Errors in Measurements and Instruments and Semiconductor

SOLUTIONS

EXERCISE - O

1. **Ans. (A)**

By the rule of round off

4.74×10^{-6} *kg*

2. **Ans. (A)**

First solve division, then multiply and then add.

$$\frac{3.88}{3.0} = 1.3,$$

$$1.3 \times 4.835 = 6.3$$

$$6.3 + 4.338 = 10.6$$

3. **Ans. (B)**

Volume $V = l \times b \times t$

$$= 12 \times 6 \times 2.45 = 176.4\ cm^3$$

$$V = 1.764 \times 10^2\ cm^3$$

Since, the minimum number of significant figures is one in breadth, hence volume will also contain only one significant figure. Hence, $V = 2 \times 10^2\ cm^3$.

4. **Ans. (B)**

$$1MSD = \left(\frac{1}{2}\right)^\circ = 30'$$

$$\Rightarrow\ 30VSD = 29MSD$$

$$\Rightarrow\ 1\ VSD = \frac{29}{30} MSD$$

$$L.C. = 1MSD - 1VSD$$

$$L.C. = 1\ MSD - \frac{29}{30} MSD$$

$$\Rightarrow\ L.C. = \frac{1}{30} MSD = \frac{30'}{30} = 1'$$

5. **Ans. (B)**

Scale has positive error.

$$8 \times 0.5mm + \frac{81}{100} \times 0.5$$

$$= 4.405mm$$

6. **Ans. (C)**

$$\text{Last count } (LC) = \frac{\text{Pitch}}{\text{no. of division on circular scale}}$$

$$\Rightarrow\ LC = \frac{0.5}{50} = 0.01mm$$

Zero error = $+5 \times LC = 5 \times 0.01$ *mm*

$VSR = 25 \times LC = 25 \times 0.01\ mm$

$MSR = 2 \times 0.5\ mm = 1\ mm$

Reading = $MSR + VSR$ – Zero Error

$= 1\ mm + 25 \times 0.01\ mm - 5 \times 0.01\ mm$

$= 1\ mm + 20 \times 0.01 mm$

$= 1\ mm + 0.20\ mm$

$= 1.20\ mm$

7. Ans. (C)

Least count $= \frac{0.5}{50} = 0.01\ mm$

Diameter of ball $D = 2.5\ mm + (20)\ (0.01)$

$D = 2.7\ mm$

$$\rho = \frac{M}{vol} = \frac{M}{\frac{4}{3}\pi\left(\frac{D}{2}\right)^3}$$

$$\left(\frac{\Delta\rho}{\rho}\right)_{max} = \frac{\Delta m}{m} + 3\frac{\Delta D}{D}$$

$$\left(\frac{\Delta\rho}{\rho}\right)_{max} = 2\% + 3\left(\frac{0.01}{2.7}\right) \times 100\%$$

$$\frac{\Delta\rho}{\rho} = 3.1\%$$

8. Ans. (B)

$$V = \frac{13.8}{4.0} = 3.45 m/s$$

$$\frac{\Delta V}{V} = \frac{\Delta s}{s} + \frac{\Delta t}{t}$$

$$\frac{\Delta V}{3.45} \Rightarrow \frac{0.2}{13.8} + \frac{0.3}{4.0}$$

$\therefore\ \Delta V = 0.3$

9. Ans. (D)

$$\frac{\Delta x}{x} = 1\% = 10^{-2}$$

$$\frac{\Delta y}{y} = 3\% = 3 \times 10^{-2}$$

$$\frac{\Delta z}{z} = 2\% = 2 \times 10^{-2}$$

$$t = \frac{xy^2}{z^3}$$

$$\frac{\Delta t}{t} = \frac{\Delta x}{x} + \frac{2\Delta y}{y} + \frac{3\Delta z}{z}$$

$= 10^{-2} + 2 \times 3 \times 10^{-2} + 3 \times 2 \times 10^{-2}$

$= 13 \times 10^{-2}$

% error in $t = \frac{\Delta t}{t} \times 100 = 13\%$

10. Ans. (D)

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$R_{eq} = \frac{3\times6}{3+6} = 2\Omega$$

$$\frac{\Delta R_{eq}}{R_{eq}} = \frac{\Delta R_1}{R_1} + \frac{\Delta R_2}{R_2}$$

$$\therefore \quad \frac{\Delta R_1}{R_1} \times 100 = 1 \Rightarrow \quad \frac{\Delta R_1}{R_1} = 1 \times 10^{-2}$$

$$\therefore \quad \frac{\Delta R_2}{R_2} \times 100 = 2 \Rightarrow \quad \frac{\Delta R_2}{R_2} = 2 \times 10^{-2}$$

$$\frac{\Delta R_{eq}}{R_{eq}} = \left[\frac{1\times10^{-2}}{3} + \frac{2\times10^{-2}}{6}\right] \times 2 = \left[\frac{4\times10^{-2}\times2}{6}\right] = \frac{4}{3}\times 10^{-2}$$

$$\therefore \quad \%\text{ error} = \frac{4}{3}\%$$

11. Ans. (A)

Most of the sound emitted by a tuning fork is propagated in the plain in which the prongs lie. Here the sound has to be directed into the tube.

12. Ans. (B)

$$\frac{V}{4(\ell+e)} = f$$

$$\Rightarrow \quad \ell + e = \frac{V}{4f}$$

$$\Rightarrow \quad \ell = \frac{V}{4f} - e$$

Here $e = (0.6)\, r = (0.6)\,(2) = 1.2\ cm$

So $\ell = \dfrac{336\times10^2}{4\times512} - 1.2 = 15.2\ cm$

13. Ans. (C)

Real depth $= x_3 - x_1 = 13.895 - 12.324 = 1.571\ cm$

Apparent depth $= x_3 - x_2 = 13.895 - 12.802$

$= 1.093\ cm$

Refractive index $= \dfrac{1.571}{1.093} = 1.437$

14. Ans. (D)

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

$\therefore \quad \dfrac{1}{f}$ is intercept

$$\therefore \quad \frac{1}{f} = 0.2\ cm^{-1}$$

$$\Rightarrow \quad P = 0.2 \times \frac{100}{m}$$

$$\Rightarrow \quad P = 20D$$

15. **Ans. (D)**

$V = u$ and $\frac{1}{V}+\frac{1}{u}=\frac{1}{f}$

$\frac{2}{V}=\frac{1}{f}$

$\Rightarrow V = 2f,\ u = 2f$

16. **Ans. (A)**

Experimental.

17. **Ans. (B)**

$\frac{mg}{\pi r^2} = (Y)\frac{x}{\ell_0}$

$Y = \frac{mg\ell_0}{\left(\pi\frac{d^2}{4}\right)x} = 2 \times 10^{11}\ N/m^2$

$\left(\frac{\Delta Y}{Y}\right)\left(\frac{\Delta d}{d}\right)\frac{\Delta x}{x}_{max}$

$= 2\left(\frac{0.01}{0.4}\right) + \frac{0.05}{0.8} = \frac{9}{80}$

$\Delta Y = \frac{9}{80} \times 2 \times 10^{11} = 0.225 \times 10^{11}\ N/m^2$

$= 0.2 \times 10^{11}\ N/m^2$

18. **Ans. (D)**

$g = 4\pi^2\frac{L}{T^2}$

$\frac{\Delta g}{g}\times 100 = \frac{\Delta L}{L}\times 100 + 2\frac{\Delta T}{T}\times 100$

$= \frac{1\ mm}{20\ cm}\times 100 + 2 \times \frac{1\ \text{sec}}{90\ \text{sec}} \times 100$

$= 2.72\ \%$

$\simeq 3\%$

19. **Ans. (C)**

$\frac{100}{40} = \frac{R}{60} \Rightarrow R \Rightarrow 150\Omega$

$\frac{\Delta R}{R} \Rightarrow \frac{\Delta\ell_1}{l_1} + \frac{\Delta\ell_2}{\ell_2} \Rightarrow \frac{1}{400} + \frac{1}{600}$

$\Delta R \Rightarrow 0.625\Omega$

20. **Ans. (B)**

$\frac{P}{Q} = \frac{R}{X}$

$\frac{10}{100} = \frac{600}{X}$

$x = 6000\ \Omega$

For second case

$\frac{P}{Q} = \frac{R}{X}$

$\frac{10}{100} = \frac{630}{X}$

$x = 6300\ \Omega$

$R_f = R_0(1 + \alpha\Delta T)$

$6300 = 6000\ (1 + \alpha 100) = a = 5 \times 10^{-4}\ {}^\circ C^{-1}$

21. **Ans. (B)**

$\ell_1 = 52 + 1 = 53\ cm$

$\ell_2 = 48 + 2 = 50\ cm$

$\frac{\ell_1}{\ell_2} = \frac{x}{R} \Rightarrow \frac{53}{50} = \frac{x}{10}$

$x = 10.6\ \Omega$

22. **Ans. (B)**

According to Pauli's exclusion principle, the electronic configuration of number of subshells existing in a shell and number of electrons entering each subshell is found. Hence, on the basis of Pauli's exclusion principle, the manifestation of bond structure in solids can be explained.

23. **Ans. (C)**

After joining p-type and n-type semiconductors, electrons from the n-region near the p-n interface, tend to diffuse into the p-region. As electrons diffuse, they leave positively charged ions (doners) in the n type region. Likewise, holes from the p-type region near the p-n interface begin to diffuse into the n-type region, leaving fixed ions (acceptors) with negative charge.

Thus, an electric filed is established at the junction directed from the n-type side to the p-type side.

