HINTS & SOLUTIONS

EXERCISE - 1
Single Choice

1. $K \propto mv^2 \Rightarrow \frac{\Delta K}{K} = \frac{\Delta m}{m} + \frac{\Delta v}{v}$

% error in kinetic energy $= 2 + 2(3) = 8\%$

3. Density $\rho = \frac{m}{v} = \frac{m}{a^3} \Rightarrow \frac{\Delta\rho}{\rho} = \frac{\Delta m}{m} + 3\frac{\Delta a}{a}$

4. $\because D = 2R \quad \therefore \frac{\Delta D}{D} = \frac{\Delta R}{R}$

5. $X = \frac{ab^2}{c^3} \Rightarrow \frac{\Delta X}{X} = \left(\frac{\Delta a}{a} + 2\frac{\Delta b}{b} + 3\frac{\Delta c}{c}\right)$

6. $T = 2\pi\sqrt{\frac{l}{g}} \Rightarrow g = \frac{4\pi^2 l}{T^2} \Rightarrow \frac{\Delta g}{g} = \frac{\Delta l}{l} + 2\frac{\Delta T}{T}$

8. $\frac{\Delta(ABC)}{ABC} = \frac{\Delta A}{A} + \frac{\Delta B}{B} + \frac{\Delta C}{C} = a + b + c$

10. Average time period

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

$$= \frac{13.12}{5} = 2.624 = 2.62\ s$$

Average absolute error

$$= \frac{0.01 + 0.06 + 0.20 + 0.09 + 0.18}{5} = \frac{0.54}{5}$$

$= 0.108 = 0.11s$

11. $F = \frac{P}{A} = \frac{P}{l^2} \Rightarrow \frac{\Delta F}{F} = \frac{\Delta P}{P} + 2\frac{\Delta l}{l}$

12. Area$(A) = 4\pi R^2$, Volume$(V) = \frac{4}{3}\pi R^3$

$\frac{\Delta A}{A} = 2\frac{\Delta R}{R}, \frac{\Delta V}{V} = 3\frac{\Delta R}{R}$

15. Circumference $\bullet = 2\pi R = \pi D \Rightarrow \bullet \propto D$

16. $X = M^aL^bT^c$

$\Rightarrow \frac{\Delta X}{X} = a\left(\frac{\Delta M}{M}\right) + b\left(\frac{\Delta L}{L}\right) + c\left(\frac{\Delta T}{T}\right) = a\alpha + b\beta + c\gamma$

17. $\rho = \frac{m}{\pi r^2 l} \Rightarrow \frac{\Delta\rho}{\rho} = \frac{\Delta m}{m} + 2\frac{\Delta r}{r} + \frac{\Delta l}{l} \Rightarrow \frac{\Delta\rho}{\rho} \times 100$

$$= \frac{0.003}{0.3} \times 100 + 2 \times \frac{0.005}{0.5} + \frac{0.06}{6} \times 100 = 4\%$$

18. Volume of 25 spheres $= 25 \times 1.76 = 44.00$

19. $V = \pi r^2 h = \frac{\pi D^2 h}{4} \Rightarrow \frac{\Delta V}{V} = \frac{2\Delta D}{D} + \frac{\Delta h}{h}$

$$\frac{\Delta V}{V} \times 100 = \left[2 \times \left(\frac{0.01}{2.00}\right) + \left(\frac{0.1}{5.0}\right)\right] \times 100 = 3\%$$

20. $R = \frac{V}{I} \Rightarrow \frac{\Delta R}{R} \times 100 = \frac{\Delta V}{V} \times 100 + \frac{\Delta I}{I} \times 100$

$$= \frac{5}{100} \times 100 + \frac{0.2}{10} \times 100 = 7\%$$

21. $T = 2\pi\sqrt{\frac{l}{g}} \Rightarrow g = \frac{4\pi^2 l}{T^2}$

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

22. Thickness of the wall

$= (4.23 \pm 0.01) - (3.89 \pm 0.01) = (0.34 \pm 0.02)$ cm

23. $\because V = \bullet bt \quad \therefore \frac{\Delta V}{V} = \frac{\Delta l}{l} + \frac{\Delta b}{b} + \frac{\Delta t}{t}$

$V = (10.0)(1.00)(0.100) = 1.00\ cm^3$

$$\Delta V = (1.00)\left[\frac{0.10}{10.0} + \frac{0.01}{1.00} + \frac{0.001}{0.100}\right] = 0.03\ cm^3$$

