CHAPTER-1
FUNDAMENTAL AND ERROR ANALYSIS

02. Ans: (a)

Sol: Probable Value = $\frac{3.12+3.15+2.97+3.10+2.99}{5}$

(Or)

(Avg Value)

$= 3.066$

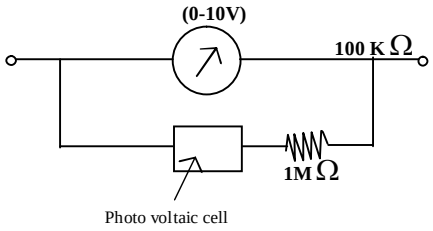
03. Ans: (b)

Sol: Req = $\frac{100\times10^3\times10^6}{10^5+10^6} = 90.909\text{K}\Omega$

$I = \frac{5}{90.909\times10^3} = 5.5\times10^{-5}$

$V = IR = 90.905\times10^3\times5.5\times10^{-5} = 4.99\text{V}$

Total Reading = 5 + 4.99 = 9.99 ≅ 10V



04. Ans: (b)

Sol: 0.125% of the span

$T_1 = 400^0\text{C}$ $T_2 = 1000^0\text{C}$

Span = $T_2 - T_1 = 1000 - 400 = 600$

0.125% of the span = $\frac{0.125}{100}$ x 600 = 0.75^0 C

05. Ans: (c)

Sol: The mean value of the voltage for every month shows a standard deviation of 0.1 mv

The voltage of a standard cell is monitored daily over a period of one year.

One year means 12 months

n = 12

$\Rightarrow$ standard value $\sigma = \sqrt{\frac{\sum_{T=1}^{n} d_i^{\,2}}{n}}$

$= \sqrt{\frac{\left(10^{-1}\right)^2}{12}} = \frac{10^{-1}}{\sqrt{12}} = \frac{0.1}{\sqrt{12}}$

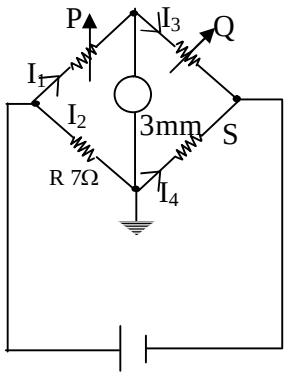
07. Ans: (a)

Sol: Span = $T_2 - T_1 = 200^o\text{C} - 150^0\text{C} = 50^0\text{c}$

$\pm$ 0.25% of the span = $\frac{\pm0.25 \text{ x } 50}{100}$ x 100 = $\pm0.125\%$

08. Ans: (b)

Sol: $S_B = \dfrac{\text{change in deflection}}{\text{unit change in voltage or Resistance}} = \dfrac{\Delta\theta}{(\Delta R / R)}$

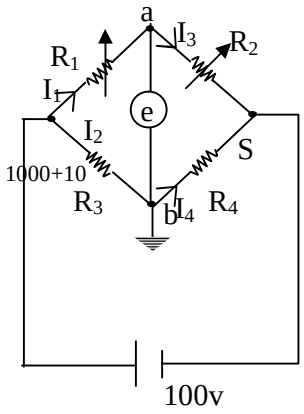


$= \dfrac{3\times10^{-3}}{7} = 0.4285 \text{ mm}/\Omega$

Deflection factor $= \dfrac{1}{S_B} = \dfrac{1}{\frac{3\times10^{-3}}{7}} = 2.33\,\Omega/\text{mm}$

11. Ans: (b)

Sol: $S_B = \dfrac{\text{change in deflection}}{\text{unit change in voltage or Resistance}} = e / 10$



$e = v_d - v_a$

Va= 100 (1000/1000+1000) = 50

Vd = 100(1010/1010+1000) = 50.25
e = 50.25 – 50 = 0.25v

S_B = 25mv/Ω

12. Ans: (b)

Sol: Power P = ± 1.5%
I = ± 1.0%

$R = \dfrac{P}{I^2} = \dfrac{\pm1.5\%}{(\pm1.0)\% \times (\pm1.0)\%}$

In case of multiplication ± % values are added

$= \dfrac{\pm1.5\%}{\pm2\%} = \pm3.5\%$

13. Ans: (c)

Sol: (0-10A) Ammeter GAE = 1% of full scale deflection

$\text{GAE} = 1\times\dfrac{10}{100} = 0.1$

The reading is 2.5A so the Limiting error will be

$2.5 \times \dfrac{x}{100} = 0.1$

x = 4%

15. Ans: (b)

Sol: Measured value = 127.5 v true value = 127.43 v

$$\% \text{ state error} = \frac{\text{Measure value} - \text{true value}}{\text{true value}}$$