24. **Ans. (A)**

Given, $\frac{n_e}{n_n} = \frac{7}{5}, \frac{I_e}{I_n} = \frac{7}{4}$

As we know, $I = neAV_d$

$$\frac{I_e}{I_h} = \frac{n_e \times (V_d)_e \times A_e}{n_h \times (V_d) \times A_d}$$

$$\frac{7}{4} = \frac{7}{5} \times \frac{(V_d)_e}{(V_d)_h}$$

$$\frac{(V_d)_e}{(V_d)_h} = \frac{5}{7} \times \frac{7}{4} = \frac{5}{4}$$

25. **Ans. (B)**

$j = \sigma E = nev_d$

$\sigma = ne\frac{v_d}{E}$

$= ne\mu$

$\frac{1}{\sigma} = \rho = \frac{1}{n_e e \mu_e}$

$= \frac{1}{10^{19} \times 1.6 \times 10^{-19} \times 1.6}$

$= 0.4\ \Omega m$

26. **Ans. (B)**

Conceptual

27. **Ans. (B)**

$j = \sigma E = nev_d$

$\sigma = ne\frac{v_d}{E}$

$= ne\mu$

$\frac{1}{\sigma} = \rho = \frac{1}{n_e e \mu_e}$

$= \frac{1}{10^{19} \times 1.6 \times 10^{-19} \times 1.6}$

$= 0.4\ \Omega m$

28. **Ans. (B)**

$$\frac{d^2V}{dx^2} = -\frac{\rho}{\varepsilon_0} \Rightarrow \frac{dE}{dx} = \frac{\rho}{\varepsilon_0} \propto x \Rightarrow E \propto x^2$$

29. **Ans. (B)**

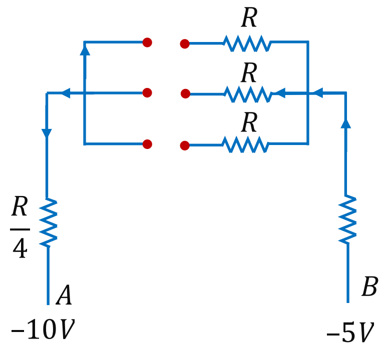
The diode, that is connected with the 50Ω resistor is in reverse bias. So, no current will be passing through that portion.

Now, if we think of an equivalent circuit, we can see that three resistors, i.e. 50Ω, 150Ω, & 100Ω are in series with a $6V$ source.

Therefore, the reading of the ammeter is

$$\frac{6V}{(50\Omega+150\Omega+100\Omega)} = \frac{6}{300}A = 0.02A$$

30. **Ans. (C)**



(i) $V_A = -10V$ & $V_B = -5V$

D_1 & D_3 reverse biased, D_2 is forward biased

$$\Rightarrow R_{AB} = R + \frac{R}{4} + \frac{R}{4} = \frac{3}{2}R$$

(ii) When $V_A = -5V$ and $V_B = -10V$

D_2 is reverse biased, D_1 & D_3 are forwards biased,

$$\Rightarrow R_{AB} = \frac{R}{4} + \frac{R}{2} + \frac{R}{4} = R$$

(iii) In this case equivalent resistance between A and B is also R.

31. **Ans. (A)**

Zener diode had the ability to maintain constant voltage across it for a large range of input voltages and is hence used as a voltage regulator.

32. **Ans. (D)**

D_1 is reverse biased therefore it will act like an open circuit

$$i = \frac{12}{6} = 2.00\ A$$

33. **Ans. (B)**

As Zener diode is being used as voltage regulator, voltage across R_L has to be constant so current I_L has to be constant, As voltage V_{in} is increasing voltage drop at R_s will increase so current through R_s increases.

Since $I = I_Z + I_L$

I_L is constant and $I\uparrow$ so $I_Z\uparrow$.

34. **Ans. (D)**

When the voltage is $-5V$, the diode will be reverse biased and the voltage drop across the resistor will be zero as there is no current in the circuit.

And when voltage is $+5V$, the diode will be forward biased, the voltage drop across resistor will be the same as input voltage.

35. **Ans. (C)**

Initially Ge & Si are both forward biased so current will effectively pass through Ge diode with a drop of $0.3\ V$.

So, $V_0 = 12 - 0.3 = 11.7\ V$

if "Ge" is reversed then current will flow through "Si" diode is

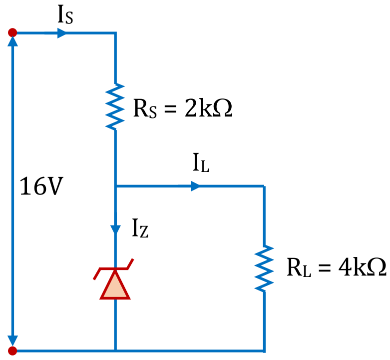
$V_0 = 12 - 0.7 = 11.3\ V$

So difference $= 11.7 - 11.3 = 0.4V$

36. Ans. (B)

Maximum current will flow from Zener if input voltage is maximum.

When Zener diode works in breakdown state, voltage across the Zener will remain same.



$\therefore$ $V_{across}\ 4k\Omega = 6V$

$\therefore$ Current through $4K\Omega = \frac{6}{4000}A = \frac{6}{4}mA$

Since input voltage = $16V$

$\therefore$ Potential difference across $2K\Omega = 10V$

$\therefore$ Current through $2k\Omega = \frac{10}{2000} = 5mA$

$\therefore$ Current through Zener diode

$= (I_S - I_L) = 3.5\ mA$

37. Ans. (B)

As there are two zener diodes in reverse polarity so if one is in forward bias the other will be in reverse bias and above $6V$ the reverse bias will too be in conduction mode. Therefore when voltage is more than $6V$ the output will be constant and when it is less than $6V$ it will follow the input voltage so correct answer is two.

38. Ans. (B)

Zener diode is heavily doped and have narrow depletion layer.

Option (B) is correct.

39. Ans. (C)

$I_L = \frac{V_L}{R_L} = 5mA$

$I = \frac{50}{4\times10^3} = 12.5mA$

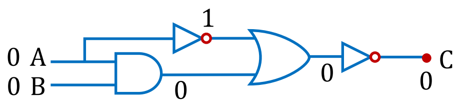
$I = I_Z + I_L$

$12.5 - 5 = I_Z$

$I_Z = 7.5mA$

40. Ans. (B)

For $A = 0, B = 0$



Similarly check for other option in the table.

41. Ans. (D)

The output D for the given combination –

$$D = \overline{(A+B)\cdot C} = \overline{(A+B)} + \overline{C}$$

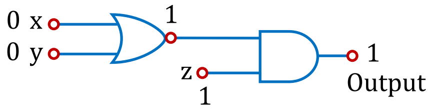
If $A = B = C = 0$ then $D = \overline{(0+0)} + \overline{0} = \overline{0} + \overline{0} = 1 + 1 = 1$

If $A = B = 1, C = 0$ then $D = \overline{(1+1)} + \overline{0} = \overline{1} + \overline{0} = 0 + 1 = 1$

42. Ans. (A)

This symbol represents NOT gate.

43. **Ans. (D)**



44. **Ans. (C)**

If either/both input are high $\Rightarrow$ output high

If both are low $\Rightarrow$ output low

Hence OR Gate.

45. **Ans. (D)**

$P = \bar{x} + y$

$Q = \overline{\bar{y}.x} = y + \bar{x}$

$O/P = \overline{P + Q}$

To make O/P

$P + Q$ must be 'O'

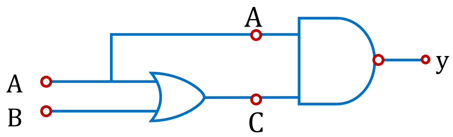
So, $y = 0$

$x = 1$

46. **Ans. (C)**

A	B	Y
0	0	1
1	0	0
0	1	0
1	1	0

47. **Ans. (A)**



$C = A + B$

and $y = \overline{A.C}$

A	B	$C=(A+B)$	$A.C.$	$y=\overline{A.C}$
0	0	0	0	1
0	1	1	0	1
1	0	1	1	0
1	1	1	1	0

48. **Ans. (BC)**

Larget face = $10.4 \times 3.8 = 39.52$

ans will have 2 sig figure

Hence ≈ 40 is correct

$\rightarrow$ Smallest face = $3.8 \times 1.02 = 3.876$

ans will have 2 sig figure

Hence $\approx 3.9\ cm^2$

$\rightarrow$ Volume $\approx 40 = 4.0 \times 10^1\ cm^3$

49. **Ans. (AC)**

$VSD = 1.1\ mm$ and $1\ MSD = 1.0\ mm$

Least count = $LC = MSD \sim VSD = 0.1\ mm$

For (A) : Zero error = – (No. of divisions of vernier scale coincident) × $LC = -7 \times 0.1 = -0.7\ mm$

For (C) : Reading = (No. of divisions coincident on main scale) × MSD

– (No. of divisions coincident on vernier scale) LC– zero error

$= 11 \times 1\ mm + 5 \times 0.1\ mm - (-0.7\ mm)$

$= 12.2\ mm = 1.22\ cm$

50. **Ans. (ABD)**

Least count = $\frac{1MSD}{100} = 0.01mm$

Zero error = $-1mm + 98\ LC$

$= -1mm + 0.98\ mm$

$= -0.02\ mm$

Diameter = Reading – Zero error

$= (2.23\ mm) - (-0.02\ mm)$

$= 2.25\ mm$

51. **Ans. (BC)**

$$\frac{\Delta R}{R} = \frac{\Delta L}{L} + \frac{2\Delta r}{r}$$

V·C → L·C = 1 MSD – 1 VSD

L·C = 1 mm – 0.9 mm = 0.1 mm

S·G → L·C = Pitch/no. of turn

L·C = 1mm/100 = 0.01 mm

for gold strip $\frac{\Delta R}{R} = \frac{5}{100}$

In option (B)

$$\frac{\Delta R}{R} = \frac{0.1}{3+3\times 0.1} + \frac{2\times 0.1}{1+0}$$

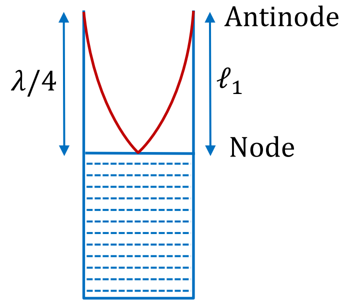
$$= \frac{1}{33} + \frac{2}{100} = 0.08$$

In option (C)

$$\frac{\Delta R}{R} = \frac{0.1}{50+0} + \frac{2\times 0.01}{0+0.01\times 40}$$

$$= \frac{1}{500} + \frac{1}{20} = 0.052$$

52. **Ans. (AD)**



(A) The intensity of sound decreases with increases of order. The intensity of sound is maximum for first resonance.