24. $\because V = \bullet bt \quad \therefore \frac{\Delta V}{V} = \frac{\Delta l}{l} + \frac{\Delta b}{b} + \frac{\Delta t}{t}$

$$\frac{\Delta V}{V} \times 100 = \left(\frac{0.01}{15.12} + \frac{0.01}{10.15} + \frac{0.01}{5.28}\right) \times 100$$

$= (0.066 + 0.098 + 0.189)\%$

$= (0.07 + 0.10 + 0.19)\% = 0.36\%$

25. Area of disk

$= \pi R^2 = (3.14)(1.2)^2 = 4.5216 = 4.5 cm^2$

26. $T = \frac{rhg}{2} \Rightarrow \frac{\Delta T}{T} = \frac{\Delta r}{r} + \frac{\Delta h}{h} + \frac{\Delta g}{g}$

$$\frac{\Delta T}{T} \times 100 = \left(\frac{0.01 \times 10^{-2}}{1.25 \times 10^{-2}} + \frac{0.01 \times 10^{-2}}{1.45 \times 10^{-2}} + \frac{0.01}{9.80}\right) \times 100$$

$= 0.80 + 0.69 + 0.10 = 1.59\% = 1.6\%$

27. Area $= 1.2 \times 2.345 = 2.884 = 2.9\ cm^2$

28. $\frac{\Delta T}{T} \times 100 = \frac{1/5}{25} \times 100 = 0.8\%$

29. Least count = 1MSD – 1VSD

but 30 VSD = 29 MSD $\Rightarrow$ VSD = $\left(\frac{29}{30}\right)$ MSD

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

$= \frac{\text{MSD}}{30} = \frac{0.5^\circ}{30} = \left(\frac{1}{60}\right)^\circ = 1'$

30. 1 MSD – 1VSD = Vernier Constant

31. ✈ L.C. = 1 MSD – 1 VSD

$\therefore 0.02 = 0.1 - \frac{m}{n} \Rightarrow \frac{m}{n} = 0.08$

32. Reading = 2.30 mm

33. Least count = 1 MSD – 1 VSD

(N–1) MSD = N(VSD) $\Rightarrow$ VSD = $\left(1 - \frac{1}{N}\right)$ MSD

Least count = 1MSD – $\left(1 - \frac{1}{N}\right)$ MSD

$= \left(\frac{1}{N}\right)(1\text{mm}) = \frac{1}{10N}$ cm

34. Let 1 MSD = S & 1 VSD = V

Given, 10V = 9S or S = V ...(i)

Also given (N× S(+2 (S–V) = NS' + 2 (S'–V')

or (N+2) (S'-S) = 2 (V'-V)

or $S\alpha_1\Delta T = \frac{2}{N+2}(V\alpha_2\Delta T)$

or $\frac{\alpha_1}{\alpha_2} = \left(\frac{2}{N+2}\right) \times \frac{V}{S} = \frac{2}{N+2} \times \frac{9}{10} = \frac{1.8}{N+2}$

35. L.C. = 1MSD – 1VSD but (N) MSD = (N + M) (VSD)

$\Rightarrow$ L.C. = 1MSD – $\left(\frac{N}{N+m}\right)$MSD

$= \left(\frac{m}{N+m}\right) = \left(\frac{1}{\frac{N}{m}+1}\right)$MSD

For minimum least count, m should be minimum so m=1

36. Deflection is zero for 324 so value of unknown resistance = $\frac{324}{100} = 3.24\ \Omega$

37. $\frac{X}{10} = \frac{90}{90} \Rightarrow X = 10\Omega$

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

$\Rightarrow (1+\alpha_1\Delta T)\left(1+\frac{\Delta l}{10}\right)^{-1} = (1+\alpha_2\Delta T)\left(1-\frac{\Delta l}{90}\right)^{-1}$

$\Rightarrow (1+\alpha_1\Delta T)\left(1-\frac{\Delta l}{10}\right) = (1+\alpha_2\Delta T)\left(1+\frac{\Delta l}{90}\right)$

$\Rightarrow 1+\alpha_1\Delta T - \frac{\Delta l}{10} = 1+\alpha_2\Delta T + \frac{\Delta l}{90}$

$\Rightarrow (\alpha_1-\alpha_2)\Delta T = \frac{\Delta l}{9} \Rightarrow \Delta$● $= 9(\alpha_1-\alpha_2)\Delta T$

EXERCISE - 2

Part # I : Multiple Choice

1. $\left(\frac{\Delta A}{A}\right)_{min} = \left|\left(\frac{\Delta\lambda}{\lambda} - \frac{\Delta b}{b}\right)\right| = \left|\frac{1}{100} - \frac{1}{100}\right| = 0$

