Q1 The diameter of a wire measured in an experiement was 0.022 cm, 0.023 cm, 0.026 cm, 0.025 cm, 0.024 cm & 0.025 cm find

(i) the mean value of diameter

(ii) absolute error in a each measurement

(iii) Percentage error

→ (i) 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 of ~~resistan~~ Diameter

$$D_m = \frac{D_1 + \ldots + D_6}{6}$$

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

$$= 0.024\,cm$$

(ii) Absolute error of D

$\Delta D_1 = D_m - D_1 = 0.002$

$\Delta D_2 = D_m - D_2 = 0.001$

$\Delta D_3 = D_m - D_3 = -0.001$

$\Delta D_4 = D_m - D_4 = -0.001$

$\Delta D_5 = D_m - D_5 = 0$

$\Delta D_6 = D_m - D_6 = -0.001$

(iii) Mean absolute error =

$$\overline{\Delta R} = \frac{|\Delta D_1| + \ldots + |\Delta D_6|}{6}$$

$$= \frac{0.006}{6}$$

$$= 0.001$$

~~Result =~~

Value of Diameter is

$$D = (0.024 \pm 0.001)\ cm$$

$$\text{Relative error} = \frac{\Delta R}{D_m}$$

$$= \frac{0.001}{0.024}\ cm$$

$$= 0.041$$

∴ Percentage error =

$$PE = \frac{\Delta D}{D_m} \times 100\%$$

$$= 0.041 \times 100\%$$

$$= 4.1\%$$

Q2 Refractive index of a flint glass (μ) was measured in an experiment and was found to be 1.655, 1.667, 1.666, 1.659, 1.669 and 1.654. Find

(i) the mean value of μ

(ii) Mean absolute error

(iii) Relative error

(iv) Percentage error

→ Let $\mu_1 = 1.655$

$\mu_2 = 1.667$

$\mu_3 = 1.666$

$\mu_4 = 1.6599$

$\mu_5 = 1.669$

$\mu_6 = 1.654$

(i) Mean value of $\mu_{mn} = \frac{\mu_1 + \mu_2 + \mu_3 + \mu_4 + \mu_5 + \mu_6}{6}$

$\mu_m = \frac{9.98}{6} = \frac{9.97}{6}$

$= 1.6616\ \mu$

$= 1.662$

(ii) Absolute error of μ

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

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

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

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

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

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

* Mean Absolute error = $\frac{|\Delta M_1| + \ldots + |\Delta M_6|}{6}$

$= \frac{0.037}{6}$

$= 0.0061$

Value of Refractive index $M = (1.662 \pm 0.0061)\ M$

(iii) Relative error $= \frac{\Delta M}{M}$

$= \frac{0.0061}{1.662}\ M$

$= 0.00367\ M$

$= 0.004$

(iv) Percentage error $= \frac{\Delta M}{M} \times 100\%$

$= 0.004 \times 100\%$

$= 0.4\%$

Q 3) While determining the time period of oscillat^n of a simple pendulum, the reading from various measurements are 1.73 s, 1.62 s, 1.52 s, 1.45 s & 1.83 s. Calculate the values of mean value of time period, absolute error, mean absolute error & relative error.

7. Let

$T_1 = 1.73s$

$T_2 = 1.62s$

$T_3 = 1.52s$

$T_4 = 1.45s$

$T_5 = 1.83s$

Mean value of Time $= \frac{T_1 + \cdots + T_5}{5}$

$= \frac{8.15}{5}$

$T_m = 1.63$

Absolute error

$\Delta T_1 = T_m - T_1 = -0.10$

$\Delta T_2 = T_m - T_2 = +0.01$

$\Delta T_3 = T_m - T_3 = +0.11$

$\Delta T_4 = T_m - T_4 = +0.18$

$\Delta T_5 = T_m - T_5 = -0.20$

Mean Absolute error $= \frac{|\Delta T_1| + \cdots + |\Delta T_5|}{5}$

$= \frac{0.60}{5}$

$= 0.12s$

Value of ~~Refrative~~ index = Time is $(1.63 \pm 0.12)s$

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

$= \frac{0.12}{1.63}$

$= \frac{12}{163}$

$= 0.073$

4) While determining the density of a sea water, the readings from various measurements are 1.03 g/cc, 1.12 g/cc, 0.92 g/cc, 1.05 g/cc & 1.13 g/cc. Calculate the values of mean density, absolute error, mean absolute error & relative error.