(B) The prongs vibrate in vertical plane.

(C) The prongs does not vibrate in amplitude of that order.

(D) Consider end correction, the length of air column is slightly less than $\lambda/4$.

53. Ans. (ACD)

$h = 6.23 - 1.43 = 4.80cm$

$\frac{\Delta h}{h} = \frac{0.01}{4.80} \times 100 = \frac{1}{4.80}\% \approx 0.280\%$

$h = \frac{2s}{rpg}$

$\frac{\Delta s}{s} = \frac{\Delta h}{h} + \frac{\Delta r}{r} = \frac{2}{480} + \frac{0.02}{0.16} \approx 12.92\%$

$S = \frac{4.80 \times 0.16 \times 10^{-4} \times 10^{9}}{2} = 0.384N/m$

54. Ans. (ABD)

When Jockey is shifted to left then

(A) D is at high potential and B at low potential so current will flow from the meter bridge to the point B.

(B) When Jockey is shifted to right then D is at low potential and B at high potential so current will flow from point B to the meter bridge.

(D) When P is heated the value of resistance increases due to which potential of B decreases so current will flow from meter bridge wire to point B.

55. Ans. (ABC)

(A) Least count of device used to measure R_2 is 0.2 Ω

(B) $R_{eq} = R_1 + R_2 \Rightarrow \frac{\Delta R_{eq}}{R_{eq}} \times 100\% = \frac{\Delta R_1 + \Delta R_2}{R_{eq}} \times 100 = 3.34\%$

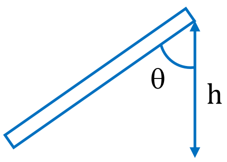
(C) $\frac{\Delta R_{eq}}{R_{eq}^2} = \frac{\Delta R_1}{R_1^2} + \frac{\Delta R_2}{R_2^2}$

$\Delta R_{eq} \simeq 0.1$ (Approx)

56. Ans. (ABC)

Experimental

57. Ans. (A)



(2) $\rho = hpg < Lpg$

(1) $\rho = \frac{h'pg}{1 + \propto \Delta T}$

$h' > h$

58. Ans. (C)

$\frac{\Delta p}{b} = \frac{\Delta h}{h} = \frac{0.05 \times 100}{752.9}$

EXERCISE – S

1. **Ans.** 7

significant number are 3, 3, 4, 4, 3, 5, 2, and 4 of p, q, r, s, t, u, v and w Respectively

$\left(\frac{p+q+r+s+t+u+w}{4}\right)$

$=\left(\frac{3+3+4+4+3+5+2+4}{4}\right)$

$=\frac{28}{4}=7$

2. **Ans.** 5

$1\ MSD = a$

$19\ MSD = 20\ VSD$

$\Rightarrow\ 1VSD = \frac{19}{20} MSD$

$\Rightarrow\ 1VSD = \frac{19}{20}a$

$L.C. = 1\ MSD - 1\ VSD$

$\Rightarrow\ L.C. = a - \frac{19a}{20} = \frac{a}{20}$

$\Rightarrow\ L.C. = \frac{a}{20} = \frac{a}{4x} \Rightarrow x = 5$

3. **Ans.** $R_t = 3.64\ mm$

Pitch = 1 mm

Least count (LC) = $\frac{\text{Pitch}}{\text{Circular divisions}}$

$\Rightarrow L.C. = \frac{1\ mm}{50}$

Zero error = – (50 – 44) × $L.C.$

$\Rightarrow$ Zero error = – 6 $L.C.$

Reading = $MSR + VSR$ – zero error

= 3 mm + 26 × LC – (– 6 LC)

= 3 mm + 32 LC

= 3 mm + $\frac{32\times 1\ mm}{50}$

Reading = 3mm + 0.64 mm = 3.64 mm

4. **Ans.** $\overline{D}=1.330cm$. $\overline{\Delta D}=0.005cm$, Relative error = + 0.004 %, error = 0.4%

$D=\frac{\Sigma(D)}{N}=\frac{1.324+1.326+1.334+1.336}{4}=1.330.$

ΔD_1 = 1.324 – 1.330 = –0.006

ΔD_2 = 1.326 – 1.330 = –0.004

ΔD_3 = 1.334 – 1.330 = 0.004

ΔD_4 = 1.336 – 1.330 = 0.006

$\Delta\ D=\frac{|\Delta D_1|+|\Delta D_2|+|\Delta D_3|+|\Delta D_4|}{4}$

$=\frac{0.006+0.004+0.004+0.006}{4}=\frac{0.020}{4}=0.005cm$

Relative error = $\frac{\Delta D}{D}=\frac{0.005}{1.330}$ =0.004

% error = $\frac{\Delta D}{D}$ × 100 = 0.4%.

5. **Ans.** 3

Least count = $\frac{1mm}{10} = 0.1\ mm$; Zero error

= $-(10-6) \times 0.1 = -0.4\ mm$;

Reading = $6 + 5 \times (0.1) - (-0.4) = 6.9\ mm$

6. **Ans.** $L.C. = \ell\left[\frac{1-\cos\theta}{\cos\theta}\right]$

Least count = $\frac{\ell}{\cos\theta} - \ell$

$= \ell\left[\frac{1}{\cos\theta} - 1\right]$

$= \ell\left[\frac{1-\cos\theta}{\cos\theta}\right]$

7. **Ans.** 5.5 ± 0.1 cm

Bench error in measurement of object distance from lens.

$u_{\text{bench error}} = (x_L - x_0) - 10\ cm$

$u_{\text{bench error}} = 9.8 - 10 = -0.2\ cm$

Bench error in measurement of image distance from lens.

$V_{\text{bench error}} = (x_I - x_L) - 10\ cm$

$V_{\text{bench error}} = (10.1) - 10\ cm = +0.1\ cm$

Now focal length for given reading

$x_0 = 0.6\ cm$ $\quad$ $x_I = 22.5\ cm$ $\quad$ $x_L = 11.4\ cm$

$u = -[(x_L - x_0) - \text{ bench error}]$

$u = -[(11.4 - 0.6)cm - (-0.2)cm]$

$u = -11\ cm$

$V = (x_I - x_L) - \text{ bench error}$

$V = 11.1\ cm - 0.1\ cm = 11\ cm$

$\frac{1}{f} = \frac{1}{V} - \frac{1}{u}$

$\Rightarrow \frac{1}{f} = \frac{1}{11} - \frac{1}{(-11)}$

$\Rightarrow f = \frac{11}{2} cm = 5.5\ cm$

$\frac{\Delta f}{f^2} = \frac{\Delta V}{V^2} + \frac{\Delta u}{u^2}$

$\Rightarrow \Delta f = \left(\frac{\Delta V}{V^2} + \frac{\Delta u}{u^2}\right) f^2$

$\Rightarrow u = x_L - x_0,\ V = x_I - x_L$

$\Delta u = \Delta x_L + \Delta x_0$

$\Delta u = 0.1 + 0.1 = 0.2$

$\Delta f = \left(\frac{0.2}{11^2} + \frac{0.2}{11^2}\right) \times \left(\frac{11}{2}\right)^2$

$\Delta f = \frac{0.4}{11^2} \times \frac{11^2}{4} = 0.1$

$f = 5.5 \pm 0.1\ cm$

8. **Ans.** 4

$E(t) = A^2 e^{-\alpha t}$

$\ln E = ln A^2 + ln e^{-\alpha t}$

$\ln E = 2 \, ln \, a - \alpha t$

$$\frac{\Delta E}{E}\times 100 = 2\frac{\Delta A}{A}\times 100 + \alpha \Delta t \times 100$$

$$= 2 \times 1.25 + \frac{2}{10}\times 1.5 \times 5$$

$= 2.5 + 1.5 = 4\%$

9. **Ans.** 1.25

$$\frac{d_I}{i} = \frac{d_0}{\mu} = \frac{h_3 - h_1}{\mu}$$

$$d_I = h_3 - h_2$$

$$\Rightarrow \quad \mu = \frac{h_3 - h_1}{h_3 - h_2} = \frac{4.80}{2.40} = 2$$

$$\frac{du}{\mu} = \frac{dh_3 + dh_1}{h_3 - h_1} + \frac{dh_3 + dh_2}{h_3 - h_2}$$

$$= \frac{0.02[3]}{4.80}\times 100$$

% error = $\frac{60}{48}$

10. **Ans.** 2.50

$$W = A^3 \ln(at^2)$$

$$dW = 3A^2 dA \ln(at^2) + \frac{A^3}{at^2}\times 2atdt$$

$$dW = 3A^2 dA \ln(at^2) + \frac{A^3 2dt}{t}$$

$$\frac{dW}{W} = \frac{3A^2 dA}{A^3} + \frac{2dt}{t\ln(at^2)}$$

$$\frac{dW}{W}\times 100 = \frac{3dA}{A}\times 100 + \frac{2}{\ln(12)}\left(\frac{dt}{t}\right)\times 100$$

11. **Ans.** 8

$$\ell_{\text{best}} = \frac{200\times 5.5}{10.0} = 110$$

Now $\frac{\delta\ell}{\ell} = \frac{\delta\ell_1}{\ell_1} + \frac{\delta\ell_2}{\ell_2} + \frac{\delta\ell_3}{\ell_3} = 7.5\%$

