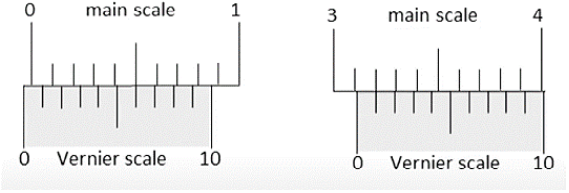
(*a*) $[\mu_0] = [\in_0] [L]^2 [T]^{-2}$
(*b*) $[\mu_0] = [\in_0] [L]^{-2} [T]^2$
(*c*) $[\mu_0] = [\in_0]^{-1} [L]^2 [T]^{-2}$
(*d*) $[\mu_0] = [\in_0]^{-1} [L]^{-2} [T]^2$

11. Let us consider a system of units in which mass and angular momentum are dimensionless. If length has dimension of L, which of the following statement (s) is/are correct?

[*JEE Advanced - 2019*]

(*a*) The dimension of force is L^{-3}
(*b*) The dimension of energy is L^{-2}
(*c*) The dimension of power is L^{-5}
(*d*) The dimension of linear momentum is L^{-1}

12. The smallest division on the main scale of a Venire callipers is $0.1\,\text{cm}$. 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 calliper 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 **[*JEE Advanced-2021*]**



(*a*) $3.07\,\text{cm}$ (*b*) $3.11\,\text{cm}$

(*c*) $3.15\,\text{cm}$ (*d*) $3.17\,\text{cm}$

13. 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 μ_0 is the permeability of free space. The dimensions of $\vec{S}$ are the same as the dimensions of which of the following quantity (ies) ? **[*JEE Advanced-2021*]**

(*a*) $\dfrac{\text{Energy}}{\text{charge} \times \text{current}}$

(*b*) $\dfrac{\text{Force}}{\text{Length} \times \text{Time}}$

(*c*) $\dfrac{\text{Energy}}{\text{Volume}}$

(*d*) $\dfrac{\text{Power}}{\text{Area}}$

JEE Mains & Advanced Past Years Questions

JEE-MAIN
PREVIOUS YEAR'S

1. (*a*) $\overline{x} = \dfrac{90+91+95+92}{4} = 92$

$\Delta x_1 = 90 - 92 = -2$

$\Delta x_2 = 91 - 92 = -1$

$\Delta x_3 = 95 - 92 = 3$

$\Delta x_4 = 92 - 92 = 0$

$|\Delta x| = \dfrac{2+1+3+0}{4} = 1.5$

2. (*b*) $LC = \dfrac{0.5}{50} = 0.01 mm$

Zero error $= -(50-45) \times 0.01\ mm = -0.05$

Thickness $= (0.5 + 25 \times 0.01) - (-0.05) = 0.80\ mm$

3. (*d*) $T = \dfrac{rhg}{2} \times 10^3$ N/m

$\dfrac{\Delta T}{T} = \dfrac{\Delta r}{r} + \dfrac{\Delta h}{h} + 0$

$100 \times \dfrac{\Delta T}{T} = \left(\dfrac{10^{-2} \times 0.01}{1.25 \times 10^{-2}} + \dfrac{10^{-2} \times 0.01}{1.45 \times 10^{-2}} \right) 100$

$= (0.8 + 0.689)$

$= (1.489)$

$= 100 \times \dfrac{\Delta T}{T} = 1.489\%$

$\simeq 1.5\%$

4. (*b*) $\text{Density} = \dfrac{\text{Mass}}{\text{Volume}}$

$\dfrac{I\Delta d}{d} = \dfrac{1\Delta M}{M} + \dfrac{3\Delta L}{L}$

$= 1.5 + 3(a)$

$= 4.5\%$

5. (*d*) $\dfrac{F}{A} = y.\dfrac{\Delta \ell}{\ell}$; $[Y] = \dfrac{F}{A}$

Now from dimension

$F = \dfrac{ML}{T^2}$; $L = \dfrac{F}{M}.T^2$

$L^2 = \dfrac{F^2}{M^2}\left(\dfrac{V}{A}\right)^4 \quad \because T = \dfrac{V}{A}$

$L^2 = \dfrac{F^2}{M^2A^2}\dfrac{v^4}{A^2} \quad F = MA$

$L^2 = \dfrac{V^4}{A^2}$

$[Y] = \dfrac{[F]}{[A]} = F^1V^{-4}A^2$

6. (*a*) $\dfrac{128\text{kg}}{m^3} = \dfrac{125(50\text{g})(20)}{(25\text{m})^4(4)^3}$