$$= \frac{127.5 - 127.43}{127.43} \times 100$$

Static error = measured value – true value

= 127.5 – 127.43 = 0.07

Correction factor= $(-\varepsilon)$

= – 0.07

16. Ans: (b)

Sol: Measured value = 95.45^0c

Static correction = $(-\varepsilon)$ = – 0.08^0c

Error = Measured value – true value

0.08^0c = 95.45^0c – true value

Tree value = 95.45^0c – 0.08^0c = 95.37^oC

17. Ans: (c)

Sol: $R_1 = 72.3\ \Omega$ $R_2 = 2.73\ \Omega$ $R_3 = 0.612\ \Omega$

Uncertainty of one unit means, the error in last digits, so we can neglect

$R_1 = 72.3\ \Omega$ $R_2 = 2.7\ \Omega$ $R_3 = 0.6\ \Omega$

$R_{eq} = R_1 + R_2 + R_3 = 72.3 + 2.7 + 0.6$

$= 75.6\ \Omega$

18. Ans: (a)

Sol: $R_1 = 28.7\ \Omega$ $R_2 = 3.624\ \Omega$ Neglect last digits

$R_1 = 28.7\ \Omega$ $R_2 = 3.6$

$R_{eq} = R_1 + R_2 = 28.7 + 3.6 = 32.3\ \Omega$

19. Ans: (b)

Sol: No. of divisions = 100

Full scale reading = 200 v

$$\text{Resolution} = \frac{\text{Full scale reading}}{\text{No. of divisions}} = \frac{200}{100} = 2$$

But he has given $\frac{1}{10}$ of scale division

$$\text{Resolution} = \frac{1}{10} \times 2 = 0.2\,\text{v}$$

20. Ans: (c)

Sol: $C = 1\ \mu F \pm 5\%$

The limits between the capacitance value

$C_1 = 1\ \mu F + 5\%$ $C_2 = 1\ \mu F - 5\%$

$C_1 = 1.05\ \mu F$ $C_2 = 0.95\ \mu F$

21. Ans: (c)

Sol: Range (0 – 150 v) GAE = 1% full scale reaching

GAE = $\frac{1}{100}$ x 150 = 1.5

The voltage measured value = 75 v. So the limiting error

$$= 75 \text{ x } \frac{x}{100} = 1.5$$

$$x = 2\ \%$$

22. Ans: (c)

Sol: Range of the Ammeter 0 – 10 A

GAE = 1% of full scale reading

GAE = 1 x $\frac{10}{100}$ = 0.1

The measured value = 2.5 A

L.E = 2.5 x $\frac{x}{100}$ = 0.1

x = 4 %

29. Ans: (a)

Sol: A pressure gauge is calibrated (0 – 50 KN/m^2)

Total no. of division = 100

$\frac{1}{5}$th of scale division

Resolution = $\frac{\text{Full scale reading}}{\text{No. of divisions}} = \frac{50}{100} = 0.5$

$\frac{1}{5}$th of scale division = $\frac{1}{5}$ x 0.5 = 0.1 kN/m^2

Two Marks Questions

30. Ans: (b)

Sol: GAE = ± 3 % of full scale

Range = (0 – 300 v)