→ Let

$D_1 = 1.03$ g/cc

$D_2 = 1.12$ g/cc

$D_3 = 0.92$ g/cc

$D_4 = 1.05$ g/cc

$D_5 = 1.13$ g/cc

Mean value of Density $= \frac{1.03 + \dots + 1.13}{5}$

$= \frac{5.25}{5}$

$D_m = 1.05$

Absolute error : $\Delta D_1 = D_m - D_1 = +0.02$

$\Delta D_2 = D_m - D_2 = -0.07$

$\Delta D_3 = D_m - D_3 = +0.13$

$\Delta D_4 = D_m - D_4 = 0$

$\Delta D_5 = D_m - D_5 = -0.08$

$$\text{Mean Absolute error} = \frac{|\Delta D_1| + \ldots + |\Delta D_5|}{5}$$

$$= \frac{0.30}{5}$$

$$= 0.06 \text{ g/cc}$$

Value of Density $= (1.05 \pm 0.06)$ g/cc

$$\text{Relative error} = \frac{\Delta D}{D_m}$$

$$= \frac{0.06}{1.05}$$

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

$$= 0.057$$

$$= 0.06 \text{ g/cc}$$

5) The Resistance of a wire as measured in an experiment was found to be 10.3Ω, 10.7Ω, 9.8Ω, 10.4Ω & 9.6Ω.

Calculate (i) Mean value of Resistance

(ii) Absolute error in each measurement

(iii) Mean absolute error

(iv) Fractional error (v) Percentage error

→ 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 $= \frac{10.3 + \cdots + 9.6}{5}$

$= \frac{50.8}{5}$

$R_m = 10.16\ \Omega$

$= 10.2$

(ii) Absolute error =

$\Delta R_1 = R_m - R_1 = -0.1$

$\Delta R_2 = R_m - R_2 = -0.5$

$\Delta R_3 = R_m - R_3 = +0.4$

$\Delta R_4 = R_m - R_4 = -0.2$

$\Delta R_5 = R_m - R_5 = +0.6$

(iii) Mean Absolute error $= \frac{|\Delta R_1| + \cdots + 0.6}{5}$

$= \frac{1.80}{5}$

$= 0.36\ \Omega$

(iv) Value of Resistance $= (10.2 \pm 0.36)\ \Omega$

(iv) Fractional error $= \frac{\Delta R}{R_m}$

$= \frac{0.36}{10.2}$

$= \frac{3.6}{102} = 0.03$

$= 0.04$

(v) % error $= \frac{\Delta R}{R_m} \times 100\%$

$= 0.04 \times 100$

$= 4\%$

6) The diameter of a wire as measured by a screw gauge was found to be 1.328 mm, 1.330 mm, 1.325 mm, 1.334 mm & 1.336 mm. Calculate

(i) Mean value of diameter

(ii) Absolute error in each measurement

(iii) Mean absolute error

(iv) fractional error

(v) percentage error

→ let

$D_1 = 1.328$

$D_2 = 1.330$

$D_3 = 1.325$

$D_4 = 1.334$

$D_5 = 1.336$

(i) Mean value of Diameter $= \frac{1.328 + \dots + 1.336}{5}$

$= \frac{6.653}{5}$

$= 1.3306$

$= 1.331$ mm

(ii) Absolute error

$\Delta D_1 = D_m - D_1 = +0.003$

$\Delta D_2 = D_m - D_2 = 0.023$

$\Delta D_3 = D_m - D_3 = +0.001$

$\Delta D_4 = D_m - D_4 = 0.026$

$\Delta D_5 = D_m - D_5 = +0.006$

$= -0.003$

$= -0.005$

(iii) Mean Absolute error $= \frac{|0.003| + \ldots + |0.005|}{5}$

$= \frac{0.018}{5}$

$= 0.0036 = 0.004$

value of Diameter $= (1.331 \pm 0.004)$ →

(iv)

Fractional error

$= \frac{\Delta D}{D_m}$

$= \frac{0.0036}{1.331} = \frac{0.004}{1.331}$

$= \frac{4}{1331}$

$= 0.003$

(v) % error $= \frac{\Delta D}{D_m} \times 100\%$

$= 0.003 \times 100\%$

$= 0.3\%$.