$= \dfrac{128}{64}(20) = 40$

7. (*c*) $t = G^a h^b c^c$

$\Rightarrow M^\circ L^\circ T^1 = (M^{-1} L^3 R^{-2})^a (ML^2T^{-1})^b (LT^{-1})^c$

$\Rightarrow -a + b = \Rightarrow a = b$

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

$\Rightarrow c = -5a$

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

$\Rightarrow a = \frac{1}{2}; b = \frac{1}{2}; c = \frac{5}{2}$

8. (*b*) $\frac{L}{RCV} = \left[A^{-1}\right]$

9. (*b*) dimension of of $\sqrt{\frac{\varepsilon_0}{\mu_0}}$

$[\varepsilon_0] = [M^{-1}L^{-3}T^4A^2][\mu_0] = [MLT^{-2}A^{-2}]$

dimensions of $\sqrt{\frac{\varepsilon_0}{\mu_0}} = \left[\frac{M^{-1}L^{-3}T^4A^2}{MLT^{-2}A^{-2}}\right]^{\frac{1}{2}}$

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

10. (*c*) $X = 5YZ^2$

$Y = \frac{X}{5Z^2}$

$[Y] = \frac{[X]}{[Z^2]}$

$= \frac{A^2.M^{-1}L^{-2}.T^4}{(MA^{-1}T^{-2})^2}$

$= M^{-3}.L^{-2}.T^8.A^4$

11. (*b*) $p = k\,S^a I^b h^c$

where k is dimensionless constant

$MLT^{-1} = (MT^{-2})^a (ML^2)^b (ML^2T^{-1})^c$

$a + b + c = 1$

$2b + 2c = 1$

$-2a - c = -1$

$a = \frac{1}{2} \qquad b = \frac{1}{2} \quad c = 0$

$S^{1/2}I^{1/2}h^0$

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

$[\mu_0] = M\ L\ T^{-2}\ A^{-2}$

$[R] = M\ L^2\ T^{-3}\ A^{-2}$

$\left[R\right] = \left[\sqrt{\frac{\mu_0}{\varepsilon_0}}\right]$

13. (*c*) Zero error $= 0 + 3 \times \frac{0.5\text{mm}}{100} = 0.015$ mm

$\text{MSR} = 5.5 + 48 \times \frac{0.5}{100}$

$= 5.74$ mm.

$\therefore$ Thickness $= 5.74 - 0.015 = 5.725$ mm

14. (*c*) $v = \pi R^2 h = \frac{\pi}{4} D^2 h$

$= 4260\ \text{cm}^2$

$\because \quad \frac{\Delta v}{v} = 2\frac{\Delta D}{D} + \frac{\Delta h}{h}$

$= \left(2 \times \frac{0.1}{12.6} + \frac{0.1}{34.2}\right) v$

$= \frac{2x426}{12.6} + \frac{426}{34.2}$

$= 67.61 + 12.459 = 80.075$

$\therefore \quad v = 4260 \pm 80\ \text{cm}^3$

15. (*b*) Least count $= \frac{\text{Pitch}}{\text{No. of divisions on circular scale}}$

$\Rightarrow 5 \times 10^{-6} = \frac{10^{-3}}{N} \qquad \Rightarrow N = 200$

16. (*c*) Total Area $= A_1 + A_2 + \ldots\ldots A_7$

$= A + A + \ldots\ldots 7$ times

$= 37.03\ \text{m}^2$

Addition of 7 terms all having 2 terms beyond decimal, so final answer must have 2 terms beyond decimal (as per rules of significant digits.)

17. **(Bonus)** $\rho = \frac{m}{v}$

maximum % error is S will be given by

$\frac{\Delta\rho}{\rho} \times 100\% = \left(\frac{\Delta m}{m}\right) \times 100\% + 3\left(\frac{\Delta L}{L}\right) \times 100\%$ .....(i)

which is only possible when error is small which is not the case in this question.

Yet if we apply equation (i), we get

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

Now, we will calculate error, without using approximation.

$\rho_{min} = \frac{m_{min}}{v_{max}} = \frac{9.9}{(0.11)^3} = 7438\ \text{kg/m}^3$

& $\rho_{max} = \frac{m_{max}}{v_{min}} = \frac{10.1}{(0.09)^3} = 13854.6\ \text{kg/m}^3$

$\Delta\rho = 67416.6\ \text{kg/m}^3$

No option is matching.

