AVIRAL CLASSES
IIT-JEE | NEET | FOUNDATIONS

PHYSICS
CRASH COURSE

LECTURE - 03

TOPICS : Error Analysis

1. The density of a cube is measured by measuring its mass and the length of its side. If the maximum errors in the measurements of mass and length are 3% and 2% respectively, then the maximum error in the measurement of density is

(a) 7% (b) 5%

(c) 9% (d) 3%

2. A physical quantity Q is found to depend on observables x, y and z, obeying relation $Q = \frac{x^3y^2}{z}$.

The percentage error in the measurements of x, y and z are 1%, 2% and 4% respectively. What is percentage error in the quantity Q ?

(a) 11% (b) 4%

(c) 1% (d) 3%

3. The side of a cubical block when measured with a vernier callipers is 2.50 cm. The vernier constant is 0.01 cm. The maximum possile error in the area of the side of hte block is

(a) ± 0.01 cm^2 (b) ± 0.02 cm^2

(c) ± 0.05 cm^2 (d) ± 0.10 cm^2

4. A physical quantity is given by $X = M^aL^bT^c$. The percentage error in measurement of M, L and T are α, β and γ respectively. Then, the maximum % error in the quantity X is

(a) $a\alpha + b\beta + c\gamma$ (b) $a\alpha + b\beta - c\gamma$

(c) $\frac{a}{\alpha} + \frac{b}{\beta} + \frac{c}{\gamma}$ (d) None of these

5. A certain body weighs 22.42 g and has a measured volume of 4.7cc. The possible error in the measurement of mass and volume are 0.01 g and 0.01 cc. Then maximum error in the density will be

(a) 22% (b) 2%

(c) 0.2% (d) 0.02%

6. Which of the following is the most precise device for measuring length ?

(a) A vernier callipers with 20 divisions on the vernier scale coinciding with 19 main scale divisions

(b) A screw gauge of pitch 1 mm and 100 divisions on hte circular scale

(c) A spherometer of pitch 0.1 mm and 100 divisions on the circular scale

(d) An optical instrument that can measure length to within a wavelength of light

7. Percentage errors in the measurement of mass and speed are 2% and 3% respectively. The error in the estimation of kinetic energy obtained by measuring mass and speed will be

(a) 8% (b) 2%

(c) 12% (d) 10%

8. The least count of the metre rod is 0.1 cm. What is the permissible error in the length of the rod measured with it ?

(a) ± 0.2 cm (b) ± 0.1 cm

(c) ± 0.05 cm (d) ± 0.01 cm

9. In a side callipers, (m + 1) number of vernier divisions is equal to m number of smallest main scale divisions. If d unit is the magnitude of the smallest main scale divisions, then the magnitude of the vernier constant is

(a) $\frac{d}{(m+1)}$ unit (b) $\frac{d}{m}$ unit

(c) $\frac{md}{(m+1)}$ unit (d) $\frac{(m+1)d}{m}$ unit

10. The temperatures of two bodies measured by a thermometer are t_1 = 20°C ± 0.5°C and t_2 = 50°C ± 0.5 C. The temperature difference and the error therein is

(a) 30 °C ± 1 °C

(b) 70 °C ± 0.5 °C

(c) 30 °C ± 0.5 °C

(d) 70 °C ± 1 °C

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TOPICS : Error Analysis (SOLUTION)

1. **(c) :** $\because \quad \rho = \frac{M}{L^3}$,

$\therefore \quad \frac{\Delta\rho}{\rho} = \frac{\Delta M}{M} + 3\frac{\Delta L}{L} = 3\% + 3(2\%) = 9\%$.