GAE = $\frac{3}{100}$ x 300 = ±9

The reading 200 v

One reading = 200 + 9 = 209 v

Another reading = 200 – 9 = 191 v

31. Ans: (d)

Sol: (i) w_1 = 100 w GAE = ± 1% of w_1,

GAE = $\frac{1}{100}$ x 100 = ±1

(ii) w_2 = – 50 w GAE = ± 0.5% of w_2

GAE = $\frac{\pm 0.5}{100} \times 100 = \pm 0.5$

Total power $= w_1 + w_2$

$= 100 \pm 1 - 50 \pm 0.5$

$= 50 \pm 1.5$

$50 \times \frac{x}{100} = 1.5$

LE $x = 3\%$

36. Ans: (a)

Sol: $R_1 = 37 \pm 5\%$ $R_2 = 75 \pm 5\%$ $R_3 = 50 \pm 5\%$

Three Resistance are connected in series

$Req = R_1 + R_2 + R_3$

$R_1 = 37 \pm 5\% \Rightarrow 37 \times \frac{5}{100} = \frac{185}{100} = 1.85$

$R_1 = 37 \pm 1.85$

$R_2 = 75 \pm 5\% \Rightarrow 75 \times \frac{5}{100} = 3.75$

$R_2 = 75 \pm 3.75$

$R_3 = 50 \pm 5\%$

$= 50 \times \frac{5}{100} = 2.5$

$R_3\ 50 \pm 2.5$

$Req = R_1 + R_2 + R_3 = 37 + 1.85 + 75 \pm 3.75 + 50 \pm 2.5$

$= 162 \pm 8.1$

$= 162 \times \frac{x}{100} = 8.1$ X = 5%

37. Ans: (c)

Sol: $R_1 = 100 \pm 5\Omega$ $R_2 = 150 \pm 15\Omega$

$Req = R_1 + R_2 = 100 \pm 5 + 150 \pm 15$

$= 250 \pm 20$

But he asking standard deviations on

$= \sqrt{\frac{d_1^{\,2} + d_2^{\,2}}{n-1}}$ n = 2 i.e <20

$= \sqrt{\frac{15^2 + 5^2}{2-1}} = 15.8\Omega$

Ans $= 250 \pm 15.8$

38. Ans: (a)

Sol: Range of voltmeter (0-300v)

GA error = $\pm$ 2% full scale deflection

GAE = $\pm 2 \times \frac{300}{100} = \pm 6$

The reading 30v

One Reading = 30+6 = 36v

Another Reading = 30-6 = 24v

39. Ans: (d)

Sol: Voltage measurement = $\pm 2\%$

Current = $\pm 3\%$ Incase of multiplication $\pm$ % will be added

Power = VI = $\pm 3\% \times \pm 2\%$

= $\pm 5\%$

40. Ans: (b)

Sol: I = $\pm 1.5\%$ R = $\pm 0.5\%$

$P = I^2R = (\pm 1.5\% \times \pm 1.5\% * 0.5\%$

$= \pm 3.5\%$

Previous IES questions

07. Ans: (b)

Sol: Measured value = 100 μF true value = 110μF

Relative error = $\pm \frac{\text{Measured value} - \text{true value}}{\text{true value}} \times 100 = \frac{100-110}{110} \times 100 = 9.09\%$

08. Ans: (b)

Sol: Voltmeter Range (0-20V)

(GAE) Accuracy = $\pm 1\%$ fsd

GAE = $20 \times \frac{1}{100} = 0.2$

Reading $2 \times \frac{x}{100} = 0.1$ Limiting error x = $\pm 10\%$

If it Reads $5V \times \frac{x}{100} = 0.2$ x = $\pm 4\%$

Reading $10 \times \frac{x}{100} = 0.2$ x = $\pm 2\%$

$20 \times \frac{x}{100} = 0.2 \Rightarrow x = \pm 1\%$

13. Ans: (d)

Sol: Range of ammeter (0-10mA)

GAE = $\pm 2\%$ of full scale

$= \pm 2 \times \frac{10}{100} = 0.2$

L.E Reading 5 mA $\Rightarrow 5 \times \frac{x}{100} = 0.2$

$X = \frac{0.2 \times 100}{5} = \pm 4\%$

24. Ans: (a)

Sol: Readings 117.02 mA, 117.11mA, 117.08 & 117.03

Range of error means

Avg value = $\frac{117.02+117.11+117.08+117.03}{4}$

Iw = 117.06 $I_{Min} = 117.02$

$I_{max} = 117.11$

Error = $\frac{\pm(I_{max}-I_{av})+(I_{av}-I_{min})}{2}$

$= \frac{(117.11-117.06)+(117.06-117.02)}{2} = \frac{\pm 0.05+0.04}{2} = \pm 0.045$

26. Ans: (d)

Sol: Range of voltmeter (0-100V)

GAE = $\pm$ 1% of full scale

$= \pm 1\times\frac{100}{100} = \pm 1$

Reading Measured value = 5V

LE $\Rightarrow 5\times\frac{x}{100} = \pm 1$ $\left(\because \text{LE = Limiting Error}\right)$

LE $x = \frac{100}{5} = \pm 20\%$

Previous Gate questions

07. Ans: (d)

Sol: Voltage value 5.9V, 5.7V, 6.1V

Standard deviation = $\sqrt{\frac{d_1^{\,2}+d_2^{\,2}+d_3^{\,2}}{n}}$

Average value 5.9 = $\frac{5.9+5.7+6.1}{3}$

$d_1 = 5.9-5.9 = 0$ $d_2 = 5.9-5.7 = 0.2$

$d_3 = 6.1-5.9 = 0.2$

$= \sqrt{\frac{(0.2)^2+(0.2)^2}{2}} = \sqrt{\frac{0.04+0.04}{2}} = 0.2$

Two Marks Questions:

08. Ans: (b)

Current (A)	0	5	10	15	20	25
Ammeter reading A	1	4	12	14	22	28

Full scale reading (0-30V)

Full scale reading = 30V

Error = 28-25 = 3V, it is 10% of full scale reading.