Therefore this question should be awarded bonus

18. (*b*) Energy density in magnetic field $= \frac{B^2}{2\mu_0}$

$= \frac{\text{Force} \times \text{displacement}}{(\text{displacement})^3} = \frac{MLT^{-2}L}{L^3} = ML^{-1}T^{-2}$

19. (*b*) $[ML^2T^{-2}]$

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

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

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

20. (*c*) Energy = Force × Distance

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

$= \left[PA^{\frac{1}{2}}T^{-1} \right]$

21. (*a*) $\because$ $[\text{Young's modulus}] = \left[\frac{\text{Force}}{\text{Area}}\right]$

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

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

22. (*d*) Solar constant $= \frac{E}{AT}$

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

23. (*c*) $= \frac{IFv^2}{WL^4}$

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

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

= [Energy density]

24. (*b*) $\frac{dQ}{dt} = \frac{KA(\Delta T)}{x}$

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

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

25. (*c*) $C = \frac{1}{\sqrt{\mu_0 \varepsilon_0}} = X$

$C = \frac{E}{B} = Y$

$\tau = RC = t$

$\Rightarrow$ $[X] = [Y] = [Z]$

26. (*d*) (official)

(*a*) (Reso)

$\frac{\Delta T}{T} = \frac{1}{2}\left(\frac{\Delta g}{g} + \frac{\Delta L}{L}\right)$

$\frac{\Delta g}{g} = \frac{2\Delta T}{T} + \frac{\Delta L}{L}$; $= 2\left(\frac{1}{50}\right) + \frac{0.1}{25.0}$

$= 4.4\,\%$

27. (*d*) Pitch $= \frac{3}{6} = 0.5\text{mm}$

L.C. $= \frac{0.5\text{mm}}{50} = \frac{1}{500}\text{mm} = 0.01\text{mm}$

$= 0.001$ cm

28. (*b*) $\rho = \frac{M}{V} \Rightarrow \left|\frac{\Delta\rho}{\rho} \times 100\right| = \left|\frac{\Delta V}{V} \times 100\right|$

$\left|\frac{\Delta\rho}{\rho} \times 100\right| = 3\alpha\Delta T \times 100$ .....(i)

Given $\frac{\Delta\ell}{\ell} = 2 \times 10^{-4}$ $\Rightarrow \alpha\Delta T = 2 \times 10^{-4}$

$\Rightarrow$ $\alpha = 2 \times 10^{-5}$

From (i), $\frac{\Delta\rho}{\rho} \times 100 = 6 \times 10^{-5} \times 10 \times 100 = 0.06$

29. (*c*) 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 $= 31.4 - 0.7$

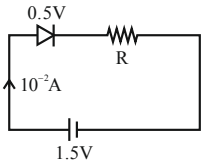
$= 30.7$ mm

$= 3.07$ cm

30. (*a*) Least count $= \frac{0.1}{50}$ cm $= 0.002$ cm

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

31. (*d*)



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

$\frac{1}{10^{-2}} = 100\Omega$

32. (*b*) $\frac{\Delta z}{z} = 2\frac{\Delta A}{A} + \frac{2}{3}\frac{\Delta b}{b} + \frac{1}{2}\frac{\Delta c}{c} + 3\frac{\Delta d}{d}$

$= 2 \times 2 + \frac{2}{3} \times 1.5 + \frac{1}{2} \times 4 + 3 \times 2.5 = 14.5\%$

33. (*b*) $d_{av} = 5.5375\,mm$

$\Delta d = 0.07395\,mm$

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

$\therefore$ $d = (5.54 \pm 0.07)\,mm$

34. [1050.00]

$$\rho = \frac{m}{\frac{4}{3}\pi\left(\frac{d}{2}\right)^3} \qquad \therefore \quad \% \frac{\Delta\rho}{\rho} = \frac{\Delta m}{m} + 3.\left(\frac{\Delta d}{d}\right)$$

$$= 6 + 3 \times 1.5 = 10.5\% = \left(\frac{1050}{100}\right)\%$$

35. (*b*) Reading $= MSR + VSD \times LC -$ zero error

$$\text{Reading} = 8.5 + \frac{(0.1)\times 6}{10} - \frac{0.2}{10} = 8.54\,cm$$

36. (*c*) $$\frac{\Delta Y}{Y} = \left(\frac{\Delta m}{m}\right) + \left(\frac{\Delta g}{g}\right) + \left(\frac{\Delta A}{A}\right) + \left(\frac{\Delta l}{l}\right) + \left(\frac{\Delta L}{L}\right)$$