2. A = ●b = 10.0 × 1.00 = 10.00

$\frac{\Delta A}{A} = \frac{\Delta\lambda}{\lambda} + \frac{\Delta b}{b}$

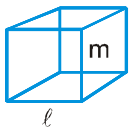
$\frac{\Delta A}{10.00} = \frac{0.1}{10.0} + \frac{0.01}{1.00} \Rightarrow \Delta A = 10.00$

$\left(\frac{1}{100} + \frac{1}{100}\right) = 10.00\left(\frac{2}{100}\right) = \pm 0.2\ \text{cm}^2.$

3. $\rho = \frac{m}{V} = \frac{m}{\lambda^3}$

Given $\frac{\Delta m}{m} = \pm\ 2\% = \pm 2 \times 10^{-2}$ $\frac{\Delta\lambda}{\lambda} = \pm 1\%$

$= \pm 1 \times 10^{-2}$



$\frac{\Delta\rho}{\rho} = \frac{\Delta m}{m} + 3\frac{\Delta\lambda}{\lambda}$

$= 2 \times 10^{-2} + 3 \times 10^{-2} \quad = 5 \times 10^{-2} = 5\%$

4. $\Delta t = 0.2$ s.

$t = 25$ s

$T = \frac{t}{N} \Rightarrow \frac{\Delta T}{T} = \frac{\Delta t}{t} = \frac{0.2}{25} = 0.8\ \%$

5. $g = 4\pi^2\frac{\lambda}{T^2}$

$\frac{\Delta\lambda}{\lambda} = 2\% = \pm 2 \times 10^{-2} \Rightarrow \frac{\Delta T}{T} = \pm 3\% = \pm\ 3 \times 10^{-2}$

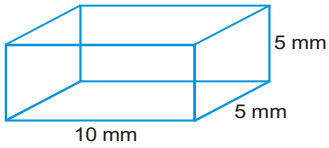
$\Rightarrow \frac{\Delta g}{g} = \frac{\Delta\lambda}{\lambda} + \frac{2\Delta T}{T} = 2 \times 10^{-2} + 2 \times 3 \times 10^{-2}$

$= 8 \times 10^{-2} = \pm 8\ \%$

6. $R_1 = (24 \pm 0.5)\,\Omega$
$R_2 = (8 \pm 0.3)\,\Omega$
$R_S = R_1 + R_2 = (32 \pm 0.8)\,\Omega$

7. $m = 1.76$ kg
$M = 25\,m$
$= 25 \times 1.76 = 44.0$ kg
Note : Mass of one unit has three significant figures and it is just multiplied by a pure number (magnified). So result should also have three significant figures.

8.



$v = \bullet bh$

$$\frac{\Delta v}{v} = \frac{\Delta \lambda}{\lambda} + \frac{\Delta b}{b} + \frac{\Delta h}{h}$$

$$= \frac{0.1}{10} + \frac{0.1}{5} + \frac{0.1}{5} = \frac{0.5}{10} = \pm 5\%$$

9. $\Delta\bullet = 0.5$ mm
$N = 100$ divisions
zero correction $= 2$ divisions
Reading = Measured value + zero correction

$$= (8 \times 0.5)\text{ mm} + (83 - 2) \times \frac{0.5}{100}.$$

$$= 4\text{ mm} + 81 \times \frac{0.5}{100}\text{ mm} = 4.405\text{ mm}$$

10. ABC

11. $\Delta\bullet = 1$ mm
$N = 50$ division
zero error $= -6$ Divisions $= -0.12$ mm
Diameter = Measured value + zero correction

$$= 3 \times 1 + (6 + 31) \times \frac{1}{50} = 3 + 0.74 = 3.74\text{ mm}$$

12. $D = 2 \times 1 + 5 \times \frac{10 - 9}{100} = 2.05$ cm

Part # II : Assertion & Reason

1. D **2.** A

1. **D.** $\frac{\Delta K}{K} \times 100 = \left(\frac{\Delta m}{m} + 2\frac{\Delta v}{v}\right) \times 100 = 2 + 2 \times 5 = 12\,\%$

2. **A.** Zeros before a non-zero significant digit are not counted, while zeros after a non-zero significant digits are counted.

EXERCISE - 3

Part # I : Matrix Match Type

1. Backlash error is caused by loose fittings, wear and tear, etc. in the screw mechanisms.
Zero error may be positive or negative but will always be subtracted.
In vernier callipers, least count is the difference between 1 MSD and 1 VSD
Error in screw gauge may be positive or negative and may be due to loose fitting of the circular scale.

