Sn 1)

Let.

$d_1 = 0.022 cm$

$d_2 = 0.023 cm$

$d_3 = 0.026 cm$

$d_4 = 0.025 cm$

$d_5 = 0.024 cm$

$d_6 = 0.025 cm$

i) Mean value, $d_m = \frac{d_1 + d_2 \ldots . d_6}{6}$

$= \frac{0.145}{6}$

$= 0.024 cm$

ii) Absolute error

$\Delta d_1 = d_m - d_1 = 0.024 - 0.022 = 0.002 cm$

$\Delta d_2 = d_m - d_2 = 0.024 - 0.023 = 0.001 cm$

$\Delta d_3 = d_m - d_3 = 0.024 - 0.026 = -0.002 cm$

$\Delta d_4 = d_m - d_4 = 0.024 - 0.025 = -0.001 cm$

$\Delta d_5 = d_m - d_5 = 0.024 - 0.024 = 0 cm$

$\Delta d_6 = d_m - d_6 = 0.024 - 0.025 = -0.001 cm$

Now,

Mean absolute error, $\overline{\Delta d} = \frac{|\Delta d_1| + |\Delta d_2| \ldots . |\Delta d_6|}{6}$

$$\overline{\Delta d} = \frac{0.002 + 0.001 + 0.002 + 0.001 + 0 + 0.001}{6}$$

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

$$= 0.0011$$

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

**Result**

$$d = (d_m \pm \overline{\Delta d}) \text{ cm}$$

$$d = (0.0024 \pm 0.001) \text{ cm}$$

iii) Percentage error $= \frac{\overline{\Delta d}}{d_m} \times 100\%$

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

$$= 0.041 \times 100\%$$

$$= 4.1\%$$

Qn.2) Soln:

Let,

$\mu_1 = 1.655$

$\mu_2 = 1.667$

$\mu_3 = 1.666$

$\mu_4 = 1.659$

$\mu_5 = 1.669$

$\mu_6 = 1.654$

i) Mean value of $\mu$, $\mu_m = \frac{\mu_1 + \mu_2 \ldots \ldots \mu_6}{6}$

$= \frac{9.97}{6}$

$= 1.6616$

$= 1.662$

Now,

$\Delta \mu_1 = \mu_m - \mu_1 = 1.662 - 1.6655 = 0.007$

$\Delta \mu_2 = \mu_m - \mu_2 = 1.662 - 1.667 = -0.005$

$\Delta \mu_3 = \mu_m - \mu_3 = 1.662 - 1.666 = -0.004$

$\Delta \mu_4 = \mu_m - \mu_4 = 1.662 - 1.659 = 0.003$

$\Delta \mu_5 = \mu_m - \mu_5 = 1.662 - 1.669 = -0.007$

$\Delta \mu_6 = \mu_m - \mu_6 = 1.662 - 1.654 = 0.008$

ii) Mean absolute error,

$$\overline{\Delta \mu} = \frac{|\Delta \mu_1| + |\Delta \mu_2| \ldots \ldots |\Delta \mu_6|}{6}$$

$$= \frac{0.007 + 0.005 + 0.004 + 0.003 + 0.007 + 0.008}{6}$$

$= \frac{0.034}{6}$

$= \cancel{0.034}\ 0.0056$

$\approx \cancel{0.006}\ 0.006$

Result

$\mu = (\mu_m \pm \overline{\Delta \mu})$

$\mu = (1.662 \pm 0.006)$

iii) Relative error = $\frac{\Delta \mu}{\mu m}$

$= \frac{0.006}{1.662}$

$= 0.0036$

$\approx 0.004$

iv) Percentage error = $\frac{\Delta \mu}{\mu m} \times 100\%$

$= \frac{0.006}{1.662} \times 100\%$

$= 0.004 \times 100\%$

$= 0.4\%$.

Qn. 3) Soln:

Let,

$T_1 = \cancel{1.62}\ s$ 1.73 s

$T_2 = 1.62$ s

$T_3 = 1.52$ s

$T_4 = 1.45$ s

$T_5 = 1.83$ s

Mean value of Time Period, $T_m$

$= \frac{T_1 + T_2 \ldots T_5}{5}$

$T_{m1} =$

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

$$= \frac{8.15}{5}$$

$$= 1.63 \text{ s}$$

Absolute error

$\Delta T_1 = T_m - T_1 = 1.63 - 1.73 = -0.10$ s

$\Delta T_2 = T_m - T_2 = 1.63 - 1.62 = 0.01$ s

$\Delta T_3 = T_m - T_3 = 1.63 - 1.52 = 0.11$ s

$\Delta T_4 = T_m - T_4 = 1.63 - 1.45 = 0.18$ s

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

Mean absolute error, $\overline{\Delta T} = \frac{|\Delta T_1| + |\Delta T_2| \ldots + |\Delta T_5|}{5}$

$$= \frac{0.10 + 0.01 + 0.11 + 0.18 + 0.20}{5}$$

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

$$= 0.12 \text{ s}$$

~~Percenta Relat~~

Result $= (T_m \pm \overline{\Delta T})$ s

$= (1.63 \pm 0.12)$ s

Relative error $= \frac{\overline{\Delta T}}{T_m}$

$$= \frac{0.12}{1.63}$$

$= 0.0736 \approx 0.07$

Qn. 4) Soln.

