JEE-MAIN

TOPIC

ERROR IN MEASUREMENT

SOLUTIONS

ERROR IN MEASUREMENT

Exercise-I

1. (C)

M.S.D. = 1 mm

L.C. = 0.02 cm

= 0.2 mm

L.C. = M.S.D. - V.S.D.

$= 1\text{ mm} - \frac{m}{n} = 0.02$

$\Rightarrow \frac{m}{n} = 0.08$

2. (A)

3. (A, B, C)

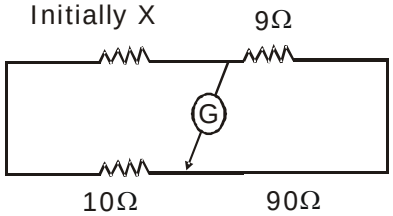
4. (A)

High Resistivity for low current flow & low Heating And low temp coef . so that Resistance doesn't vary with temprature

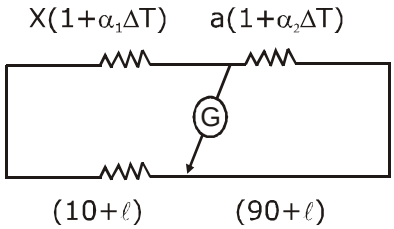
5. (A)

x(90) = 9(10)

x = 1Ω



In second condition



Now x (1+ $\alpha_1 \Delta T$)(90-ℓ) = 9(1+$\alpha_2 \Delta T$) (10+ℓ))

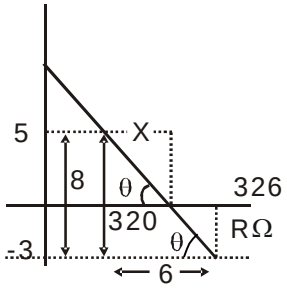
$\frac{(1+\alpha_1\Delta T)}{(1+\alpha_2\Delta T)} = \frac{9(10+\ell)}{(90-\ell)}$

$1+(\alpha_1-\alpha_2)\Delta T = \left[1+\frac{\ell}{10}\right]\left[1+\frac{\ell}{90}\right]$

$9(\alpha_1-\alpha_2)\Delta T = \ell$

6. (B)

deflection



$\tan\theta = 8/6 = \frac{4}{3}$

$\theta = 53^\circ$

$\simeq$ ly $\tan\theta = 5/x \Rightarrow x = 3.75$

So R = 320 + x = 323.75 = 3.24 Ω

7. (D)

ensures zero Magnetic field.

Exercise-II

1 . **(A)** 3,**(B)**3 ,**(C)**4, **(D)**4,**(E)**3,**(F)**5,**(G)**2,**(H)**4 Notes

2. **(A)**

$$\begin{array}{r} 703.00 \\ +\,7.00 \\ +\,0.66 \\ \hline 710.66 \end{array}$$

$\simeq 711$

(B)
2.21 x 0.3
= 0.663 = 0.7
(C) 12.4 x 84 = 1041.6 = 1.0×10^3
(D) 14.28 / 0.714 = 20 = 20.0

3. **(i)** $\begin{array}{r} 6.50 \\ -6.32 \\ \hline 0.18 \end{array}$

$\simeq 0.2$

$\sqrt{0.2} = 0.4$

(ii) $\dfrac{2.91 \times 0.3842}{0.080}$

= 13.975 = 14

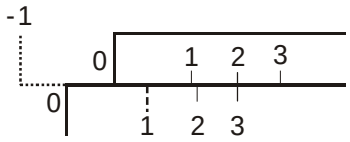
4. L.C. = M.S.D. - V.S.D.

= 1mm - $\frac{9}{10}$mm = 0.1 mm

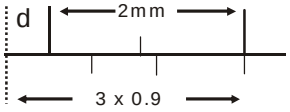
$\dfrac{\text{ZERO ERROR}}{\text{Z.E.} = 0.7\text{mm}}$

Reading →
(M.S.R. + n x L.C.) - Z.E.
= (31mm + 4 x 0.1) - 0.7
= 31.4 - 0.7 = 30.7

5. **(i)**

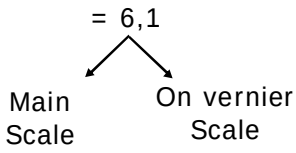


M.S.R. + V.S.R. X L.C.
-1 + 3 x 0.1 = -0.7
OR

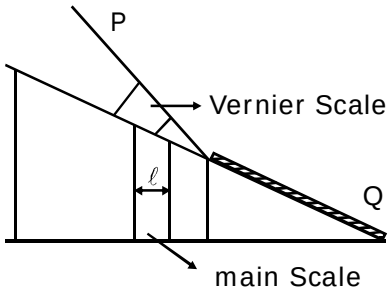


= 2.7 mm d = 2.7 - 2
= 0.7 mm

(ii)
ACTUAL READING
= READING - Z.E.
= 5.4 - (-0.7)
= 6,1



6.