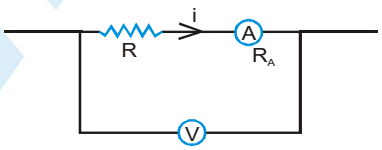
2. We know that least count is given by s/n, so
(i) least count = s/n = 1/10 = 0.1 mm
(ii) least count = s/n = 0.5/10 = 0.05 mm
(iii) least count = s/n = 0.5/20 = 0.025 mm
(iv) least count = s/n = 1/100 = 0.01 mm

3. All digits are significant after decimal.
$47.23 \div (2.3) = 20.5$; 21 (should have only two significant digits)
3 is a number with one significant digit.

Part # II : Comprehension

Comprehension # 1

1.



Reading of Ammeter = i
Reading of voltmeter = P.d. across voltmeter
= P.d. across $(R + R_A)$ system $= i\,(R + R_A)$

$\Rightarrow$ Measured resistance $= \frac{V}{i} = \frac{i(R + R_A)}{i} = R + R_A$

2. Reading of Ammeter = i

and $i_v R_V = (i - i_v) R \Rightarrow i_V = \frac{iR}{R + R_v}$

Reading of Voltmeter $V = i_V R_V = \left(\frac{iR}{R + R_v}\right) R_V$

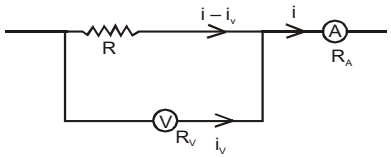
$$= \frac{iRR_v}{(R + R_v)}$$

Comprehension # 2

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

2. $ID = 321 + 7(0.5) + 17(0.01) = 324.67$ mm

3. Zero error $= -(50-41)(0.01) = -0.09$ mm



$$\text{measured resistance} = \frac{v}{i} = \frac{iRR_v/(R+R_v)}{i}$$

$$= \frac{RR_v}{R+R_v}$$

If R is very large $(\sim K\Omega)$
Then measured resistance from arrangement (a) will be
$R_{measured} = R + R_A \approx R$
So (a) will be preferred
If R is very small (~ few Ohm)
then measured resistance from (b) will be

$$R_{measured} = \frac{R}{1+\frac{R}{R_v}} \text{ where } R/R_v \text{ is negligible}$$

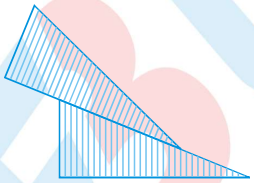
So, $R_{measured} \longrightarrow R$
So (b) will be preferred

EXERCISE - 4
Subjective Type

1. Least count = 1MSD – IVSD

$$= \frac{l}{\cos\theta} - l$$

$$= \left(\frac{1-\cos\theta}{\cos\theta}\right) l$$



2. Least count = 1MSD – 1VSD

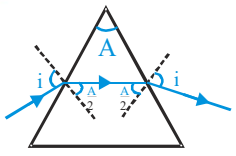
$$= 0.5 - \frac{9}{10}(0.5) = 0.05 \text{ mm}$$

3. Zero error $= -(50-44)\left(\frac{1\text{mm}}{50}\right) = -0.12$ mm

Thickness of plate $= 3 + 26\times\frac{1}{50} + 0.12\text{mm} = 3.64\text{mm}$

4. $\theta = 2i - 2r = 2i - A$

$$\Rightarrow i = \frac{\theta + A}{2} = \frac{60^\circ + 30^\circ}{2} = 45^\circ$$



But $\sin i = \mu \sin\frac{A}{2}$

$$\Rightarrow \sin\left(\frac{\theta+A}{2}\right) = \mu\sin\frac{A}{2} \Rightarrow \mu = \sqrt{2}$$

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

$$\Rightarrow \Delta\mu = \left(\text{cosec}\frac{A}{2}\right)\cos\left(\frac{\theta+A}{2}\right)\left(\frac{\Delta\theta}{2}\right)B$$

$$= (\text{cosec } 30^\circ)\cos 45^\circ\left(\frac{1^\circ}{2}\right) = \frac{1}{\sqrt{2}}\left(\frac{\pi}{180^\circ}\right)$$

$$\frac{\Delta\mu}{\mu}\times 100 = \left\{\left(\frac{\pi}{\sqrt{2}(180)}\right)\frac{1}{\sqrt{2}}\right\}100 = \frac{5\pi}{18}\%$$