2. 8. **(a) :** $Q = \frac{x^3 y^2}{z}$

The percentage error in the quantity Q is

$$\frac{\Delta Q}{Q}\times 100 = \left(3\frac{\Delta x}{x} + 2\frac{\Delta y}{y} + \frac{\Delta z}{z}\right)\times 100$$

$$= 3\left(\frac{\Delta x}{x}\times 100\right) + 2\left(\frac{\Delta y}{y}\times 100\right) + \frac{\Delta z}{z}\times 100$$

$= 3 \times 1\% + 2 \times 2\% + 4\% = 11\%$

3. **(c) :** Here $l = 2.50$ cm and $\Delta l = 0.01$ cm

Since $A = l^2 = (2.50 \text{ cm})^2$

$\therefore \quad \frac{\Delta A}{A} = 2\cdot\frac{\Delta l}{l}; \quad \frac{\Delta A}{A} = 2\times\frac{0.01 \text{ cm}}{2.50 \text{ cm}}$

$\therefore \quad \Delta A = \frac{2\times 0.01 \text{ cm}}{2.50 \text{ cm}}\times(2.50 \text{ cm})^2$

$= 2 \times 0.01 \times 2.50 \text{ cm}^2 = 0.01 \times 5 \text{ cm}^2$

or $\quad \Delta A = \pm 0.05 \text{ cm}^2$

4. **(a) :** $X = M^a L^b T^c$

Percentage error in X

$\frac{\Delta X}{X}\times 100 = a\frac{\Delta M}{M}\times 100 + b\frac{\Delta L}{L}\times 100 + c\frac{\Delta T}{T}\times 100$ As given,

$\frac{\Delta M}{M}\times 100 = \alpha, \quad \frac{\Delta L}{L}\times 100 = \beta, \quad \frac{\Delta T}{T}\times 100 = \gamma$

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

5. **(b) :** Density $\rho = \frac{\text{mass } m}{\text{volume } V}$ ...(i)

Take logarithm on the both sides of eqn. (i), we get

$\ln\rho = \ln m - \ln V$ ...(ii)

Differentiate eqn. (ii), on both sides, we get

$$\frac{\Delta\rho}{\rho} = \frac{\Delta m}{m} - \frac{\Delta V}{V}$$

Errors are always added for maximum error.

$\therefore$ Maximum error in the density ρ will be

$$= \left[\frac{\Delta m}{m} + \frac{\Delta V}{V}\right]\times 100\% = \left[\frac{0.01}{22.42} + \frac{0.1}{4.7}\right]\times 100\% = 2\%$$

6. **(d) :** The most precise device is one whose least count is the least.

(a) Least count of vernier callipers

$= 1 \text{ MSD} - 1 \text{ VSD} = 1 \text{ MSD} - \frac{19}{20} \text{ MSD}$

$= \frac{1}{20} \text{ MSD} = \frac{1}{20} \text{ mm} = \frac{1}{200} \text{ cm} = 0.005 \text{ cm}$

($\because$ 1 MSD = 1 mm)

(b) Least count of screw gauge

$$= \frac{\text{Pitch}}{\text{No.of divisions on circular scale}}$$

7. **(a) :** As $K = \frac{1}{2}mv^2$

$\therefore \quad \frac{\Delta K}{K}\times 100 = \frac{\Delta m}{m}\times 100 + \frac{2\Delta v}{v}\times 100 = 2\% + 2 \times 3\% = 8\%$

8. **(b) :** Permissible error = ± least count = ± 0.1 cm

9.

32. **(a)** : $(m + 1)$ V.S.D. = m M.S.D.

$$1 \text{ V.S.D.} = \frac{m}{m+1} \text{ M.S.D.}$$

Vernier constant = 1 M.S.D. – 1 V.S.D.

$$= 1 \text{ M.S.D.} - \left(\frac{m}{m+1}\right) \text{M.S.D.}$$

$$= \frac{1}{(m+1)} \text{ M.S.D.} = \frac{d}{m+1} \text{ unit}$$

10.

(a) : Here, $t_1 = 20\ °C \pm 0.5\ °C$

$t_2 = 50\ °C \pm 0.5\ °C$

The temperature difference of two bodies is

$t = t_2 - t_1 = 50\ °C - 20\ °C = 30\ °C$

The error in temperature difference is given by

$\Delta t = (\Delta t_1 + \Delta t_2)$

$= (0.5\ °C + 0.5\ °C) = 1\ °C$

$\therefore$ The temperature difference is $30\ °C \pm 1\ °C$.