I.M.S.D. = $\dfrac{\ell}{\cos\theta}$

I.V.S.D. = ℓ

L.C. = $-\ell + \dfrac{\ell}{\cos\theta}$

$= \ell\dfrac{(-\cos\theta + 1)}{\cos\theta}$

7 .

L.C. = $\dfrac{0.5\text{mm}}{50\,\text{division}}$

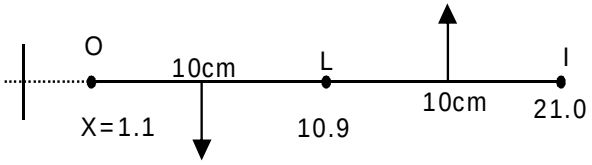
= 0.01 mm
Reading = L.S.R.
+ L.C. x V.S.R.
= 5 x 0.5 + 34 x 0.01
= 2.5 + 0.34
= 2.84 mm

8. L.C. = $\dfrac{1\text{mm}}{50\text{div}} = 0.02\text{mm}$

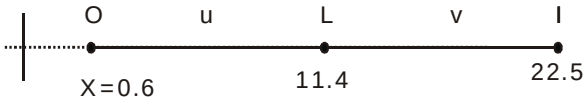
Z.E. = L.S.R. + L.C. x VSR
= -1 + 0.02 x 44
= -1 + 0.88
= -0.12
Now Reading
= L.S.R. + L.C. x V.S.R. -Z.E.
= 3+ 0.02 x 26 + 0.12
= 3.64 mm

9 . Ist data

21.0 – 10.9 = 10.1+0.1



10.9 - 1.1 = 9.8
error = –0.2



U = (11.4 - 0.6) + 0.2 = 11 cm
V=22.5 - 11.4 - 0.1 = 11 cm

$$\frac{1}{f}=\frac{1}{v}-\frac{1}{u}\Rightarrow f=5.5\,cm$$

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

$$=5.5\times 5.5\left(\frac{0.1}{11^2}+\frac{0.1}{11^2}\right)=0.05\,cm$$

10. (CD, AB, EF)

11. av. $V=\frac{13.8}{4.0}=3.45=3.4$ m/s

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

$$\Rightarrow\frac{\Delta V}{3.4}=\frac{0.2}{13.8}+\frac{0.3}{4.0}\qquad\Rightarrow\Delta V=0.3$$

So V = 3.4 $\pm$0.3

12. S = (1.20 $\pm$ 0.18)cm

13. (i) series

av. $R=5+10=15\Omega$

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

So
$R=15\pm0.3$

OR $\frac{0.3}{15}\times100=2\%\qquad\Rightarrow R=15\pm2\%$

(ii) av. $R=\frac{R_1R_2}{R_1+R_2}$

So $R=\frac{10}{3}=3.3$

Now $\frac{1}{R}=\frac{1}{R_1}+\frac{1}{R_2}\qquad\Rightarrow\frac{\Delta R}{R^2}=\frac{\Delta R_1}{R_1^2}+\frac{\Delta R_2}{R_2^2}$

So $\Delta R = 0.1$

In % age $\frac{\Delta R}{R}\times100=\frac{10}{3.3}=3\%$

14. $\rho=\frac{m}{v}\qquad=\frac{5.74}{1.2}$

$= 4.78\qquad = 4.8$ (Rounding)

15. $T=2\pi\sqrt{l/g}$

$$g=\frac{4\pi^2l}{T^2};\qquad100\frac{\Delta g}{g}=100\frac{\Delta l}{l}+200\frac{\Delta T}{T}$$

$$100\times\frac{0.1}{10}+200\times\frac{0.02}{0.5}$$

1 + 8 = 9%

16.