5. $\frac{100}{0.451} = \frac{1110}{400} \Rightarrow \bullet = 40\text{m}$

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

$\Delta D_1 = 1.324 - 1.330 = -0.006$
$\Delta D_2 = 1.326 - 1.330 = -0.004$
$\Delta D_3 = 1.334 - 1.330 = 0.004$
$\Delta D_4 = 1.336 - 1.330 = 0.006$

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

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

$$\frac{\Delta\bar{D}}{D} = \frac{0.005}{1.330} = 0.004$$

$$\% \text{ Error} = \frac{\Delta\bar{D}}{D}\times 100 = 0.4\%.$$

7. $S = x\cos\theta = (2)\cos 53^\circ = (2)\left(\frac{3}{5}\right) = 1.2$

$$\frac{\Delta S}{S} = \frac{\Delta x}{x} + \frac{\Delta(\cos\theta)}{\cos\theta} = \frac{\Delta x}{x} + (\tan\theta)\Delta\theta \Rightarrow \Delta S = 1.2$$

$$\left[\frac{0.2}{2} + \left(\frac{4}{3}\right)\left(2\times\frac{\pi}{180}\right)\right] = 0.12 + 0.06 = 0.18$$

$\Rightarrow S = (1.2 \pm 0.18)$ cm

8. Index (Bench) error
= observed distance – Actual distance
$= (x_L - x_o) - 10\text{ cm} = -0.2$ cm
$u = (x_L - x_o) - (-0.2) = 10.8 - (-0.2) = 11$ cm
$v = (x_L - x_o) - (0.2) = 22.5 - 11.4 - 0.2 = 10.9$ cm

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u} = \frac{1}{10.9} - \frac{1}{-11} \Rightarrow f = 5.5 \text{ cm and}$$

$$\frac{\Delta f}{f^2} = \frac{\Delta u}{u^2} + \frac{\Delta v}{v^2} \Rightarrow \Delta f = \left[\frac{0.1}{(11)^2} + \frac{0.1}{(10.9)^2}\right][5.5]^2 = 0.05$$

$\Rightarrow f = (5.5 \pm 0.05)$ cm

9. **(i)** 1, zero before and after decimal but preceding first non-zero digit are insignificant.

(ii) 3, Power of 10 in scientific notation is insignificant.

(iii) 4, Trailing zero's after NZD's in fraction are significant.

(iv) 4, Trailing zero's after NZD's in fraction are significant.

(v) 4, Zero's between NZD's are significant.

(vi) 4, Zero's before NZD's in fractional part (< 1) are insignificant.

10. $v = 2f_0(\lambda_2 - \lambda_1)$,

$$\Rightarrow \left(\frac{\Delta v}{v}\right)_{max} = \frac{\Delta f_0}{f_0} + \frac{\Delta\lambda_1 + \Delta\lambda_2}{\lambda_2 - \lambda_1} = \frac{1}{100} + \frac{0.1+0.1}{74-24}$$

$= 1.4\%$.

11. **(i)** 0.0393 kg **(ii)** 4.08×10^8 sec

(iii) 5.24 m **(iv)** 4.74×10^{-6} kg

EXERCISE - 5

Part # I : AIEEE/JEE-MAIN

3. Diameter = M.S.R. + C.S.R × L.C. + Z.E. = 3 + 35 × (0.5/50) + 0.03 = 3.38 mm

4. Least count of venier callipers

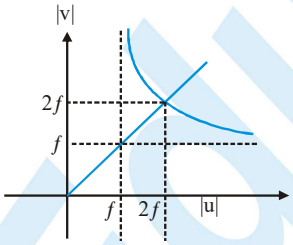
L.C. = 1MSD – 1VSD

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

$$\Rightarrow \text{L.C.} = 1\text{MSD} - \frac{29}{30}\text{MSD} = \frac{1}{30}\text{MSD} = \frac{1}{30} \times 0.5^\circ$$

$$= \left(\frac{1}{60}\right)^\circ = 1 \text{ minute.}$$

5.