7) Using a screw gauge, the diameter of a metal rod was measured. The observatn are given as follows: 0.39mm, 0.38mmm, 0.37mm, 0.41mm, 0.38mm, 0.38mm, 0.37mm, 0.40 mm, 0.39mm. Calculate

(i) the most accurate value of the diameter,

(ii) the relative error, &

(iii) The percentage error in the measurement of the diameter.

→ let

$D_1 = 0.39$

$D_2 = 0.38$

$D_3 = 0.37$

$D_4 = 0.41$

$D_5 = 0.38$

$D_6 = 0.38$

$D_7 = 0.37$

$D_8 = 0.40$

$D_9 = 0.39$

(i) The most accurate value of diameter

$$= \frac{0.39 + \text{---} - +0.39}{4}$$

$$= \frac{3.47}{4}$$

$$= 0.385$$

$$= 0.39$$

(ii) Absolute error

$\Delta D_1 = D_m - D_1 = 0$

$\Delta D_2 = D_m - D_2 = +0.01$

$\Delta D_3 = D_m - D_3 = +0.02$

$\Delta D_4 = D_m - D_4 = -0.02$

$\Delta D_5 = D_m - D_5 = +0.01$

$\Delta D_6 = D_m - D_6 = +0.01$

$\Delta D_7 = D_m - D_7 = +0.02$

$\Delta D_8 = D_m - D_8 = -0.01$

$\Delta D_9 = D_m - D_4 = 0$

Mean Absolute Error $= \frac{|\Delta D_1| + \ldots + |\Delta D_9|}{9}$

$= \frac{0.10}{9}$

$= 0.011$

The ~~relative~~ error $= \Delta D$

Value of Diameter $= (0.39 \pm 0.011)$

the relative error $= \frac{\Delta D}{D_m}$

$= \frac{0.011}{0.39}$

$= \frac{1.1}{39}$

$= 0.02$

(iii) % error $= \frac{\Delta D}{D_m} \times 100\%$

$= 0.02 \times 100\%$

$= 2\%$

Q8) A student performs an experiment & found following values of the refractive index of 1.29, 1.33, 1.34, 1.35, 1.32, 1.36, 1.30, 1.33
Find the mean valve of refractive index, the mean absolute error. The

(8) relative error & percentage error

⇒ let $R_1 = 1.29$

$R_2 = 1.33$

$R_3 = 1.34$

$R_4 = 1.35$

$R_5 = 1.32$

$R_6 = 1.36$

$R_7 = 1.30$

$R_8 = 1.33$

Mean Refractive index

$$= \frac{R_1 + \cdots + R_8}{8}$$

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

$$R_m = 1.327 = 1.33$$

Absolute error :-

$\Delta R_1 = R_m - R_1 = +0.04$

$\Delta R_2 = R_m - R_2 = 0$

$\Delta R_3 = R_m - R_3 = -0.01$

$\Delta R_4 = R_m - R_4 = -0.02$

$\Delta R_5 = R_m - R_5 = +0.01$

$\Delta R_6 = R_m - R_6 = -0.03$

$\Delta R_7 = R_m - R_7 = +0.03$

$\Delta R_8 = R_m - R_8 = 0$

Mean Absolute error $= \frac{(0.04| + \ldots + 0.0)}{8}$

$= \frac{0.14}{8}$

$= 0.017 = 0.02$

Value of Refractive index $= (1.33 \pm 0.02)$

The relative error $= \frac{\Delta R}{R_m}$

$= \frac{0.02}{1.33} = \frac{2}{133}$

$= 0.015$

$= 0.01$

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

$= 0.01 \times 100\%$

$= 1\%$