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

$$100\frac{\Delta P}{P}=\left(3\frac{\Delta A}{A}\right)x100+\left(\frac{2\Delta B}{B}\right)x100$$

$$+\frac{1}{2}\frac{\Delta C}{C}x100+100\frac{\Delta D}{D}$$

$$=\ 3\ x\ 1\%\ +\ 2\ x\ 3\%\qquad+\ \frac{1}{2}x\,2\%+4\%$$

$= 3 + 6 + 1 + 4 = 14\%$

$$\Delta P=\frac{14P}{100}=\frac{14x3.73}{100}$$

$= 0.52$

17.

$$\mu=\frac{\sin\left(\frac{A+S_m}{2}\right)}{\sin\left(A/2\right)},\qquad\mu=\frac{\sin45}{\sin30}=\sqrt{2}$$

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

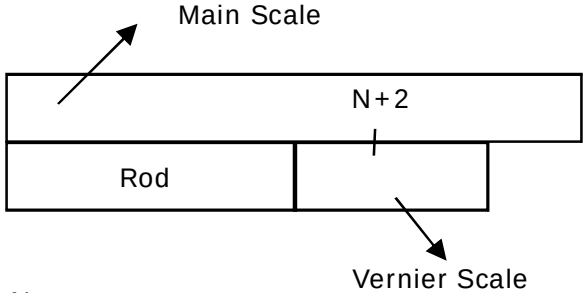
$$\frac{\Delta\mu}{\mu}=\frac{\cos\left(\frac{A+\delta m}{2}\right)}{\sin\left(\frac{A+\delta m}{2}\right)}\times\Delta\left(A+\frac{\delta m}{2}\right)$$

$$=\tan\left(\frac{A+\delta m}{2}\right)\times\frac{1}{2}\Delta(\delta m)$$

$$=\tan45^\circ\times\frac{1}{2}\times\frac{\pi}{180}\,rad\times100\%\qquad=\frac{5\pi}{18}\%$$

18.

Let M.S.D. = 1mm Å



Now
(N+2) x 1 mm = l (Rod) + 2 x 0.9

$\Rightarrow N+2=l+1.8$

Now charge for (N+2) mm on M.S. is equal to change of 1.8 mm on V.S.

$\Rightarrow\alpha_1(N+2)\Delta T\Rightarrow\alpha_2(1.8)\Delta T$

$$\Rightarrow\frac{\alpha_1}{\alpha_2}=\frac{1.8}{N+2}$$

Exercise-III

1. (A)

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

$V = a^3 = (1.2)^3 \times 10^{-6}$

$= 1.728 \times 10^{-6}$

$= 1.7 \times 10^{-6}$

2. a/(n+1)

L.C. = M.S.D. - V.S.D.

$= a - \frac{an}{n+1}$ $= \frac{a(n+1-n)}{n+1}$

$= \frac{a}{n+1}$

3. (D)

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

$= 100\frac{\Delta\rho}{\rho} = 100\frac{\Delta m}{m} + 200\frac{\Delta r}{r} + 100\frac{\Delta l}{l}$

$= 100x\frac{0.003}{0.3} + 200x\frac{0.005}{0.5} + \frac{100x0.06}{6}$

$= 1+2+1 = 4\%$

4. $d = 0.050\,cm \pm 0.001cm$

$F = 50N$

$l = 0.125\,cm \pm 0.001cm$

$L = 110.0\,cm \pm 0.1cm$

Now $\frac{F}{A} = \frac{Yl}{L}$

$\Rightarrow Y = \frac{Fl}{Al} = \frac{50\,x\,1.10}{\frac{3.14}{4}(5x10^{-4})^2}$

$Y = 2.24 \times 10^{11} N/m^2$

Now

$Y = \frac{FL}{\frac{\pi d^2}{4} l}$

$\frac{\Delta Y}{Y} = \frac{\Delta L}{L} + 2\frac{\Delta d}{d} + \frac{\Delta l}{l}$

$= \frac{1}{1100} + \frac{2}{50} + \frac{1}{125}$

$\Delta Y = Y\left(\frac{1}{1100} + \frac{1}{25} + \frac{1}{125}\right)$

$= 6.47 \times 10^9\ N/m^2$

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

Reading = L.S.R. + C.S.R. x L.C.

$= 1mm + 47\,x\,0.01$

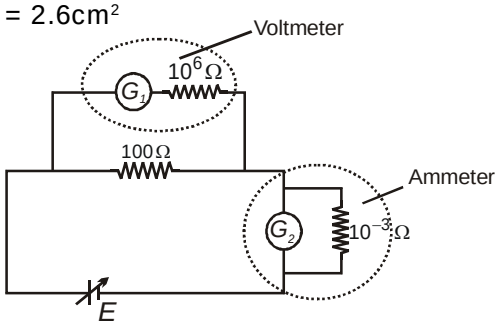
$= 1.47mm$

C.S.R. = $2\pi rl = \pi dl$

$= 3.14x\frac{1.47}{10}x5.6$

$= 2.6cm^2$

6.