$$= \left(\frac{1g}{1kg}\right) + 0 + 2\left(\frac{\Delta r}{r}\right) + \left(\frac{\Delta l}{l}\right) + \left(\frac{\Delta L}{L}\right)$$

$$= \left(\frac{1g}{1kg}\right) + 2\left(\frac{0.001cm}{0.2\,cm}\right) + \left(\frac{0.001cm}{0.5\,cm}\right) + \left(\frac{0.001m}{1m}\right)$$

$$= \left(\frac{1}{1000}\right) + 2\left(\frac{1\times 10}{2\times 10^3}\right) + \left(\frac{1}{5}\times\frac{10^2}{10^3}\right) + \left(\frac{1}{10^3}\right)$$

$$= \frac{1}{1000} + \frac{1}{100} + \frac{2}{10^3} + \frac{1}{10^3}$$

$$= \frac{1+10+2+1}{1000} = \frac{14}{1000}\times 100\%$$

$$= 1.4\%\,.$$

37. (*a*) $VSD = (n-1)\,MSD$

$$\Rightarrow VSD = \left(\frac{R-1}{R}\right) MSD$$

$$\Rightarrow \text{L.C.} = 1\,MSD - 1\,VSD$$

$$= 1\,MSD - \left(\frac{R-1}{R}\right) MSD$$

$$= 1\,MSD - 1\,MSD + \frac{MSSD}{R} = \frac{MSQD}{R} = \frac{a}{R}\,cm$$

$$= \frac{10R}{R}\,mm$$

JEE-ADVANCED PREVIOUS YEAR'S

1. (*a*) $d = \Delta\ell = \frac{0.5}{100}\,mm$

$$y = \frac{4MLg}{\pi\ell d^2}$$

$$\left(\frac{\Delta y}{y}\right)_{max} = \frac{\Delta\ell}{\ell} + 2\frac{\Delta d}{d}$$

error due to ℓ measurement $\frac{\Delta\ell}{\ell} = \frac{0.5/100\,mm}{0.25\ mm}$

error due to d measurement

$$2\frac{\Delta d}{d} = \frac{2\times\frac{0.5}{100}}{0.5\ mm} = \frac{0.5/100}{0.25}$$

So error in y due to ℓ measurement = error in y due to d measurement

2. (*c*) (p) $U = \frac{1}{2}kT \Rightarrow ML^2T^{-2} = [k]\,K \Rightarrow [K] = ML^2T^{-2}K^{-1}$

(q) $F = \eta A\frac{dv}{dx} \Rightarrow [\eta] = \frac{MLT^{-2}}{L^2LT^{-1}L^{-1}} = ML^{-1}\,T^{-1}$

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

(s) $\frac{dQ}{dt} = \frac{kA\Delta\theta}{\ell} \Rightarrow [k] = \frac{ML^2T^{-3}L}{L^2K} = MLT^{-3}\,K^{-1}$

3. (*b*) $50\,VSD = 2.45\,cm$

$1\,VSD = \frac{2.45}{50}\,cm = 0.049\,cm$

Least count of vernier = 1MSD – 1 VSD

$= 0.05\,cm - 0.049\,cm$

$= 0.001\,cm$

Thickness of the object = Main scale reading + vernier scale reading × least count

$= 5.10 + (24)\,(0.001)$

$= 5.124\,cm.$

4. (*a, b, d*) $T = 2\pi\sqrt{\frac{7}{5}\frac{(R-r)}{g}}$

$$\ln T = \ln 2\pi\sqrt{\frac{7}{5}} + \frac{1}{2}\ln(R-r) + \frac{1}{2}\ln g$$

$$\frac{\Delta g}{g} = 2\frac{\Delta T}{T} + \frac{\Delta R + \Delta r}{R-r}$$

$$\frac{\Delta g}{g}\times 100 = \left(2\times\frac{0.02}{0.556} + \frac{1+1}{60-10}\right)\times 100$$

$$= 11.2\% \simeq 11\%$$

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

$$\frac{\Delta T}{T}\times 100 = \frac{0.02}{0.556}\times 100 = 3.57\%$$

Hence, (a, b, d)