So final answer is $\ell = (110 \pm 8)\, ft$

12. **Ans.** (i) 10 V (ii) 90 V (iii) 4 mA

(i) Here output voltage will be equal to zener voltage

$V_L = 10V$

(ii) $V_R = V_{\text{total}} - 10V$

= 100 – 10

$V_R = 90V$

(iii) $I_L = \dfrac{10}{5 \times 10^3}$

$= 2 \times 10^{-3} A$

$I_L = 2mA$

$I_t = \dfrac{90}{15 \times 10^3} A$

= 6×10^{-3} A

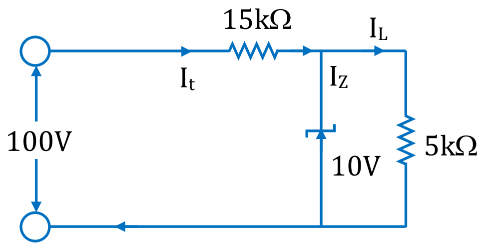
= 6 mA

By KCL

$I_t = I_Z + I_L$

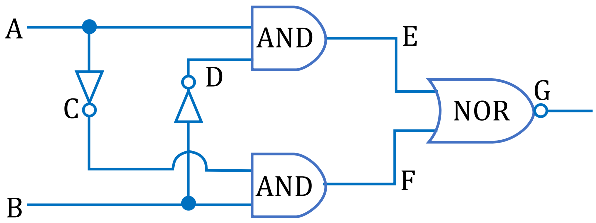
$6\ mA = I_Z + 2\ mA$

$I_Z = 4\ mA$



13. **Ans.**

A	B	C	D	E	F	G
0	0	1	1	0	0	1
0	1	1	0	0	1	0
1	0	0	1	1	0	0
1	1	0	0	0	0	1



C,D $\rightarrow$ Not gate

A	B	C	D	E	F	G
0	0	1	1	0	0	1
1	0	0	1	1	0	0
0	1	1	0	0	1	0
1	1	0	0	0	0	1

EXERCISE - JEE (Main) PYQ

1. **Ans. (3)**

$I = \left(e^{\frac{1000V}{T}} - 1\right) mA$

$T = 300\ K, \quad I = 5\ mA$

$5 = e^{\frac{1000V}{T}} - 1$

$e^{\frac{1000\,V}{T}} = 6$

Also, $\Delta I = e^{\frac{1000\,V}{T}} \times \frac{1000}{T} \times \Delta V$

$= 6 \times \frac{1000}{300} \times 0.01 mA$

$= 0.2\ mA$

2. **Ans. (4)**

$\ell = 3.50\ cm$

So LC of instrument is $0.01\ cm$

(1) $LC = \frac{1\ mm}{100} = 0.01\ mm = 0.001\ cm$

So it can't be the answer

(2) $LC = \frac{1\ mm}{50} = 0.02\ mm$

(3) Meter scale has $1\ cm$ as LC

(4) $LC = 1\ MSD - 1\ VSD \begin{bmatrix} 10\ VSD = 9\ MSD \\ 1\ VSD = 0.9\ MSD \end{bmatrix}$

$= 1\ MSD - 0.9\ MSD$

$= 0.1\ MSD$

and $\quad 1\ MSD = \frac{1\ cm}{10} = 0.1\ cm$

$\therefore \quad LC = 0.01\ cm \quad$ So this is correct option.

3. **Ans. (4)**

To make diode as forward biased the 'p' side (which is on left side here) should be at high potential than n side (which is at right side here.)

4. **Ans. (3)**

$LC = \frac{0.5\ mm}{50} = 0.01\ mm$

Zero error $= -0.5\ mm + 45\ (0.01)$

$= -0.05\ mm$

Reading taken $= 0.5\ mm + 25(0.01) = 0.75\ mm$

Actual reading = Measured reading – zero error

$= 0.75\ mm - (-0.05\ mm)$

$= 0.80\ mm$

5. **Ans. (2)**

$T_{avg} = \frac{90+91+95+92}{4} = 92\ sec.$

$\Delta T_{avg} = \frac{\sum_{i=1}^{4} |\Delta T_i|}{4} = \frac{2+1+3+0}{4} = 1.5\ sec.$

LC of $T_{avg}=92$ is 1 $sec.$ So LC of ΔT_{avg} should also be 1 $\quad \therefore \Delta T_{avg} \simeq 2\ sec.$

$\therefore \quad T = (92 \pm 2)\ sec.$

6. **Ans. (4)**

Output of OR gate is 0 when all inputs are 0 & output is 1 when at least one of the input is 1.

Observing output x: It is 0 when all inputs are 0 & it is 1 when at least one of the inputs is 1.

$\therefore$ OR gate

7. **Ans. (2)**

Zener diode works in breakdown region

So simple diode $\rightarrow$ (a), Solar cell $\rightarrow$ (c)

Zener diode $\rightarrow$ (b), Light dependent resistance $\rightarrow$ (d)

8. **Ans. (4)**

$$T = \frac{rhg}{2} \times 10^3$$

$$\frac{\Delta T}{T} \times 100 = \frac{\Delta r}{r} \times 100 + \frac{\Delta h}{h} \times 100$$

$$= \left(\frac{0.01\times10^{-2}}{1.25\times10^{-2}} \times 100 + \frac{0.01\times10^{-2}}{1.45\times10^{-2}} \times 100\right)$$

$= 1.5\ \%$

Value of g is given, not measured so it has no error.

9. **Ans. (2)**

$$\rho = \frac{m}{a^3}$$

$$\frac{\Delta\rho}{\rho} \times 100 = \frac{\Delta m}{m} \times 100 + 3\frac{\Delta a}{a} \times 100$$

$= (1.5\ \%) + 3(1\ \%)$

$= 4.5\ \%$

10. **Ans. (4)**

Assuming zener diode does not undergo breakdown, current in circuit $= \frac{120}{15000} = 8mA$

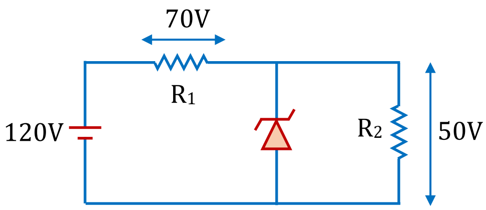
$\therefore$ Voltage drop across diode = 80 V > 50 V.

The diode undergo breakdown.

Current is $R_1 = \frac{70}{5000} = 14mA$

Current is $R_2 = \frac{50}{10000} = 5mA$

$\therefore$ Current through diode = $9mA$



11. **Ans. (3)**

$\ell = 25.0\ cm \quad \Rightarrow \quad \lambda.C. = 0.1\ cm$

$T = (50 \pm 1)s$

$$\frac{\Delta g}{g} = \frac{\Delta\ell}{\ell} + \frac{2\Delta T}{T} = \frac{0.1}{25} + \frac{2\times1}{50} = 0.004 + 0.04 = 0.044$$

$$\Rightarrow \frac{\Delta g}{g} \times 100 = 4.4\%$$

12. Ans. (4)

$L.C. = 0.1\ mm$

Given scale has $+ve$ zero error = $0.1\ mm \times 7 = 0.7\ mm$

Reading = $3.1\ cm + 4 \times 0.1\ mm - 0.7\ mm$

$\Rightarrow\ 3.07\ cm$

13. Ans. (4)

$L.C. = \dfrac{0.1cm}{50} = 0.002\ cm$

$\Rightarrow$ Last digit after decimal should be even

14. Ans. (2)

$$\frac{\Delta Z}{Z} = \frac{2\Delta a}{a} + \frac{2}{3}\frac{\Delta b}{b} + \frac{1}{2}\frac{\Delta C}{C} + 3\ \frac{\Delta d}{d}$$

$$= 2 \times 2 + \frac{2}{3}\ (1.5)\ +\ \frac{1}{2}(4) + 3\ (2.5)$$

$\Rightarrow\ 4 + 1 + 2 + 7.5 = 14.5\%$

15. Ans. (3)

As all reading have only three *S.F.*, so value should also be reported upto three *S.F.* Also error will be upto two decimal places.

16. Ans. (3)

$$T = 2\pi\sqrt{\frac{\ell}{g}}$$

$$\frac{\Delta T}{T} = \frac{1}{2}\frac{\Delta \ell}{\ell}$$

$$\Delta T = \frac{1}{2} \times \frac{0.1}{100} \times 24 \times 3600$$

$\Delta T = 43.2s$

17. Ans. (1)

$$R = \frac{\rho\ell}{A} = \frac{V}{I}$$

$$\rho = \frac{AV}{I\ell} = \frac{\pi d^2 V}{4I\ell} \qquad \left(A = \frac{\pi d^2}{4}\right)$$

$$\therefore\ \frac{\Delta\rho}{\rho} = \frac{2\Delta d}{d} + \frac{\Delta V}{V} + \frac{\Delta I}{I} + \frac{\Delta \ell}{\ell}$$

$$\frac{\Delta\rho}{\rho} = 2\left(\frac{0.01}{5.00}\right) + \frac{0.1}{5.0} + \frac{0.01}{2.00} + \frac{0.1}{10.0}$$

$$\frac{\Delta\rho}{\rho} = 0.004 + 0.02 + 0.005 + 0.01$$

$$\frac{\Delta\rho}{\rho} = 0.039$$

$$\%\ \text{error} = \frac{\Delta\rho}{\rho} \times 100 = 0.039 \times 100 = 3.9\%$$

18. Ans. (2)

$$y = \frac{MgL^3}{4bd^3\delta}$$

$$\frac{\Delta y}{y} = \frac{\Delta M}{M} + \frac{3\Delta L}{L} + \frac{\Delta b}{b} + \frac{3\Delta d}{d} + \frac{\Delta\delta}{\delta}$$

$$\frac{\Delta y}{y} = \frac{10^{-3}}{2} + \frac{3\times10^{-3}}{1} + \frac{10^{-2}}{4} + \frac{3\times10^{-2}}{4} + \frac{10^{-2}}{5}$$

$$= 10^{-3}[0.5 + 3 + 2.5 + 7.5 + 2] = 0.0155$$

19. Ans. (5)

$n_e n_h = n_i^2$

$$n_e = \frac{n_i^2}{n_h} = \frac{(1.5\times10^{16})^2}{4.5\times10^{22}} = \frac{1.5\times1.5\times10^{32}}{4.5\times10^{22}}$$

$5 \times 10^9\ /m^3$

20. Ans. (3)

When $V_i > 3$ volt, $V_R > 0$

Because diode will be in forward biased state

When $V_i \leq 3volt$; $V_R = 0$

Because diode will be in reverse biased state.