7. (D)

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

$\Delta V = 2f(\Delta\ell_2 + \Delta\ell_1)$

$= 2 \times 512\,(0.1+0.1)$

$= 512 \times 0.4$

$= 204.8\ cm/s$

8. L.C. = 0.1 mm

Reading = 10 + 1 x 0.1

= 10.1 mm

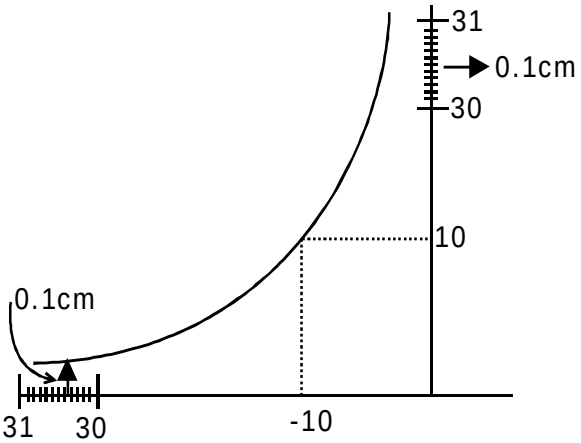
$\rho = \frac{m}{v} = \frac{2.736}{(10.1)^3}$

$= \frac{2.736\,gm}{1.03cm^3}$

$= 2.6563\ g/cm^3$

$= 2.66 g/cm^3$

9. (C)



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

$$=\frac{1}{10}+\frac{1}{10}=\frac{1}{5}$$

f = 5 cm

L.C. 0.1 cm

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

$$\Rightarrow \Delta f = 25\left(\frac{0.1}{100}+\frac{0.1}{100}\right)=0.05$$

10. (C)

$$\text{L.C.} = \frac{0.5\text{mm}}{50\,\text{division}} = 0.01\text{ mm}$$

Z.E. = 0 + 5 x 0.01
= 0.05
Reading = 2 x 0.5 + 25 x 0.01- Z.E.
= 1 + 0.25 - 0.05
= 1.20

11. (D)

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

Δl is least in (D) (i.e 1mm)
and

$\frac{\Delta T}{T}=\frac{0.1}{50}$ is also least in D

So least error is in D.
We can also see that amplitude is also less so it is more closes to S.H.M.

12. (B)

13. (A) P, Q; (B) R, S; (C) R, S; (D) R, S

14. (B)

$$\frac{F}{A}=Y\frac{l}{L}$$

$$\Rightarrow Y=\frac{FL}{Al}=\frac{mgL}{Al}$$

$$Y=\frac{1\,x\,9.8\,x\,2}{\frac{\pi\,x\,d^2}{4}+0.4\,x\,10^{-3}}$$

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

$$\frac{\Delta Y}{Y}=\frac{\Delta l}{l}+2\frac{\Delta d}{d}$$

$$=\frac{0.05}{0.8}+2x\frac{0.01}{0.4}$$

$$=\frac{0.09}{0.8}=\frac{9}{80}$$

$$\Delta Y=\frac{9Y}{80}=\frac{9x2}{80}x10^{11}=0.225x10^{11}$$

$$\Rightarrow Y=(2\pm0.2)x10^{11}$$

15. (B)

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

$$E=\frac{\Delta g}{g}=\frac{\Delta l}{l}+\frac{2\Delta T}{T}$$

$$E_I=\frac{0.1}{64.0}+\frac{2x0.1}{128}$$

$$E_{II}=\frac{0.1}{64.0}+2x\frac{0.1}{64}$$

$$E_{III}=\frac{0.1}{20}+2x\frac{0.1}{36}$$

Clearly $E_1 < E_2 < E_3$.

16. (C,D)

17. (A,C)

18. (D)

19. (C)

20. $Y=\frac{4MgL}{\pi\ell d^2}$

$$\frac{\Delta Y}{Y}=\frac{\Delta M}{M}+\frac{\Delta g}{g}+\frac{\Delta L}{L}+\frac{\Delta\ell}{\ell}+\frac{2\Delta d}{d}$$

$\Delta\ell = \Delta d$ (same instrment)

so $\frac{\Delta\ell}{\ell}=\frac{2\Delta d}{d}$ hence both contribute same in error

21. (B)

$$\text{L.C.}=\left(0.05-\frac{2.45}{50}\right)\text{cm}=10^{-3}\text{cm}.$$

Reading = 5.10 cm + 24 × 10^{-3} cm.
= 5.124 cm.