Error Calculation

Q: 1) ~~The diameter of a wire~~

Ans Let,

$D_1 = 0.022$ cm

$D_2 = 0.023$ cm

$D_3 = 0.026$ cm

$D_4 = 0.025$ cm

$D_5 = 0.024$ cm

$D_6 = 0.025$ cm

$$\therefore D_m = \frac{D_1 + D_2 + \dots + D_6}{6}$$

$$\neq \frac{0.022 + 0.023 + 0.026 + 0.025 + 0.024 + 0.025}{6}$$

$$= \frac{0.145}{6} = 0.02416$$

$$\approx 0.024 \text{ cm}$$

$\therefore \Delta D_1 = D_m - D_1 = 0.024 - 0.022 = 0.002$ cm

$\Delta D_2 = D_m - D_2 = 0.024 - 0.023 = 0.001$ cm

$\Delta D_3 = D_m - D_3 = 0.024 - 0.026 = -0.002$ cm

$\Delta D_4 = D_m - D_4 = 0.024 - 0.025 = -0.001$ cm

$\Delta D_5 = D_m - D_5 = 0.024 - 0.024 = 0$ cm

$\Delta D_6 = D_m - D_6 = 0.024 - 0.025 = -0.001$ cm

$$\therefore \quad \Delta\overline{D} = \frac{|\Delta D_1| + |\Delta D_2| \ldots + |\Delta D_6|}{6}$$

$$= \frac{0.007}{6}$$

$$= \approx 0.001 \text{ cm}$$

$$\therefore \text{ percentage error} = \frac{\Delta\overline{D}}{D_m} \times 100\%$$

$$= \frac{0.001}{0.024} \times 100\%$$

$$= \frac{1}{24} \times 100\%$$

$$= \frac{25}{6}\% = 4.16\%$$

$$= 4.2\%$$

a) 2) Ans

Let,

$\mu_1 = 1.655$

$\mu_2 = 1.667$

$\mu_3 = 1.666$

$\mu_4 = 1.659$

$\mu_5 = 1.669$

$\mu_6 = 1.654$

$$\therefore \mu_m = \frac{\mu_1 + \mu_2 + \dots + \mu_6}{6}$$

$$= \frac{9.970}{6}$$

$$\approx 1.661$$

$\Delta \mu_1 = \mu_m - \mu_1 = 1.661 - 1.655 = 0.006$

$\Delta \mu_2 = \mu_m - \mu_2 = 1.661 - 1.667 = -0.006$

$\Delta \mu_3 = \mu_m - \mu_3 = 1.661 - 1.666 = -0.005$

$\Delta \mu_4 = \mu_m - \mu_4 = 1.661 - 1.659 = 0.002$

$\Delta \mu_5 = \mu_m - \mu_5 = 1.661 - 1.669 = -0.008$

$$\Delta \mu_6 = \mu_m - \mu_6 = 1.661 - 1.654 = 0.007$$

$\therefore$ Mean absolute error, $\Delta \bar{\mu} = \dfrac{|\Delta \mu_1| + |\Delta \mu_2| + \ldots |\Delta \mu_6|}{6}$

$$= \frac{0.034}{6}$$

$$= 0.00566$$

$$\approx 0.006$$

$\therefore$ Relative error, $RE = \dfrac{\Delta \bar{\mu}}{\mu_m}$

$$= \frac{0.006}{1.661}$$

$$= \frac{6}{1661}$$

$$= 0.0036$$

$$\approx 0.004$$

$\therefore$ percentage error, $PE = \dfrac{\Delta \bar{\mu}}{\mu_m} \times 100\%$

$$= 0.004 \times 100\%$$

$$= 0.4\%$$

2) 3) Ans

Let,

$T_1 = 1.73\ s$

$T_2 = 1.62\ s$

$T_3 = 1.52\ s$

$T_4 = 1.45\ s$

$T_5 = 1.83\ s$.