21. Ans. (4)

To convert pulsating *dc* into steady *dc* both of mentioned method are correct.

22. Ans. (4)

Truth table of the given gate:

A	B	C
0	0	0
0	1	1
1	0	0
1	1	0

Truth table of option (1)

A	B	C
0	0	1
0	1	1
1	0	0
1	1	1

Truth table of option (2)

A	B	C
0	0	1
0	1	0
1	0	1
1	1	1

Truth table of option (3)

A	B	C
0	0	1
0	1	0
1	0	0
1	1	0

Truth table of option (4)

A	B	C
0	0	0
0	1	1
1	0	0
1	1	0

Since option (1) has same truth table, hence answer is option (4) is correct.

Alternative solution :

Given Boolean expression can be written as

$\overline{A + \bar{B}} = C$

$\therefore \quad C = \bar{A}.\bar{\bar{B}} = \bar{A}.B$

Hence option (4) is correct.

23. Ans. (2)

$V_A = 5V \quad \Rightarrow \quad A = 1$

$V_A = 0\ V \quad \Rightarrow \quad A = 0$

$V_B = 5\ V \quad \Rightarrow \quad B = 1$

$V_B = 0\ V \quad \Rightarrow \quad B = 1$

If $A = B = 0$, there is no potential anywhere here

$V_0 = 0$

If $A = 1$, $B = 0$, Diode D_1 is forward biased, here $V_0 = 5V$

If $A = 0$, $B = 1$, Diode D_2 is forward biased hence $V_0 = 5V$

If $A = 1$, $B = 1$, Both diodes are forward biased hence $V_0 = 5V$

Truth table for I^{st}

A	B	Output
0	0	0
0	1	1
1	0	1
1	1	1

$\therefore$ Given circuit is OR gate

For II^{nd} circuit

$V_B = 5V, \quad A = 1$

$V_B = 0V, \quad A = 0$

When $A = 0$, E-B junction is unbiased there is no current through it

$\therefore \quad V_0 = 1$

When $A = 1$, E-B junction is forward biased

$\therefore \quad V_0 = 0$

$\therefore$ Hence this circuit is not gate.

24. **Ans. (3)**

$$\rho = \frac{m}{\pi r^2 l} \Rightarrow \left|\frac{d\rho}{\rho}\right|_{max} = \left|\frac{dm}{m}\right| + 2\left|\frac{dr}{r}\right| + \left|\frac{dl}{l}\right|$$

$$= \frac{0.01}{0.4} + \frac{2(0.03)}{6} + \frac{0.04}{8}$$

$$\Rightarrow \ \% \text{ error in density} = \left(\frac{d\rho}{\rho}\right) \times 100\%$$

$$= (2.5 + 1 + 0.5)\% = 4\%$$

25. **Ans. (1)**

$LC = 0.1\ mm$

Zero Error = $6 \times LC = 0.6\ mm$

Reading = $MSR + VSR \times LC$ – Zero Error

= $[32\ mm + (0.1)4\ mm] - 0.6\ mm$

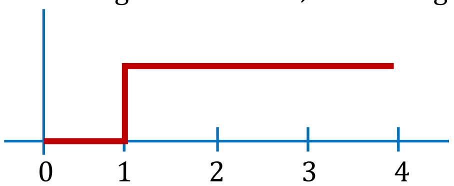
= $31.8\ mm$

= $3.18\ cm$

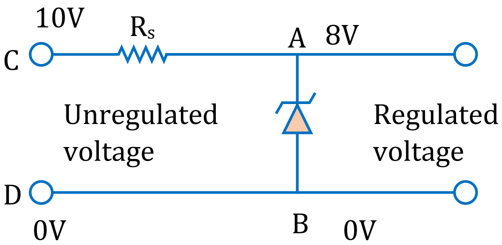
26. **Ans. (4)**

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

According to truth table, resultant graph is



27. **Ans. (3)**



$V_b = 8$ volt

$V_A - V_B = 8$ volt

Current through zener diode,

$$i = \frac{P}{V} = \frac{1.6W}{8V} = 0.2A$$

$V_C - V_A = 10 - 8$ volt

$$\therefore \quad R = \frac{V_C - V_A}{i} = \frac{2V}{0.2A} = 10\Omega$$

[Note : A zener diode can regulate only if input voltage is ≥ zener breakdown voltage the range of input voltage should be 8 to 10 V so that output voltage remains constant = 8 V]

EXERCISE - JEE (Advanced) PYQ

1. Ans. (D)

$d = \frac{\lambda}{2\sin\theta}$

$\frac{dd}{d\theta} = \frac{-\lambda}{2\sin^2\theta}\cos\theta$

$|\Delta d| = \frac{\lambda}{2}\frac{\cos\theta}{\sin^2\theta}\Delta\theta$

$\theta \uparrow \cos\theta \downarrow \sin^2\theta \uparrow \Delta d \downarrow$

$\frac{\Delta d}{d} = \frac{\cos\theta}{\sin\theta}\Delta\theta = \cot\theta\,\Delta\theta$

$\theta \uparrow \cot\theta \downarrow \frac{\Delta d}{d} \downarrow$

2. Ans. (4)

$Y = \frac{Mg}{A}\frac{\ell}{\Delta\ell}$

$\frac{\Delta Y}{Y} \times 100 = \frac{d(\Delta\ell)}{\Delta\ell} \times 100$

As M, A & ℓ are given

So, they don't have any errors.

$d(\Delta\ell) = LC = (1.0 \times 10^{-5})m$

and $\Delta\ell = \ell_f - l_i = (MSR + VSR_f \times LC) - (MSR + VSR_i \times LC)$

$= (45 - 20)\ LC = 25\ LC$

$\therefore \frac{\Delta Y}{Y} \times 100 = \frac{LC}{25 \times LC} \times 100 = 4\%$

3. Ans. (BC)

For Vernier 1 $msd = \frac{1}{8}\ cm$

and 5 vsd = 4 $msd \Rightarrow 1\ vsd = \frac{4}{5} \times \frac{1}{8} cm = \frac{1}{10} cm$

Least count $(L.C.) = \frac{1}{8} - \frac{1}{10} = \frac{1}{40} cm = \frac{1}{4} mm$

For screw gauge

1 pitch = 2 msd

$L.C. = \frac{1\ pitch}{100} = \frac{2\ msd}{100}$

(A, B) Pitch $=2\left(\frac{1}{4}mm\right) \Rightarrow L.C. = \frac{1/2}{100} = \frac{1}{200}\ mm$

$=0.005\ mm$

(C, D) 1 $msd = 2\left(\frac{1}{4}mm\right) \Rightarrow L.C. = \frac{2\left(\frac{1}{2}\right)}{100} = \frac{1}{100} mm = 0.01\ mm$

4. Ans. (4)

Energy $E = A^2 e^{-\alpha t}$

For small error

$dE = 2AdAe^{-\alpha t} + A^2(-\alpha e^{-\alpha t}dt)$

$\frac{dE}{E} = \frac{2dA}{A} - \alpha dt = \frac{2dA}{A} - \alpha\frac{dt}{t} \cdot t$

for error calculation

$\frac{dE}{E}\% = 2(1.25) + (0.2)\ (5)\ (1.5) = 4\%$

(Errors always add)

5. **Ans. (C)**

For C_1, 1 MSD=1 mm

And 10 VSD = 9 $MSD \Rightarrow$1 VSD =0.9 mm

Least count L_1=1- 0.9 = 0.1 mm

$M.V. = MSR + VSR = 28 + 7(0.1) = 28.7\ mm = 2.87\ cm$

For C_2, $1\ MSD = 1\ mm$

And 10 VSD = 11 $MSD \Rightarrow 1VSD = \frac{11}{10}$ mm= 1.1 mm

$36 = R + 7 \times 1.1$

$R = 36 - 7.7 = 28.3mm = 2.83\ cm$

6. **Ans. (ABD)**

T	$\Delta T = T - T_{\text{avg}}$
0.52	- 0.04
0.56	00
0.57	+ 0.01
0.54	- 0.02
0.59	+ 0.03

$$T_{avg} = \frac{0.52+0.56+0.57+0.54+0.59}{5}$$

$$= 0.556 = 0.56$$

$$\Delta T_{avg} = \frac{0.04+0+0.01+0.02+0.03}{5} = 0.02$$

$\Rightarrow$ T=0.56±0.02

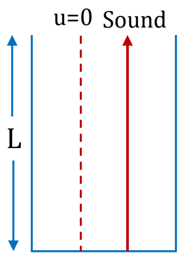
$$T=2\pi\sqrt{\frac{7(R-r)}{5g}} \Rightarrow \frac{\Delta T}{T} = \frac{\Delta(R-r)}{2(R-r)} + \frac{\Delta g}{2g} = \frac{\Delta R+\Delta r}{2(R-r)} + \frac{\Delta g}{2g}$$

$$\frac{\Delta g}{g}\% = \frac{1+1}{50} \times 100 + 2\left(\frac{0.02}{0.56}\right) \times 100 \approx 11\%$$

7. **Ans. (D)**

Time $T=\sqrt{\frac{2L}{g}} + \frac{L}{V}$ ($V \to$ speed of sound)

Differentiate both side



$$dT = \sqrt{\frac{2}{g}} \cdot \frac{1}{2\sqrt{L}} dL + \frac{1}{V} dL$$

$$dT = \left(\frac{1}{\sqrt{2\times10\times20}} + \frac{1}{300}\right) dL$$

$$dT = \frac{16}{300} dL$$

$$dL = \frac{300\times0.01}{16} = \frac{3}{16}$$

$$\frac{dL}{L}\% = \frac{3}{16\times20} \times 100 = \frac{15}{16}\% \approx 1\%$$

8. **Ans. (B)**

$$r = \frac{1-a}{1+a}$$

$$\Rightarrow dr = \frac{(1+a)(-da)-(1-a)(da)}{(1+a)^2} = \frac{2da}{(1+a)^2}$$

$$\Delta r = \frac{2\Delta a}{(1+a)^2}$$

9. **Ans. (C)**

Number of nuclei after 1 *sec.*

$N = 3000 - (1000 \pm 40) = 2000 \pm 40$

$N = N_0 e^{-\lambda t}$

$\ln N = lnN_0 - \lambda t$

$\Rightarrow \dfrac{dN}{N} = -(\lambda dt + td\lambda) = -td\lambda \ (dt = 0)$

$\dfrac{\Delta N}{N} = t\Delta\lambda$

$\Rightarrow \Delta\lambda = \dfrac{40}{2000\times1} = 0.02s^{-1}$

10. **Ans. 3 [2.99, 3.01]**

Given $d = 0.5\ mm, y = 2\times10^{11}, L = 1\ m$

Also $\ell = \dfrac{4mgL}{\pi d^2 Y} = \dfrac{4\times1.2\times10\times1}{\pi\left(5\times10^{-4}\right)^2\times2\times10^{11}} \approx 0.3\ mm$

Reading Vernier = $0.3\ mm = 0 + 3(0.1)$

$\Rightarrow$ 3^{rd} division of Vernier concide with main scale.