7. Least count = $\frac{1\,mm}{100} = 0.01$ mm

Diameter of the wire = 0 + 52 × 0.01 mm = 0.52 mm

= 0.052 cm

8. $1\,VSD = \frac{29}{30} \times 0.5^\circ = \left(\frac{29}{60}\right)^\circ$ and

$$1\,MSD = \left(\frac{1}{2}\right)^\circ = \left(\frac{30}{60}\right)^\circ$$

$$\text{Least count} = 1\text{MSD} - 1\text{VSD} = \left(\frac{1}{60}\right)^\circ$$

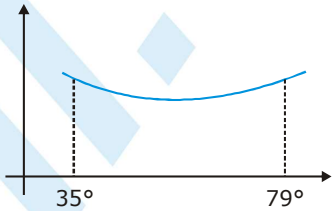
$$\text{Reading} = 58.5^\circ + 9x\left(\frac{1}{60}\right)^\circ = 58.65^\circ$$

9. $R = \frac{V}{I} \Rightarrow \frac{\Delta R}{R} = \frac{\Delta V}{V} + \frac{\Delta I}{I} = 3\% + 3\% = 6\%$

10. 3 **11.** 4

12. Photoelectric experiment is linked with particle nature of light

13.



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

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

zero error = 0.50 – 0.45 = – 0.05

Thickness = (0.5 + 25 × 0.01) + 0.05

= 0.5 + 0.25 + 0.05

= 0.8 mm

Part # II : IIT-JEE ADVANCED

1. $V = a^3 = (1.2 \times 10^{-2})^3 = 1.728 \times 10^{-6} m^3 = 1.7 \times 10^{-6} m^3$

2. $\rho = \frac{m}{\pi r^2 l} \Rightarrow \frac{\Delta\rho}{\rho} = \frac{\Delta m}{m} + 2\frac{\Delta r}{r} + \frac{\Delta l}{l}$

$$\frac{\Delta\rho}{\rho} \times 100 = \frac{0.003}{0.3} \times 100 + 2 \times \frac{0.005}{0.5} + \frac{0.06}{6} \times 100 = 4\%$$

4. $v = f\lambda = 2f(\lambda_2 - \lambda_1)$

$= 512 \times 2\,(63.2 - 30.7) \times 10^{-2} = 332.8\ ms^{-1}$

$$\frac{\Delta v}{v} = \left(\frac{\Delta\lambda}{\lambda}\right) = \left(\frac{\Delta l_2 + \Delta l_1}{l_2 - l_1}\right)$$

$$\Rightarrow \Delta v = v\left(\frac{\Delta l_2 + \Delta l_1}{l_2 - l_1}\right) = (332.8)\left(\frac{0.1+0.1}{32.5}\right) = 2.048\ m/s$$

5. From $\frac{1}{f}=\frac{1}{v}-\frac{1}{u}=\frac{1}{10}-\frac{1}{-10}=\frac{1}{5} \Rightarrow f=5\text{cm}$

From graph $\Delta u = 0.1$ cm, $\Delta v = 0.1$ cm

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

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

$\Rightarrow f=(5\pm 0.05)$ cm

6. $g=\frac{4\pi^2 l}{T^2} \Rightarrow \frac{\Delta g}{g}=\frac{\Delta l}{l}+\frac{2\Delta T}{T}$ Here T ; 2 sec

For (A) $\frac{\Delta g}{g}=\frac{0.5}{1}+\frac{0.2(0.1)}{2}=0.6$

For (B) $\frac{\Delta g}{g}=0.5+\frac{0.2}{2}=0.6$

For (C) $\frac{\Delta g}{g}=0.5+\frac{0.02}{2}=0.51$

For (D) $\frac{\Delta g}{g}=0.1+\frac{0.1}{2}=0.15$

$\Rightarrow \frac{\Delta g}{g}$ is minimum for (D). Also number of observations are maximum in (D).

7. least count $=\frac{0.5}{50}=0.01$ mm

Diameter of sphere $= 2\times 0.5+(25-5)\times 0.01 = 1.2$ mm

8. $Y=\frac{Fl}{A\Delta l}=\frac{Mgl}{A\Delta l}=\frac{(1)(9.8)(2)}{\pi(0.2\times10^{-3})^2(0.8\times10^{-3})}$

$=1.95\times10^{11}=2.0\times10^{11}\ \text{Nm}^{-2}$

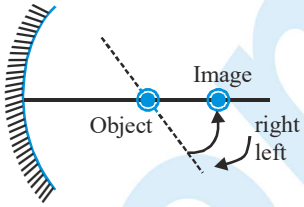
$\frac{\Delta Y}{Y}=\frac{\Delta(\Delta l)}{\Delta l}+2\frac{\Delta r}{r}=\frac{0.05}{0.8}+2\left(\frac{0.01}{0.4}\right)$

$=0.0625+0.05=0.1125$

$\Delta Y=(2.0\times10^{11})(0.1125)=0.2\times10^{11}$

$\Rightarrow Y=(2\pm0.2)\times10^{11}\ \text{Nm}^{-2}$

10. Since object and image move in opposite direction, the positioning should be as shown in the figure. Object lies between focus and centre of curvature $f < x < 2f$



11. 50 divisions = 2.45 cm

$\Rightarrow$ 1 division $=\frac{2.45}{50}=0.049\text{cm}$

$\Rightarrow$ least count = 1 MSD – 1VSD = 0.05 – 0.049
= 0.001 cm.