$\therefore T_m = \dfrac{T_1 + T_2 + T_3 + T_4 + T_5}{5}$

$= \dfrac{1.73 + 1.62 + 1.52 + 1.45 + 1.83}{5}$

$= \dfrac{8.15}{5}$

$= 1.63\ s$

$\therefore \Delta T_1 = 1.63 - 1.73 = -0.10$

$\Delta T_2 = 1.63 - 1.62 = 0.01$

$\Delta T_3 = 1.63 - 1.52 = 0.11$

$\Delta T_4 = 1.63 - 1.45 = 0.18$

$\Delta T_5 = 1.63 - 1.83 = -0.20$

∴ Mean absolute error,

$$\Delta\bar{T} = \frac{|\Delta T_1| + |\Delta T_2| + \ldots |\Delta T_5|}{5}$$

$$= \frac{0.60}{5}$$

$$= 0.12 \text{ s}.$$

∴ Retative error, RE =

$$\frac{\Delta\bar{T}}{T_m}$$

$$= \frac{0.12 \cancel{s}}{1.63 \cancel{s}} = \frac{12}{163} = 0.073$$

$$\approx 0.07$$

Q.) 4) dm

Let,

$P_1 = 1.03$ g/cc

$P_2 = 1.12$ g/cc

$P_3 = 0.92$ g/cc

$P_4 = 1.05$ g/cc

$P_5 = 1.13$ g/cc

$\therefore$ Mean value, $\rho_m = \dfrac{\rho_1 + \rho_2 + \cdots \rho_5}{5}$

$= \dfrac{1.03 + 1.12 + 0.92 + 1.05 + 1.13}{5}$

$= \dfrac{5.25}{5}$

$= 1.05 \text{ g/cc}$

$\therefore \Delta\rho_1 = 1.05 - 1.03 = 0.02 \text{ g/cc}$

$\Delta\rho_2 = 1.05 - 1.12 = -0.07 \text{ g/cc}$

$\Delta\rho_3 = 1.05 - 0.92 = 0.13 \text{ g/cc}$

$\Delta\rho_4 = 1.05 - 1.05 = 0 \text{ g/cc}$

$\Delta\rho_5 = 1.05 - 1.13 = -0.08 \text{ g/cc}$

$\therefore$ Mean absolute error, $\Delta\bar{\rho} = \dfrac{|\Delta\rho_1| + \cdots + |\Delta\rho_5|}{5}$