11. **Ans. (1.35 to 1.45)**

$1\ MSD = \frac{1}{4}\ cm \Rightarrow \Delta v = \Delta u = 2\left(\frac{1}{4} cm\right) = \frac{1}{2} cm$

$X_{\text{lens}} = 75\ cm, X_{\text{object}} = 45\ cm, X_{\text{image}} = 135\ cm$

$u = -(75-45) = -30\ cm$ and $v = (135-75) = 60\ cm$

$\dfrac{1}{f} = \dfrac{1}{v} - \dfrac{1}{u} = \dfrac{1}{60} + \dfrac{1}{30} \Rightarrow f = 20\ cm$

Also $\dfrac{\Delta f}{f^2} = \dfrac{\Delta v}{v^2} + \dfrac{\Delta u}{u^2} \Rightarrow \dfrac{\Delta f}{f}\% = \left(\dfrac{\Delta v}{v^2} + \dfrac{\Delta u}{u^2}\right) \times f \times 100\%$

$\dfrac{\Delta f}{f}\% = \left(\dfrac{1/2}{(60)^2} + \dfrac{1/2}{(30)^2}\right) 20 \times 100\ \% \approx 1.39\%$

12. **Ans. (1.30)**

Series $= \left(\dfrac{C_1C_2}{C_1+C_2}\right) = 1200\ PF$

$\dfrac{\Delta C_{eq}}{C^2} = \dfrac{\Delta C_1}{C_1^2} + \dfrac{\Delta C_2}{C_2^2}$

$\dfrac{\Delta C_{eq}}{(1200)^2} = \dfrac{10}{(2000)^2} + \dfrac{15}{(3000)^2}$

$\Delta C_{eq} = 10 \times \left(\dfrac{1200}{2000}\right)^2 + 15\left(\dfrac{1200}{3000}\right)^2$

$= 10 \times (0.36) + 15(0.16)$

$\Rightarrow \Delta C_{eq} = 6\ PF$

$\Rightarrow U = \frac{1}{2}CV^2$

$\Rightarrow \dfrac{\Delta U}{U} = \dfrac{\Delta C}{C} + \left(\dfrac{2\Delta V}{V}\right)$

$= \dfrac{6}{1200} + \dfrac{2\times0.02}{5} = .005 + .008$

$= 0.013 = 1.3\ \%$

13. Ans. (C)

Given 10 VSD = 9 MSD Here $MSD \to$ Main Scale division

1 $VSD = \frac{9}{10} MSD$ $VSD \to$ Vernier Scale division

Least count $= 1\ MSD - 1\ VSD$

$= \left(1 - \frac{9}{10}\right) MSD$

$= 0.1\ MSD$

$= 0.1 \times 0.1\ cm$

$= 0.01\ cm$

As '0' of $V.S.$ lie before '0' of $M.S.$

Zero error $= -[10 - 6]L.C.$

$= -4 \times 0.01\ cm$

$= -0.04\ cm$

Reading $= 3.1\ cm + 1 \times LC$

$= 3.1\ cm + 1 \times 0.01\ cm$

$= 3.11\ cm$

True diameter = Reading – Zero error

$= 3.11 - (-0.04)\ cm = 3.15\ cm$

14. Ans. (C)

$LC = \frac{0.1}{100} = 0.001 mm$

Zero error $= 4 \times 0.001 = 0.004\ mm$

Reading 1 $= 0.5 \times 4 + 20 \times 0.001 - 0.004 = 2.16\ mm$

Reading 2 $= 0.5 \times 4 + 16 \times 0.001 - 0.004 = 2.12\ mm$

Mean value $= 2.14\ mm$

Mean absolute error $= \frac{0.02+0.02}{2} = 0.02$

Diameter $= 2.14 \pm 0.02$

Area $= \frac{\pi}{4} d^2$

15. Ans. (1)

$u = 10 \pm 0.1\ cm$, $v = 20 \pm 0.2\ cm$

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{v^2} dv + \frac{1}{u^2} du = -\frac{1}{f^2} df$$

$$\frac{1}{20} + \frac{1}{10} = \frac{1}{f} \Rightarrow \frac{1}{f} = \frac{3}{20} \Rightarrow f = \frac{20}{3} cm$$

$$\Rightarrow \frac{1}{(20)^2}(0.2) + \frac{1}{(10)^2}(0.1) = \frac{9}{400} df$$

$$df = \frac{1}{9}\left(\frac{400}{400} \times 0.2 + \frac{400}{100} \times 0.1\right)$$

$$df = \frac{1}{9}(0.2 + 0.4) \Rightarrow df = \frac{0.6}{9}$$

$$\frac{df}{f} = \frac{0.6}{9} \times \frac{3}{20} = \frac{1}{100}$$

% error = 1 %

JEE (Main) Practice Paper

SECTION–A

1. Ans. (3)

$a + b = 14 \pm 0.14 \quad \Rightarrow \quad \%\text{ error} = \frac{0.14}{14} \times 100 = 1\%$

$a - b = 2 \pm 0.14 \quad \Rightarrow \quad \%\text{ error} = \frac{0.14}{2} \times 100 = 7\%$

$a \times b = 48 \pm 0.96 \quad \Rightarrow \quad \%\text{ error} = \frac{0.96}{48} \times 100 = 2\%$

Order of % error $x < z < y$.

2. Ans. (1)

Volume of cube $\Rightarrow v = a^3$

$a = 1.2 \times 10^{-2}\ m$

Significant digit = 2

$V = a^3 \Rightarrow V = (1.2 \times 10^{-2} m)^3$

$\Rightarrow V = 1.728 \times 10^{-6}\ m^3$

In this operation, minimum two significant digit is involved during multiplication of side.

The answer expressed with least significant digit hence volume expressed with two significant digit only.

$V = 1.7 \times 10^{-6}\ m^3$

3. Ans. (1)

(i) $1MSD = 0.05\ cm$

$1VSD = \frac{2.45}{50}\ cm$

Least count $= 1MSD - 1VSD$

$\Rightarrow LC = 0.05\ cm - \frac{2.45}{50} cm$

$\Rightarrow LC = 0.001\ cm$

(ii) One circular scale division = 0.01 mm

Least count = 0.01 mm = 0.001 cm

Same least count in the both the experiments.

4. Ans. (1)

Pitch = 1 mm

$\Delta\ell$ = Quarter turn $= \frac{\text{Pitch}}{4} = \frac{1}{4} mm$

$\Rightarrow \Delta\ell = 0.25 \times 10^{-3} m$

$\ell = 3m$, Load $(W) = 50\ kg$

$A = 10^{-5}\ m^2$

$$Y = \frac{\frac{F}{A}}{\frac{\Delta\ell}{\ell}} = \frac{F\ell}{A\Delta\ell} = \frac{500 \times 3}{10^{-5} \times 0.25 \times 10^{-3}}$$

$Y = 6 \times 10^{11}\ N/m^2$

5. Ans. (2)

$v_d = \frac{eE\tau}{m} = v$

$T \uparrow \Rightarrow \tau \downarrow \Rightarrow v \downarrow$

As $T \uparrow \Rightarrow$ new electron hole pair created $\Rightarrow n \uparrow$

6. Ans. (3)

The P-type semiconductor is formed when the trivalent impurity is added to the pure semiconductor.

7. Ans. (2)

Temperature coefficient is positive for conductors, so for copper as $T \downarrow \Rightarrow \rho \downarrow$

For semiconductor temperature coefficient $-ve$ then for germanium as $T \downarrow \Rightarrow \rho \uparrow$.

8. Ans. (4)

As we know from theory of diode that the forward bias resistance of diode is very high; almost infinity for small values of V and after a certain value it becomes very low and the reverse bias resistance of diode is very high in the beginning up to breakdown voltage is not achieved.

9. Ans. (2)

When $+ve$ terminal is connected to A, D_2 is reversed biased & D_1 will forward biased.

$$i = \frac{2}{5} = 0.4A$$

When $+ve$ terminal is connected to B, D_1 is reversed biased and D_2 is forward biased.

$$i' = \frac{2}{10} = 0.2A$$

10. Ans. (2)

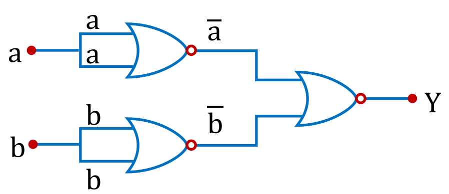
In reverse bias, current will be blocked by diode.

11. Ans. (2)

Circuit is closed when neither A nor B is closed $\Rightarrow$ current flows for $A = 0$, $B = 0$ when either or both of A and B is closed we get current bypass from switch

Hence it is "NOR" gate.

12. Ans. (1)



$Y = \overline{\bar{a} + \bar{b}} = a \cdot b$

The truth table for the given circuit will be

a	b	output
0	0	0
0	1	0
1	0	0
1	1	1

Hence it will be equivalent to AND gate.

