MEASUREMENT TECHNIQUES AND UNCERTAINTIES

TUTORIAL ANSWERS

1.) The readings taken for the 2 ends of the metal rod are

L_1 =5.45 ± 0.01 cm

L_2 =8.13 ± 0.01 cm

Hence by subtraction, the length of the rod and the associated error in the measurement is

L = (8.13 ± 0.01)- (5.45 ± 0.01)

L = (8.13 – 5.45) ± 0.02 = **2.68 ± 0.02 cm**

2.) Zero reading = 0.06 mm

Diameter reading = 1.50 + 0.48 = 1.98 mm

Diameter of the ball = 1.98 – 0.06 = **1.92 mm**

3.) Diameter of 1 steel ball = ¼ (Y – X)

= ¼ (4.0 ± 0.4) = **1.0 ± 0.1 cm**

4.) At low fuel levels in the tank, the gauge is more sensitive if a small change in volume V causes a large change in angular deflection θ.

i.e. sensitivity α $\frac{d\theta}{dV}$ or sensitivity α $\frac{1}{(dV/d\theta)}$

In other word, V versus θ should have a small slope / gradient for high sensitivity. **Answer is D.**

5.) $P = I^2R$

$(\frac{\Delta P}{P} \times 100\%) = (\frac{2\Delta I}{I} \times 100\%) + (\frac{\Delta R}{R} \times 100\%)$

= 4% + 2% = **6%**

6.) Systematic errors = P_1 , Q_1 , R_2

Random errors = P_2 , Q_2 , R_1

7.) Since volume V = L^3, thus

$$\left(\frac{\Delta V}{V}\ x\ 100\%\right) = \left(\frac{3\Delta L}{L}\ x\ 100\%\right) = \left(\frac{3(0.1)}{30}\ x\ 100\%\right) = \mathbf{1\%}$$

8.) A small spread of the measurements in an experiment is said to be precise.

On the other hand, the set of results is not accurate if the measured mean value deviates too far from the true value.

Acceleration of free-fall, g = 9.81 ms^{-2}

Student	Max. deviation (max. value – min value)	Mean of the set of value
A	9.84 – 9.79 = 0.05	9.82
B	10.12 – 8.94 = 1.18	9.69
C	9.45 – 8.76 = 0.69	9.10
D	8.50 – 8.41 = 0.09	8.46

Hence, set of values measured by **student D** can say to be precise but not accurate.

9.) A small spread of the measurements in an experiment is said to be precise.

On the other hand, the set of results is not accurate if the measured mean value deviates too far from the true value. So graph **B** is the answer.

10.) density = $\frac{mass}{volume} = \frac{mass}{(length\ x\ breadth\ x\ height)}$

$$\frac{\Delta D}{D} = \left(\frac{0.1}{25.0} + \frac{0.01}{5.00} + \frac{0.01}{2.00} + \frac{0.01}{1.00}\right) = 0.021$$

$\Delta D = 0.021 \times D = 0.021 \times 2.50$

$= \pm 0.0525$ (round off to 1 sig. figure)

$= \mathbf{\pm 0.05\ g\ cm^{-3}}$

11.) **same as question 3.**

12.) Mean measurement = $\frac{(1.02 \text{ x } 4) + 1.01}{5}$ = 1.018 mm

Value of d = 1.018 – (-0.02) = 1.038 mm

Value of d with precision appropriate to micrometer screw gauge = **1.04 mm**

13.) Period = 1/frequency = 1/50 = 20 ms

1 complete cycle of the trace should occupy 2 divisions since the time-base is 10 ms per division.

The amplitude of the trace should occupy 1 division since the peak value is 5.0 V and the Y-gain is 5V per division.

So answer is **D.**

14.) $(\frac{\Delta g}{g} \; x \; 100\%) = (\frac{\Delta L}{L} \; x \; 100\%) = (\frac{2\Delta T}{T} \; x \; 100\%)$

= **6%**