$= \dfrac{0.02 + 0.07 + 0.13 + 0.08}{5}$

$= \dfrac{0.30}{5}$

$= 0.06 \text{ g/cc}$

∴ Relative error, $RE = \frac{\Delta P_t}{P_m}$

$= \frac{0.06}{1.05}$

$= \frac{6}{105} = 0.057$

$= 0.06$

a) 5) ~~Ans~~

Let,

$R_1 = 10.3\ \Omega$

$R_2 = 10.7\ \Omega$

$R_3 = 9.8\ \Omega$

$R_4 = 10.4\ \Omega$

$R_5 = 9.6\ \Omega$

∴ Mean value, $R_m = \frac{R_1 + R_2 + \cdots R_5}{5}$

$= \frac{10.3 + 10.7 + 9.8 + 10.4 + 9.}{5}$

$= \frac{50.8}{5}$

$= 10.16 \approx 10.2\ \Omega$

$\therefore \quad \Delta R_1 = 10.2 - 10.3 = -0.1\ \Omega$

$\Delta R_2 = 10.2 - 10.7 = -0.5\ \Omega$

$\Delta R_3 = 10.2 - 9.8 = 0.4\ \Omega$

$\Delta R_4 = 10.2 - 10.4 = -0.2\ \Omega$

$\Delta R_5 = 10.2 - 9.6 = 0.6\ \Omega$

$\therefore$ mean absolute error, $\overline{\Delta R}$

$$= \frac{|\Delta R_1| + \ldots + |\Delta R_5|}{5}$$

$$= \frac{1.8}{5} = 0.3 \times 6$$

$$\approx 0.4\ \Omega$$

$\therefore$ Fractional error

$$= \frac{\overline{\Delta R}}{R_m}$$

$$= \frac{0.4}{10.2} = \frac{4}{102} = \frac{2}{51} = 0.039$$

$$\approx 0.04$$

$\therefore$ percentage error, PE

$$= \frac{\overline{\Delta R}}{R_m} \times 100\% = 0.04 \times 100\%$$

$$= 4\%$$

Q) 6) Ans

Let,

$D_1 = 1.328$ mm

$D_2 = 1.330$ mm

$D_3 = 1.325$ mm

$D_4 = 1.334$ mm

$D_5 = 1.336$ mm

$\therefore$ Mean value, $D_m = \dfrac{D_1 + \cdots + D_5}{5}$

$= \dfrac{1.328 + 1.330 + 1.325 + 1.334 + 1.336}{5}$

$= \dfrac{6.653}{5} = 1.3306$

≈ 1.331 mm.

$\therefore \Delta D_1 = 1.331 - 1.328 = 0.003$ mm

$\Delta D_2 = 1.331 - 1.330 = 0.001$ mm

$\Delta D_3 = 1.331 - 1.325 = 0.006$ mm

$\Delta D_4 = 1.331 - 1.334 = -0.003$ mm

$\Delta D_5 = 1.331 - 1.336 = -0.005$ mm

∴ Mean absolute error, $\overline{\Delta D}$

$$= \frac{|\Delta D_1| + |\Delta D_2| + \ldots + |\Delta D_5|}{5}$$

$$= \frac{0.018}{5} = 0.0036$$

$$\approx 0.004 \text{ mm}$$

∴ Fractional error, RE

$$= \frac{\overline{\Delta D}}{D_m} = \frac{0.004}{1.331} = \frac{4}{1331} = 0.003$$