So vernier reading = 0.001 × 24 = 0.024 cm.

Therefore diameter of cylinder = 5.10 + 0.024 = 5.124 cm.

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

$\delta(d)=\left(\frac{\lambda}{2\sin^2\theta}\right)\cos\theta\delta\theta \quad \{\delta\theta = \text{constant}\}$

as θ increases, $\frac{\cos\theta}{\sin^2\theta}$ decreases so

Absolute error $|\delta(d)|$ decreases

Also fractional error $=\left|\frac{\delta(d)}{d}\right|=\frac{\left(\frac{\lambda\cos\theta}{2\sin^2\theta}\right)\delta\theta}{\frac{\lambda}{2\sin\theta}}$

$=(\cot\theta)\delta\theta$

as θ increases, $\cot\theta$ decreases, so fractional error decreases

13. B

MCQ's

1. By using mirror formula $\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$

Set 1 $\rightarrow u=-42$ cm $\Rightarrow v=-56$ cm
Set 2 $\rightarrow u=-48$ cm $\Rightarrow v=-48$ cm
Set 3 $\rightarrow u=-60$ cm $\Rightarrow v=-40$ cm
Set 4 $\rightarrow u=-66$ cm $\Rightarrow v=-37.7\pm0.2\neq33$ cm
Set 5 $\rightarrow u=-78$ cm $\Rightarrow v=-34.67\pm0.2\neq39$cm

2. For a longer air column, absorption of energy is more.

Due to end correction $l+e=\frac{\lambda}{4}$.

3. B,C **4.** A,B,C,D

Subjective

1. Least count = 1MSD – 1VSD

Here n(MSD) = (n+1) (VSD) $\Rightarrow$ 1 VSD $= \frac{na}{n+1}$

$\Rightarrow$ Least count $= a - \frac{na}{n+1} = \frac{a}{n+1}$

2. $Y = \frac{Fl}{\left(\frac{\pi D^2}{4}\right)\Delta l} = \frac{4Fl}{\pi D^2 \Delta l}$

$\frac{\Delta Y}{Y} = \frac{\Delta l}{l} + 2\frac{\Delta D}{D} + \frac{\Delta(\Delta l)}{\Delta l}$

$= \frac{0.1}{110} + 2\left(\frac{0.001}{0.050}\right) + \frac{0.001}{0.125}$

Maximum percentage error

$\frac{\Delta Y}{Y} \times 100 = \frac{1}{11} + 4 + 0.8 = 4.89\%$

4. Least count $= \frac{1\,mm}{100} = 0.01$ nn

Diameter D = 1mm + (47) (0.01)mm = 1.47mm

= 0.147 cm

Curved surface area = $2\pi r\bullet = \pi D\bullet$

= (3.14) (0.147) (5.6) = 2.6 cm^2

5. Least count of vernier callipers

$= \left(1 - \frac{9}{10}\right)$ mm = 0.1 mm

Side of cube = 10mm + 1 × 0.1 mm = 10.1 mm = 1.01 cm

Density $= \frac{2.736}{(1.01)^3} = 2.66$ g/cm^3

MOCK TEST

1. **(C)** Zero error $= 5 \times \frac{0.5}{50} = 0.05$mm

Actual measurement $= 2 \times 0.5\text{mm} + 25 \times \frac{0.5}{50} - 0.05$ mm

= 1 mm + 0.25 mm – 0.05 mm = 1.20 mm.

2. $\left(\frac{\Delta v}{v}\right)_{max} = \frac{\Delta f_0}{f_0} + \frac{\Delta\lambda_1 + \Delta\lambda_2}{\lambda_2 - \lambda_1} = \frac{1}{100} + \frac{0.1+0.1}{74-24}$

$= \left(\frac{1}{100} + \frac{0.2}{50}\right) \times 100\% = 1.4\%$

3. $T = 2\pi\sqrt{\frac{\lambda}{g}} \Rightarrow g = \frac{4\pi^2 l}{T^2}$

$\left(\frac{\Delta g}{g}\right)_{max} = \frac{\Delta\lambda}{\lambda} + 2\frac{\Delta T}{T}$