Let, $\rho_1 = 1.03$ g/cc

$\rho_2 = 1.12$ g/cc

$\rho_3 = 0.92$ g/cc

$\rho_4 = 1.05$ g/cc

$\rho_5 = 1.13$ g/cc

Mean ~~value~~ density, $\rho_m = \frac{\rho_1 + \rho_2 \ldots \rho_5}{5}$

$= \frac{5.25}{5}$

$= 1.05$ g/cc

Absolute error

$\Delta \rho_1 = \rho_m - \rho_1 = 1.05 - 1.03 = 0.02$ g/cc

$\Delta \rho_2 = \rho_m - \rho_2 = 1.05 - 1.12 = -0.07$ g/cc

$\Delta \rho_3 = \rho_m - \rho_3 = 1.05 - 0.92 = 0.13$ g/cc

$\Delta \rho_4 = \rho_m - \rho_4 = 1.05 - 1.05 = 0$ g/cc

$\Delta \rho_5 = \rho_m - \rho_5 = 1.05 - 1.13 = -0.08$ g/cc

Mean absolute error, $\overline{\Delta \rho} = \frac{|\Delta \rho_1| + |\Delta \rho_2| \ldots |\Delta \rho}{5}$

$= \frac{0.02 + 0.07 + 0.13 + 0 + 0}{5}$

$= \frac{0.30}{5}$

$= 0.06$ g/cc

Result = $(\rho_m \pm \overline{\Delta\rho})$ g/cc

= $(1.05 \pm 0.06)$ g/cc

Relative error = $\frac{\overline{\Delta\rho}}{\rho_m}$

= $\frac{0.06}{1.05}$

= $\frac{6}{105}$

= 0.057

= 0.06

Qn. 5)

Let,

$R_1 = 10.3\ \Omega$

$R_2 = 10.7\ \Omega$

$R_3 = 9.8\ \Omega$

$R_4 = 10.4\ \Omega$

$R_5 = 9.6\ \Omega$

i) mean value of resistance, $R_m$

= $\frac{R_1 + R_2 \ldots\ldots R_5}{5}$

= $\frac{10.3 + 10.7 + 9.4 + 10.4 + 9.6}{5}$

= ~~10.16 Ω~~

≈ ~~10.1 Ω~~

= $\frac{50.8}{5}$

= 10.16 Ω

≈ 10.2 Ω

ii) Absolute error

$\Delta R_1 = Rm - R_1 = 10.2 - 10.3 = -0.1\ \Omega$

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

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

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

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

iii) Mean absolute error,

$$\overline{\Delta R} = \frac{|\Delta R_1| + |\Delta R_2| \ldots\ldots |\Delta R_5|}{5}$$

$$\overline{\Delta R} = \frac{0.1 + 0.5 + 0.4 + 0.2 + 0.6}{5}$$

$$\overline{\Delta R} = \frac{1.8}{5}$$

$$\overline{\Delta R} = 0.36$$

$$\overline{\Delta R} \approx 0.4\ \Omega$$

iv) Fractional error $= \dfrac{\overline{\Delta R}}{Rm}$

$$= \frac{0.4}{10.2}$$

$$= \frac{4}{102}$$

$$= 0.039$$

$$\approx 0.04$$

(v) Percentage error $= \frac{\overline{\Delta R}}{Rm} \times 100\%$

$= \frac{0.4}{10.2} \times 100\%$.

$= \frac{4}{102} \times 100\%$.

$= 0.039 \times 100\%$.

~~$= 0.004 \times 100\%$.~~

~~$= 0.39\%$.~~

$= 0.04 \times 100\%$.

$= 4\%$.

Qn. 6)

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

i) mean value of diameter,

$$dm = \frac{d_1 + d_2 \ldots . d_5}{5}$$

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

$= \frac{6.653}{5}$

$= 1.3306$

$\approx 1.330$ mm

ii) Absolute error.

$\Delta d_1 = d_1 - dm = 1.328 - 1.330 = -0.002$

$\Delta d_1 = dm - d_1 = 1.330 - 1.328 = 0.002 mm$

$\Delta d_2 = dm - d_2 = 1.330 - 1.330 = 0 mm$

$\Delta d_3 = dm - d_3 = 1.330 - 1.325 = 0.005 mm$

$\Delta d_4 = dm - d_4 = 1.330 - 1.334 = -0.004 mm$

$\Delta d_5 = dm - d_5 = 1.330 - 1.336 = -0.006 mm$

iii) mean absolute error,

$$\overline{\Delta d} = \frac{|\Delta d_1| + |\Delta d_2| + \dots |\Delta d_5|}{5}$$

$$\overline{\Delta d} = \frac{0.002 + 0 + 0.005 + 0.004 + 0.006}{5}$$

$$\overline{\Delta d} = \frac{0.017}{5}$$

$$= 0.0034 mm$$

$$\approx 0.003 mm$$

(iv) fractional error $= \frac{\overline{\Delta d}}{dm}$

$$= \frac{0.003}{1.330}$$

$$= 0.0022$$

$$\approx 0.002$$

(v) percentage error $= \frac{\overline{\Delta d}}{dm} \times 100\%$.