∴ percentage error, PE

$$= \frac{\overline{\Delta D}}{D_m} \times 100\% = 0.003 \times 100\% = 0.3\%.$$

Q) 7) Ans

Let,

$D_1 = 0.39$ mm

$D_2 = 0.38$ mm

$D_3 = 0.37$ mm

$D_4 = 0.41$ mm

$D_5 = 0.38$ mm

$D_6 = 0.38$ mm

$D_7 = 0.37$ mm

$D_8 = 0.40$ mm

$D_9 = 0.39$ mm

$\therefore$ Mean value, D_m

$$= \frac{D_1 + D_2 + \ldots + D_9}{9}$$

$$= \frac{0.39 + 0.38 + 0.37 + 0.41 + 0.38 + 0.38 + 0.37 + 0.40 + 0.39}{9}$$

$$= \frac{3.47}{9} = 0.385$$

$$\approx 0.38 \text{ mm}$$

$\therefore \Delta D_1 = 0.38 - 0.39 = -0.01$

$\therefore \Delta D_2 = 0.38 - 0.38 = 0$

$\Delta D_3 = 0.38 - 0.37 = 0.01$

$\Delta D_4 = 0.38 - 0.41 = -0.03$

$\Delta D_5 = 0.38 - 0.38 = 0$

$\Delta D_6 = 0.38 - 0.38 = 0$

$\Delta D_7 = 0.38 - 0.37 = 0.01$

$\Delta D_8 = 0.38 - 0.40 = -0.02$

$\Delta D_9 = 0.38 - 0.39 = -0.01$

∴ Mean absolute error,

$$\overline{\Delta D} = \frac{|\Delta D_1| + \ldots + |\Delta D_9|}{9}$$

$$= \frac{0.01 + 0.01 + 0.03 + 0.01 + 0.01 + 0.02}{9}$$

$$= \frac{0.09}{9}$$

$$= 0.01 \text{ mm}$$

∴ $D = (D_m \pm \overline{\Delta D})$

$= (0.38 \pm 0.01)$ mm

∴ Relative error, RE =

$$\frac{\overline{\Delta D}}{D_m} = \frac{0.01}{0.38} = \frac{1}{38} = 0.03$$

∴ Percentage error, PE

$$= \frac{\overline{\Delta D}}{D_m} \times 100\% = 0.03 \times 100\% = 3\%.$$

Q) 8) dm

Let,

$\mu_1 = 1.29$

$\mu_2 = 1.33$

$\mu_3 = 1.34$

$\mu_4 = 1.35$

$\mu_5 = 1.32$

$\mu_6 = 1.36$

$\mu_7 = 1.30$

$\mu_8 = 1.33$

∴ Mean value, μ_m

$$= \frac{\mu_1 + \dots + \mu_8}{8}$$

$$= \frac{1.29 + 1.33 + 1.34 + 1.35 + 1.32 + 1.36 + 1.30 + 1.33}{8}$$

$$= \frac{10.62}{8} = 1.327$$

$$\approx 1.33$$

$\therefore \Delta \mu_1 = 1.33 - 1.29 = 0.04$

$\Delta \mu_2 = 1.33 - 1.33 = 0$

$\Delta \mu_3 = 1.33 - 1.34 = -0.01$

$\Delta \mu_4 = 1.33 - 1.35 = -0.02$

$\Delta \mu_5 = 1.33 - 1.32 = 0.01$

$\Delta \mu_6 = 1.33 - 1.36 = -0.03$

$\Delta \mu_7 = 1.33 - 1.30 = 0.03$

$\Delta \mu_8 = 1.33 - 1.33 = 0$

$\therefore$ Mean absolute error, $\overline{\Delta \mu}$

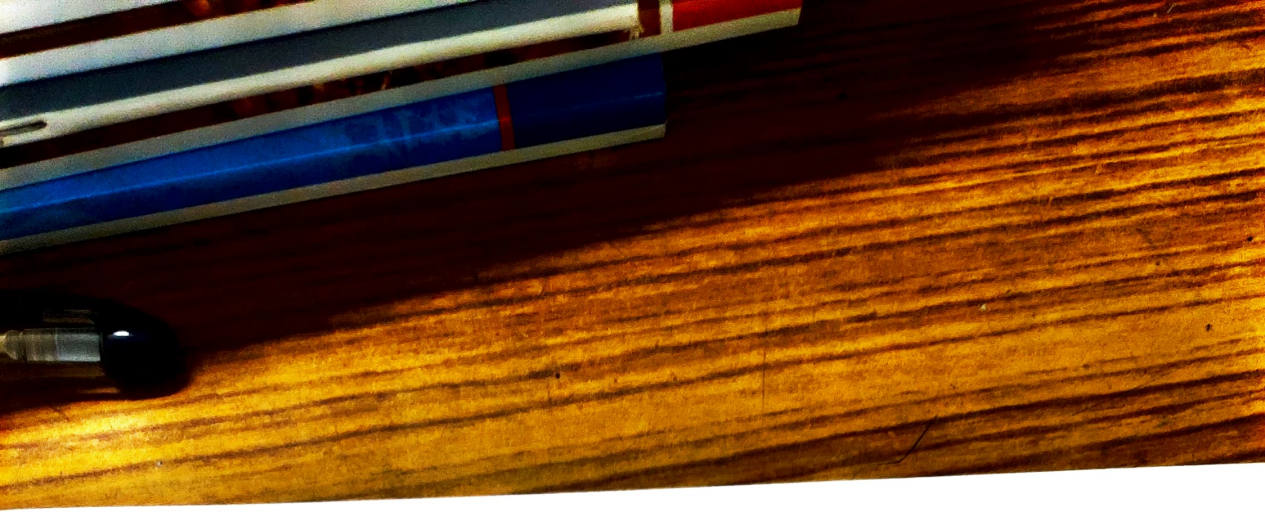
$$= \frac{|\Delta \mu_1| + |\Delta \mu_2| + \dots + |\Delta \mu_8|}{8}$$

$$= \frac{0.04 + 0.01 + 0.02 + 0.01 + 0.03 + 0.03}{8}$$

$$= \frac{0.14}{8} = 0.017 \approx 0.02$$

$\therefore$ Relative error, RE

$$= \frac{\overline{\Delta \mu}}{}$$



∴ percentage error, PE

$$= \frac{\Delta \bar{\mu}}{\mu_m} \times 100\% = 0.02 \times 100\%.$$

$$= 2\%$$