5. (*d*) $2d\sin\theta = \lambda$

$$d = \frac{\lambda}{2\sin\theta}$$

differntiate

$$\partial(d) = \frac{\lambda}{2}\ \partial(\text{cosec}\theta)$$

$$\partial(d) = \frac{\lambda}{2}(-\cos ec\theta \cot\theta)\partial\theta$$

$$\partial(d) = \frac{-\lambda\cos\theta}{2\sin^2\theta}\partial\theta$$

as θ = increases , $\frac{\lambda\cos\theta}{2\sin^2\theta}$ decreases

2nd Method

$$d = \frac{\lambda}{2\sin\theta}$$

$$\ell n\ d = \ell n\ \lambda - \ell n\, 2 - \ell n\ \sin\theta$$

$$\frac{\Delta(d)}{d} = 0 - 0 - \frac{1}{\sin\theta}\times\cos\theta(\Delta\theta)$$

Fractional error $|+(d)| = |\cot\theta\ \Delta\theta|$

Absoulute error $\Delta d = (d\cot\theta)\ \Delta\theta$

$$\frac{d}{2\sin\theta}\times\frac{\cos\theta}{\sin\theta}$$

$$\Delta d = \frac{\cos\theta}{\sin^2\theta}$$

6. [3]

$$d = k\,(\rho)^a\,(S)^b\,(f)^c$$

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

$$0 = a + b$$

$$1 = -3a \Rightarrow a = -\frac{1}{3}$$

So $b = \frac{1}{3}$

So $n = 3$

7. (*b,d*)

$$\left[k_B T\right] = \left[Fl\right]$$

$$\&\ \left[\frac{q^2}{\in}\right] = \left[Fl^2\right]$$

8. (*d*) $R_1 = 2.8 + 0.01\times 7 = 2.87$

$$R_2 = 2.8 + (8\text{MSD} - 7\text{VSD}) = 2.8 + (8\times 0.1 - 7\times\frac{11}{10})$$

$= 2.83$

Hence, (*d*)

9. (*c*) We have $\frac{E}{C} = B$

$$\therefore\ [B] = \frac{[E]}{[C]} = [E]L^{-1}T^1$$

$$\Rightarrow\ [E] = [B]\,[L]\,[T]^{-1}$$

10. (*d*) We have

$$C = \frac{1}{\sqrt{\mu_0\in_0}}$$

$$\therefore\ [C^2] = \left[\frac{1}{\mu_0\in_0}\right]$$

$$\Rightarrow\ L^2T^{-2} = \frac{1}{[\mu_0][\in_0]}$$

$$\Rightarrow\ [\mu_0] = [\mu_0] = [\in_0]^{-1}\,[L]^{-2}\,[T]^2$$

11. (*a,b,d*)

Mass = $M^0L^0T^0$

MVr = $M^0L^0T^0$

$$M^0\frac{L^1}{T^1}.\ L^1 = M^0L^0T^0$$

$L^2 = T^1$ .....(*a*)

Force = $M^1L^1T^{-2}$ (in SI)

$= M^0L^1L^{-4}$ (In new system from equation (*a*))

$= L^{-3}$

Energy = $M^1L^2T^{-2}$ (In SI)

$= M^0L^2L^{-4}$(In new system from equation (*a*))

$= L^{-2}$

$$\text{Power} = \frac{\text{Energy}}{\text{Time}}$$

$= M^1L^2T^{-3}$ (in SI)

$= M^0L^2L^{-6}$(In new system from equation (*a*))

$= L^{-4}$

Linear momentum = $M^1L^1T^{-1}$ (in SI)

$= M^0L^1L^{-2}$(In new system from equation(*a*))

$= L^{-1}$

12. (c) Given 10VSD = 9MSD

$$1\text{VSD} = \frac{9}{10}\text{MSD}$$ Least count

$$= 1\text{MSD} - 1\text{VSD} = \left(1 - \frac{9}{10}\right)\text{MSD}$$

$= 0.1\text{MSD} = 0.1\times 0.1\text{cm} = 0.01\text{cm}$

As '0' of V.S. lie before ' 0 ' of M.S.

Zero error $= -[10 - 6]$ L.C.

$= -4\times 0.01\text{cm}$

$= -0.04\text{cm}$

Reading $= 3.1\text{cm} + 1\times\text{LC} = 3.4\text{cm} + 1\times 0.01\text{cm} = 3.11\text{cm}$

True diameter = Reading - Zero error

$= 3.11 - (-0.04)\text{cm} = 3.15\text{cm}$

13. (*b, d*)

$$\vec{S} = [\vec{E}\times\vec{B}]\frac{1}{\mu_0}$$

S is pointing vector denotes flow of energy per unit area per unit time

$$\vec{S} = \frac{\text{watt}}{m^2}$$

Hence *b*, *d* are correct