13. Ans. (1)

Truth table for NAND gate is

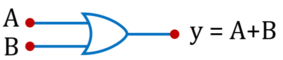
A	B	$Y = \overline{A \cdot B}$
0	0	1
0	1	1
1	0	1
1	1	0

On the basis of given input A and B the truth table is

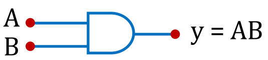
A	B	Y
1	1	0
0	0	1
0	1	1
1	0	1
1	1	0
0	0	1
0	1	1

So the correct answer is Option 1.

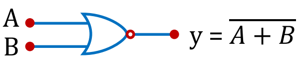
14. Ans. (3)



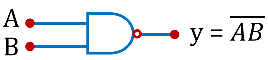
(1) OR Gate



(2) AND Gate



(3) NOR Gate



(4) NAND Gate

15. Ans. (2)

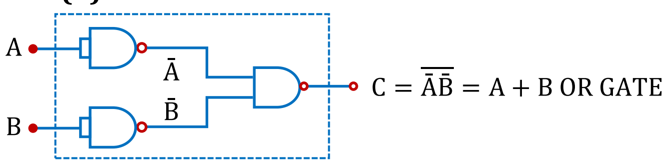
From the table $A + B = X \Rightarrow$ OR Gate

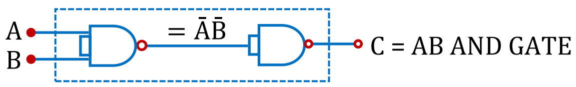
16. Ans. (3)

$AB = C \Rightarrow$ AND Gate

A	B	C
1	1	1
0	1	0
1	0	0
0	0	0

17. Ans. (1)





SECTION-B

1. **Ans. (200)**

$L.C. = \dfrac{\text{pitch}}{\text{no. of divisions}}$

$5 \times 10^{-6}\, m = \dfrac{1mm}{n} = \dfrac{10^{-3}m}{n}$

$\Rightarrow \quad n = \dfrac{1000}{5} = 200$

2. **Ans. (5)**

$20\ MSD = 1cm$

$1MSD = \dfrac{1}{20}cm$

$10\ VSD = 9MSD$

$1VSD = \dfrac{9}{10}MSD$

$= \dfrac{9}{10} \times \dfrac{1}{20}cm$

$1VSD = \dfrac{9}{200}cm$

$VC = 1\ MSD - 1\ VSD$

$= \dfrac{1}{20}cm - \dfrac{9}{200}cm$

$= \dfrac{1}{200} \times 10mm$

$VC = 5 \times 10^{-2}\ mm$

3. **Ans. (13)**

For (A)

Reading = $MSR + CSR$ + Error

$0.322 = 0.300 + CSR + 5 \times LC$

$0.322 = 0.300 + CSR + 0.005$

$CSR = 0.017$

For (B)

Reading = $MSR + CSR$ + Error

$0.322 = 0.200 + CSR + 0.092$

$CSR = 0.030$

Difference = $0.030 - 0.017 = 0.013\ cm$

Division on circular scale = $\dfrac{0.013}{0.001} = 13$

4. **Ans. (5)**

$VI = 100 \times 10^{-3}W \Rightarrow I = \dfrac{10^{-1}}{V} = \dfrac{10^{-1}}{0.5} = \dfrac{1}{5}A$

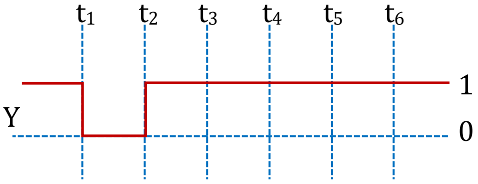
Applying KVL: $1.5 - \dfrac{1}{5}R - 0.5 = 0 \Rightarrow R = 5\Omega$

5. **Ans. (100)**

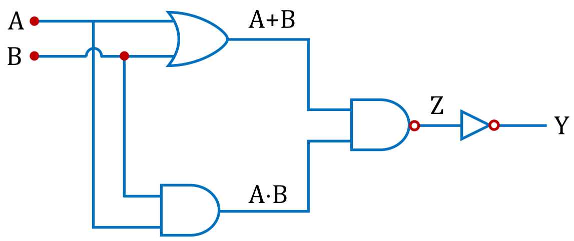
In half wave rectifier $E_{rms} = \dfrac{\int_0^{\frac{T}{2}} E_0 \sin \omega t dt}{\int_0^T dt} = \dfrac{E_0}{2} = \dfrac{200}{2} = 100V$

6. **Ans. (1)**

$Y = \overline{\overline{A} \cdot B} = A + \overline{B}$



7. **Ans. (1)**



$Z = \overline{(A + B).(A.B)}$

$Y = \overline{Z} = (A+B).(A.B)$

$Y = A.B$

$\therefore$ It is an AND Gate

8. **Ans. (25)**

Current through $2k\Omega$ resistance

$$I = \frac{5}{2\times10^3} = 2.5 \times 10^{-3} A$$

$$I = 25 \times 10^{-4} A$$

JEE (Advanced) Practice Paper

1. **Ans. (D)**

Mass = $0.3 \pm 0.003 g$

Radius = $0.5 \pm 0.005\ mm$

Length = $6 \pm 0.06\ cm$

$$\rho = \frac{m}{v} = \frac{m}{\pi r^2 \ell}$$

$$\Rightarrow \frac{\Delta\rho}{\rho} = \frac{\Delta m}{m} + \frac{2\Delta r}{r} + \frac{\Delta\ell}{\ell}$$

$$\Rightarrow \frac{\Delta\rho}{\rho} = \frac{0.003}{0.3} + 2 \times \frac{0.005}{0.5} + \frac{0.06}{6}$$

$$\Rightarrow \frac{\Delta\rho}{\rho} = 10^{-2} + 2 \times 10^{-2} + 10^{-2}$$

$$\Rightarrow \frac{\Delta\rho}{\rho} = 4 \times 10^{-2}$$

$$\% \text{ error} = \frac{\Delta\rho}{\rho} \times 100 = 4\%$$

2. **Ans. (C)**

$1MSD = 0.1cm$

Least count = 0.02 cm

Least count = 1 MSD – 1VSD

$0.02\ cm\ = 0.1cm - 1VSD$

$\Rightarrow \quad 1VSD = 0.08cm$

n division on vernier scale = m length of vernier scale

$\Rightarrow \quad n \times VSD = m$

$1VSD = \frac{m}{n} = 0.08\ cm$

Only option C have $\frac{m}{n} = 0.08cm$

3. **Ans. (D)**

Error = 5 × $L.C.$

= 5 × 0.005 mm

MSR = 4 mm

VSR = 5 × (5 × 0.005) mm

Reading = MSR + VSR – Error

= 4mm + (20 × 0.005) mm

Reading = 4 mm + 0.1 mm

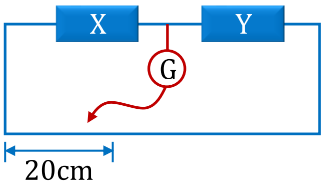
= 4.1 mm

This reading is measurement of diameter.

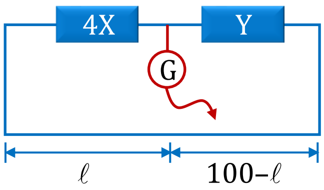
Radius = $\frac{\text{Diameter}}{2} = \frac{4.1}{2}mm$

Radius = 2.05 mm

4. **Ans. (A)**



$\frac{X}{Y} = \frac{20}{(100-20)} \Rightarrow \frac{X}{Y} = \frac{1}{4}$



$\frac{4X}{Y} = \frac{\ell}{100-\ell} \Rightarrow 4 \times \frac{1}{4} = \frac{\ell}{100-\ell}$

$\Rightarrow\ 100 - \ell = \ell \Rightarrow \ell = 50\ cm$

5. **Ans. (D)**

$$g = \frac{4\pi^2 \ell}{T^2}$$

$$\frac{\Delta g}{g} = \frac{\Delta \ell}{\ell} + 2\frac{\Delta T}{T}$$

$$\Rightarrow \frac{\Delta g}{g} = \frac{\Delta \ell}{\ell} + 2 \times \frac{\Delta t}{nt}$$

In option *D* we get least error.

6. **Ans. (B)**

When object is moved in left, then image moves in right. It means object must be between centre (2*f*) and focus (*f*).

7. **Ans. (B)**

Experimental.

8. **Ans. (D)**

$\ell_1 = 30.7\ cm$

$\ell_2 = 63.2\ cm$

Least count = 0.1cm = $\Delta\ell_2 = \Delta\ell_1$

$f = 512Hz,\ \Delta f = 0$

$\lambda = 2(\ell_2 - \ell_1)$

$\Rightarrow \Delta\lambda = \Delta\ell_2 + \Delta\ell_1 = 0.1 + 0.1 = 0.2cm$

$v = f\lambda$ ...(1)

Where $v = 512 \times 2(63.2 - 30.7)$

$\Rightarrow v = 33280 cm/sec$ ...(2)

$\Rightarrow \lambda = 2(\ell_2 - \ell_1) = 2 \times (63.2 - 30.7)\ cm$

$\Rightarrow \lambda = 65\ cm$ ...(3)

$$\Rightarrow \frac{\Delta v}{v} = \frac{\Delta f}{f} + \frac{\Delta \lambda}{\lambda}$$

$$\Rightarrow \frac{\Delta v}{33280} = 0 + \frac{0.2}{65}$$

$\Rightarrow \Delta v = 102.4 cm/sec$

9. **Ans. (ABC)**

Experimental

10. **Ans. (AB)**

$R_1 = 5.0 \pm 0.2\Omega$

$R_2 = 10.0 \pm 0.1\Omega$

Equivalent resistance Rs : when R_1 and R_2 is connected in series

$Rs = R_1 + R_2$

$\Delta R_s = \Delta R_1 + \Delta R_2 = 0.3\ \Omega$

$$\%\ \text{error} = \frac{\Delta R_S}{R_S} \times 100 = \frac{0.3}{15} \times 100 = 2\%$$

$\Rightarrow$ $R_S = 15.0\Omega \pm 2\%$

Equivalent resistance R_P : when R_1 and R_2 is connected in parallel.

