

ERROR & MEASUREMENT

1. 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 :
 (1) 3.40% (2) 5.40% (3) 4.40% (4) 2.40%
2. 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 :
 (1) 0.001 mm (2) 0.001 cm
 (3) 0.02 mm (4) 0.01 cm
3. For the four sets of three measured physical quantities as given below. Which of the following options is correct ?
 (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) $A_4 + B_4 + C_4 < A_1 + B_1 + C_1 < A_3 + B_3 + C_3 < A_2 + B_2 + C_2$
 (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) $A_4 + B_4 + C_4 < A_1 + B_1 + C_1 = A_2 + B_2 + C_2 = A_3 + B_3 + C_3$
4. 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)
 (1) 3.21 cm (2) 2.99 cm
 (3) 3.2 cm (4) 3.07 cm

5. 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 :
 (1) 2.123 cm (2) 2.125 cm
 (3) 2.121 cm (4) 2.124 cm
6. A physical quantity z depends on four observables a, b, c and d , as $z = \frac{a^2 b^3}{\sqrt{c} d^3}$. The percentage of error in the measurement of a, b, c and d 2%, 1.5%, 4% and 2.5% respectively. The percentage of error in z is:
 (1) 12.25% (2) 14.5%
 (3) 16.5% (4) 13.5%
7. 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 :
 (1) Negative, 2 μm (2) Positive, 10 μm
 (3) Positive, 0.1 μm (4) Positive, 0.1 mm
8. 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 .
9. 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:
 (1) (5.5375 ± 0.0739) mm
 (2) (5.538 ± 0.074) mm
 (3) (5.54 ± 0.07) mm
 (4) (5.5375 ± 0.0740) mm

SOLUTION

1. NTA Ans. (3)

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

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

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

$$= \frac{0.1}{25} + \frac{2 \times 1}{50}$$

$$\frac{\Delta g}{g} = 4.4\%$$

2. NTA Ans. (2)

Sol. Given on six rotation, reading of main scale changes by 3mm.

$$\therefore 1 \text{ rotation corresponds to } \frac{1}{2} \text{ mm}$$

Also no. of division on circular scale = 50.

\therefore Least count of the screw gauge will be

$$\frac{0.5}{50} \text{ mm} = 0.001 \text{ cm.}$$

3. NTA Ans. (BONUS)

$$\text{Sol. } A_1 + B_1 + C_1 = 24.36 + 0.0724 + 256.2$$

$$= 280.6324$$

$$= 280.6 \text{ (After rounding off)}$$

$$A_2 + B_2 + C_2 = 24.44 + 16.082 + 240.2$$

$$= 280.722$$

$$= 280.7 \text{ (After rounding off)}$$

$$A_3 + B_3 + C_3 = 25.2 + 19.2812 + 236.183$$

$$= 280.6642$$

$$= 280.7 \text{ (After rounding off)}$$

$$A_4 + B_4 + C_4 = 25 + 236.191 + 19.5$$

$$= 280.691$$

$$= 281 \text{ (After rounding off)}$$

$$A_4 + B_4 + C_4 > A_3 + B_3 + C_3 = A_2 + B_2 + C_2 >$$

$$A_1 + B_1 + C_1$$

No option is matching Question should be (BONUS)

Best possible option is (2)

\therefore Correct answer (2)

4. Official Ans. by NTA (4)

Sol. Least count = 1 mm or 0.01 cm

$$\text{Zero error} = 0 + 0.01 \times 7 = 0.07 \text{ cm}$$

$$\text{Reading} = 3.1 + (0.01 \times 4) - 0.07$$

$$= 3.1 + 0.04 - 0.07$$

$$= 3.1 - 0.03$$

$$= 3.07 \text{ cm}$$

5. Official Ans. by NTA (4)

$$\text{Sol. } LC = \frac{\text{pitch}}{\text{CSD}} = \frac{0.1 \text{ cm}}{50} = 0.002 \text{ cm}$$

So any measurement will be integral

Multiple of LC.

So ans. will be 2.124 cm

6. Official Ans. by NTA (2)

$$\text{Sol. } \frac{\Delta Z}{Z} = \frac{2\Delta a}{a} + \frac{2}{3} \frac{\Delta b}{b} + \frac{1}{2} \frac{\Delta c}{c} + \frac{3\Delta d}{d} = 14.5\%$$

7. Official Ans. by NTA (2)

Sol. Least count of screw gauge

$$= \frac{\text{Pitch}}{\text{no. of division on circular scale}}$$

$$= \frac{0.5}{50} \text{ mm} = 1 \times 10^{-5} \text{ m}$$

$$= 10 \text{ } \mu\text{m}$$

Zero error in positive

Ans. (2)

8. Official Ans. by NTA (1050.00)

Sol.
$$\rho = \frac{M}{V} = \frac{M}{\frac{4}{3}\pi\left(\frac{D}{2}\right)^3}$$

$$\rho = \frac{6}{\pi} M D^{-3}$$

taking log

$$\ell n \rho = \ell n \left(\frac{6}{\pi} \right) + \ell n M - 3 \ell n D$$

Differentiates

$$\frac{d\rho}{\rho} = 0 + \frac{dM}{M} - 3 \frac{d(D)}{D}$$

for maximum error

$$100 \times \frac{d\rho}{\rho} = \frac{dM}{M} \times 100 + \frac{3dD}{D} \times 100$$

$$= 6 + 3 \times 1.5$$

$$= 10.5 \%$$

$$= \frac{1050}{100} \% \text{ so } x = 1050.00$$

9. Official Ans. by NTA (3)

Sol. Use significant figures. Answer must be upto three significant figures.

Ans. (3)