$= \frac{0.003}{1.330} \times 100\%$.

$= 0.002 \times 100\%$.

$= 0.0 \; 0.0 \; 0.2\%$.

Qn. 7)

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

i) Accurate value of the diameter,

$dm = \frac{d_1 + d_2 \ldots\ldots d_9}{9}$

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

$= \frac{3.47}{9}$

$= 0.385$ mm

$\approx 0.38$ mm

Now,

$\Delta d_1 = d_1 - dm = 0.39 - 0.38 = 0.01$ mm

$\Delta d_2 = d_2 - dm = 0.38 - 0.38 = 0$ mm

$\Delta d_3 = d_3 - dm = 0.37 - 0.38 = -0.01$ mm

$\Delta d_4 = d_4 - dm = 0.41 - 0.38 = 0.03$ mm

$\Delta d_5 = d_5 - dm = 0.38 - 0.38 = 0$ mm

$\Delta d_6 = d_6 - dm = 0.38 - 0.38 = 0$ mm

$\Delta d_7 = d_7 - dm = 0.37 - 0.38 = -0.01$ mm

$\Delta d_8 = d_8 - dm = 0.40 - 0.38 = 0.02$ mm

$\Delta d_9 = d_9 - dm = 0.39 - 0.38 = 0.01$ mm

$$\overline{\Delta d} = \frac{|\Delta d_1| + |\Delta d_2| \ldots\ldots |\Delta d_3|}{9}$$

$$= \frac{0.01 + 0 + 0.01 + 0.03 + 0 + 0 + 0.01 + 0.02 + 0}{9}$$

$$= \frac{0.089}{9}$$

$$= 0.01 \text{ mm}$$

ii) Relative error $= \frac{\overline{\Delta d}}{dm}$

$$= \frac{0.01}{0.38}$$

$$= 0.0263$$

~~0.026~~ ~~0.026~~ ~~0.026~~

$\approx 0.03$

iii) Percentage error $= \frac{\overline{\Delta d}}{dm} \times 100\%$

$= 0.026 \times 100\%$

~~$= .03 \times 100\%$~~

$= 0.03 \times 100\%$

~~$= 3\%$~~

~~$= 0.6\%$~~

$= 0.03 \times 100\%$

$= 3\%$

Qn. 8) Soln:

Let,

$n_1 = 1.29$

$n_2 = 1.33$

$n_3 = 1.34$

$n_4 = 1.35$

$n_5 = 1.32$

$n_6 = 1.36$

$n_7 = 1.30$

$n_8 = 1.33$

mean value, $n_m = \frac{n_1 + n_2 \ldots\ldots n_8}{8}$

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

$= \frac{10.62}{8}$

$= 1.3275$

$\approx 1.33$

Now, Absolute error

$\Delta n_1 = n_m - n_1 = 1.33 - 1.29 = 0.04$

$\Delta n_2 = n_m - n_2 = 1.33 - 1.33 = 0$

$\Delta n_3 = n_m - n_3 = 1.33 - 1.34 = -0.01$

$\Delta n_4 = n_m - n_4 = 1.33 - 1.35 = -0.02$

$\Delta n_5 = n_m - n_5 = 1.33 - 1.32 = 0.01$

$\Delta n_6 = n_m - n_6 = 1.33 - 1.36 = -0.03$

$\Delta n_7 = n_m - n_7 = 1.33 - 1.30 = 0.03$

$\Delta n_8 = n_m - n_8 = 1.33 - 1.33 = 0$

~~Mean = $|\Delta n_1| + |\Delta n_2| \ldots$~~

Mean absolute error,

$$\overline{\Delta n} = \frac{|\Delta n_1| + |\Delta n_2| \ldots |\Delta n_8|}{8}$$

$$= \frac{0.04 + 0 + 0.01 + 0.02 + 0.01 + 0.03 + 0.03 + 0}{8}$$

$$= \frac{0.14}{8}$$

$$= 0.0175$$

$$= 0.02$$

Relative error, $= \frac{\overline{\Delta n}}{n_m}$

$$= \frac{0.02}{1.33} = 0.015 \approx 0.02$$

Percentage error $= \frac{\overline{\Delta n}}{n_m} \times 100\%$

$= \frac{0.02}{1.33} \times 100\%$

$= 0.02 \times 100\%$

$= 2\%$