$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\Rightarrow \frac{1}{R_P} = \frac{1}{5} + \frac{1}{10} \Rightarrow R_p = \frac{10}{3}\Omega$$

$$\Rightarrow R_P = 3.3\ \Omega$$

$$\frac{\Delta R_P}{(R_P)^2} = \frac{\Delta R_1}{{R_1}^2} + \frac{\Delta R_2}{R_2^2}$$

$$\Rightarrow \frac{\Delta R_P}{R_P} = \left(\frac{0.2}{25} + \frac{0.1}{100}\right) \times \frac{10}{3}$$

$$\Rightarrow \frac{\Delta R_P}{R_P} = 0.03$$

% error $\Rightarrow \frac{\Delta R_P}{R_P} \times 100 = 3\%$

$R_P = 3.3\Omega \pm 3\%$

(A) and (B).

11. Ans. (BC)

$$P = \frac{4\pi^2 A^3 B^2}{\sqrt{C}D}, P = 3.763$$

$$\frac{\Delta P}{P} \times 100 = \frac{3\Delta A}{A} + \frac{2\Delta B}{B} + \frac{1}{2}\frac{\Delta C}{C} + \frac{\Delta D}{D}$$

$$\frac{\Delta P}{P} \times 100 = (3 \times 1 + 2 \times 3 + \frac{1}{2} \times 2 + 4)\%$$

$$\Rightarrow \frac{\Delta P}{P} \times 100 = 14\%$$

Percentage error = 14%

$$\frac{\Delta P}{P} \times 100 = 14$$

$$\Delta P = \frac{14}{100} \times P$$

$$\Delta P = \frac{14}{100} \times 3.763$$

$$\Rightarrow \Delta P = 0.53$$

Absolute error = 0.53

12. Ans. (AD)

$$T = \frac{T_1 + T_2 + T_3 + T_4 + T_5}{5}$$

$$\Rightarrow T = \frac{2.63 + 2.56 + 2.42 + 2.71 + 2.80}{5}$$

$$\Rightarrow T = 2.624 \simeq 2.62 \text{ sec}$$

Absolute error

$$\Delta T_1 = 2.63 - 2.62 = 0.01$$

$$\Delta T_2 = 2.56 - 2.62 = -0.06$$

$\Delta T_3 = 2.42 - 2.62 = -0.2$

$\Delta T_4 = 2.71 - 2.62 = 0.9$

$\Delta T_5 = 2.80 - 2.62 = 0.18$

Average absolute error

$$\Delta T_{avg} = \frac{|\Delta T_1|+|\Delta T_2|+|\Delta T_3|+|\Delta T_4|+|\Delta T_5|}{5}$$

$$\Delta T_{avg} = \frac{0.01+0.06+0.2+0.09+0.18}{5}$$

$$\Delta T_{avg} = 0.108 \approx 0.11\, sec.$$

$$\% \text{ error} = \frac{\Delta T}{T} \times 100$$

$$= \frac{0.11}{2.62} \times 100\%$$

% error = 4.2 %

13. **Ans. (9)**

$$T = 2\pi\sqrt{\frac{\ell}{g}}$$

$$\Rightarrow\ g = \frac{2\pi\ell}{T^2}$$

$$\Rightarrow\ \frac{\Delta g}{g} = \frac{\Delta \ell}{\ell} + \frac{2\Delta T}{T}$$

Here $\ell = 10.0,\ \Delta\ell = 0.1$

$T = 0.50,\ \Delta T = 0.02$

$$\frac{\Delta g}{g} \times 100 = \left(\frac{10^{-1}}{10} + 2 \times \frac{2\times10^{-2}}{\frac{1}{2}}\right) \times 100$$

$$= (10^{-2} + 8 \times 10^{-2}) \times 100 = 9\%$$

14. **Ans. (266)**

$1MSD = 1mm$, $9MSD = 10\ VSD \Rightarrow 1\ VSD = \frac{9}{10}\ MSD$

Least count $(LC) = MSD - 1\ VSD = MSD - \frac{9}{10}\ MSD$

$$\Rightarrow\ LC = \frac{1}{10}\ MSD = \frac{1mm}{10} = 0.1mm$$

Reading = 10 mm + 1 × 0.1 mm = 10.1 mm = 1.01 cm

Side of cube = 1.01 cm

$$\text{Density} = \frac{m}{a^3} = \frac{2.736g}{(1.01cm)^3} = \frac{2.736gm}{1.030301cm^3}$$

$\Rightarrow$ density = 2.6555346 g/cm^3

Least significant digit is 3 in this operation, so answer will be correct upto 3 significant digit only.

density = 2.66 g/cm^3

15. **Ans. (26)**

Pitch = 1 mm

Division on circular scale = 100

$L.C. = \frac{\text{Pitch}}{\text{Circular scale division}}$

$\Rightarrow L.C. = \frac{1mm}{100} = 0.01mm$

$MSR = 1\ mm$

$VSR = 47 \times LC = 0.47$ mm

Measured diameters = 1.47 mm = 0.147 cm

Length of wire = 5.6 cm

Curved surface area = $2\pi r\ell$

$A = 2\pi \times \frac{0.147}{2} \times 5.6$

$A = 2.5816cm^2$

In this operation, least significant digit is two in 5.6 cm length.

So answer of surface must not be consist more than two significant digit.

i.e. $A = 2.6\ cm^2$

16. **Ans. (11)**

Diameter $D = 0.050\ cm$, $\Delta D = 0.001\ cm$

Length $L = 110.0\ cm$

$\Delta L = 0.1\ cm$

Weight $W = 50\ N$

Extension $\ell = 0.125\ cm = \Delta\ell = 0.001\ cm$

$Y = \frac{\frac{W}{A}}{\frac{\ell}{L}} \Rightarrow Y = \frac{4WL}{\pi D^2 \ell}$

$\Rightarrow Y = \frac{4\times50\times1.1}{\pi\times25\times10^{-8}\times125\times10^{-5}} \frac{N}{m^2}$

$\Rightarrow Y = 0.02241 \times 10^{13} N/m^2$

$Y = 2.241 \times 10^{11} N/m^2$

$\frac{\Delta Y}{Y} = \frac{\Delta L}{L} + \frac{2\Delta D}{D} + \frac{\Delta\ell}{\ell}$

$\Rightarrow \frac{\Delta Y}{Y} = \frac{0.1}{110} + 2 \times \frac{0.001}{0.050} + \frac{0.001}{0.125}$

$\Rightarrow \frac{\Delta Y}{Y} = 0.04891$

$\Rightarrow \Delta Y = Y \times 0.04891$

$\Rightarrow \Delta Y = 2.241 \times 10^{11} \times 0.04891$

$\Rightarrow \Delta Y = 0.1096 \times 10^{11} N/m^2$

$\Rightarrow \Delta Y = 1.096 \times 10^{10} N/m^2$

Least significant digit in this operation is two

$\Delta Y = 1.1 \times 10^{10} N/m^2 = 11 \times 10^9\ N/m^2$

17. Ans. (23)

$A = 60°$

$\delta_{min} = 30°$

$\Delta\delta = 1°$

$$\mu = \frac{sin\left(\frac{A+\delta}{2}\right)}{sin\left(\frac{A}{2}\right)}$$

Differencing μ w.r.t. δ

$$\Rightarrow \Delta\mu = \left[cos\,e\,c\left(\frac{A}{2}\right)\right]\left[\left(cos\left(\frac{A+\delta}{2}\right)\right) \times \frac{\Delta\delta}{2}\right]$$

$$\Rightarrow \Delta\mu = [\text{cosec}(30°)]\left[\left(cos\left(\frac{60°+30°}{2}\right)\right) \times \frac{1°}{2}\right]$$

$$\Rightarrow \Delta\mu = 2 \times \frac{1}{\sqrt{2}} \times \frac{1°}{2} = \left(\frac{1}{\sqrt{2}}\right)^{°}$$

$$\Rightarrow \Delta\mu = \frac{1}{\sqrt{2}} \times \frac{\pi}{180} \quad ...(1)$$

$$\mu = \frac{\frac{sin(A+\delta)}{2}}{sin\left(\frac{A}{2}\right)} = \frac{sin\left(\frac{60°+30°}{2}\right)}{sin\,30°}$$

$$\mu = \frac{\frac{1}{\sqrt{2}}}{\frac{1}{2}} \Rightarrow \sqrt{2} \quad ...(1)$$

$$\frac{\Delta\mu}{\mu} \times 100 = \frac{\pi}{\sqrt{2}\times 180} \times \frac{1}{\sqrt{2}} \times 100\%$$

$$\frac{\Delta\mu}{\mu} \times 100 = \frac{100\pi}{360} = \frac{5\pi}{18}\%$$

18. Ans. (1)

$10VSD = 9MSD$

$$\Rightarrow 1VSD = \frac{9}{10}MSD$$

$\ell_{MSR} = (N+2)(MSD)$

$\Delta\ell_{MSR} = (N+2)(MSD) \times \alpha_1 \Delta T \quad ...(1)$

$\ell_{VSR} = (2)\ (VSD)$

$\Delta\ell_{VSR} = (2)(VSD) \times \alpha_2 \Delta T \quad ...(2)$

Given Reading of instrument remain same

$\Rightarrow \Delta\ell_{MSR} = \Delta\ell_{VSR}$

$\Rightarrow (N+2)(MSD)\alpha_1\Delta T = 2(VSD)\alpha_2\Delta T$

$$\Rightarrow (N+2)(MSD)\alpha_1 = 2 \times \left(\frac{9}{10}\right)(MSD)\alpha_2$$

$$\Rightarrow \frac{\alpha_1}{\alpha_2} = \frac{18}{10(N+2)} = \frac{1.8}{(N+2)}$$

Important Notes

Important Notes