$= \left(\frac{0.1}{50.0} + 2\frac{0.01}{2.00}\right) \times 100\,\%. = 1.2\,\%$

4. $M_E = K + U = 300.0 \pm 3.0J = E \pm \Delta E.$

$\therefore \quad \frac{\Delta E}{E} \times 100 = 1\%$

5. $y = \bullet^2 - \frac{l^3}{z}$

$dy = 2\bullet d\bullet - \left(\frac{z3l^2\,dl - l^3 dz}{z^2}\right) = \left(2l - \frac{3l^2}{z}\right) d\bullet + \frac{l^3}{z^2}$

$dz = \left(2 \times 2 - \frac{3\times 2^2}{1}\right)(\pm 0.1) + \frac{8}{1}(\pm 0.1)$

$= |-8(\pm 0.1)| + 8(\pm 0.1) = \pm 1.6$

$y = \bullet^2 - \frac{l^3}{z^2} = 2^2 - \frac{2^3}{1} = 4 - 8 = -4$

$\therefore \quad y = -4 \pm 1.6$

6. Fractional error $= \frac{\Delta M}{M}$ as $\Delta M_A = \Delta M_B$ as

$M_B > M_A \Rightarrow \frac{\Delta M_A}{M_A} > \frac{\Delta M_B}{M_B}$

7. equivalent length of pendulum

L = 23.2 cm + 1.32 cm = 24.5 cm

time period $T = \frac{10.0}{10} = 1.00$ sec

(Three significant figures)

$g = 4\pi^2 \frac{L}{T^2} = 4 \times 10\ \frac{24.5\times 10^{-2}\,m}{(10.0/10)^2\,sec^2} = 9.80\ m/s^2$

8. Since $\bullet = \left(\frac{g}{4\pi^2}\right)T^2$ so, slope of curve L v/s T^2 is $\left(\frac{g}{4\pi^2}\right)$

slope $= \frac{0.49}{2} = \frac{g}{4\pi^2} \Rightarrow g = 9.8\ m/s^2.$

9. $\bullet_1 = 24.0$ cm

$\bullet_2 = 74.0$ cm

$v = 2f_0(\bullet_2 - \bullet_1) = 2(330)(0.740 - 0.240)$

$= (2)(330)\,m(0.500) = 330$ m/sec.

10. $v \propto \sqrt{T}$ $\quad \frac{V_{27^0}}{V_{0^0}} = \sqrt{\frac{300}{273}}$

$\Rightarrow V_{0^o} = V_{27^o}\sqrt{\frac{273}{300}} = 330\sqrt{\frac{273}{300}} = 314$ m/sec.

11. $\ell_1 + \varepsilon = \frac{V}{4f_0}$ $\quad \ell_2 + \varepsilon = \frac{3V}{4f_0}$

solve both equations and get $\varepsilon = 1$cm

for third resonance, $\ell_3 + \varepsilon = \frac{5V}{4f_0}$ $\quad$ get $\ell_3 = 124$cm

12. $\varepsilon = 1\text{ cm} = 0.3\,d \quad d = \frac{1\text{cm}}{0.3} = 3.3\text{ cm}$

13.

S.No.	Value of g	Absolute error $\Delta g = \lvert g_i - \bar{g}\rvert$
1	9.81	0.01
2	9.80	0.00
3	9.82	0.02
4	9.79	0.01
5	9.78	0.02
6	9.84	0.04
7	9.79	0.01
8	9.78	0.02
9	9.79	0.01
10	9.80	0.00
	g_{mean} = 9.80	$\Delta g_{mean} = \frac{\sum \Delta g_i}{10} = \frac{0.14}{10} = 0.014$

Percentage error $= \frac{\Delta g_{mean}}{g_{mean}} \times 100 = \frac{0.014}{9.80} \times 100\,\%$

$= 0.14\,\%$

14. Due to error in ℓ $\left(\frac{\Delta\rho}{\rho}\right)_{max} = \frac{\Delta l}{l} + \frac{\Delta l}{100 - l}$

$= \frac{\Delta l\,(100)}{l\,(100-l)}$

When $\ell(100 - \ell)$ is maximum then $\left(\frac{\Delta\rho}{\rho}\right)_{max}$ will be minimum, that means $\ell = 50$ cm

15. $\frac{mg}{\pi d^2/4} = Y\left(\frac{x}{l}\right) \Rightarrow Y = \frac{mgl}{(\pi/4)\,d^2 x}$ .....(1)

$\left(\frac{dY}{Y}\right)_{max} = \frac{\Delta m}{m} + \frac{\Delta\lambda}{\lambda} + 2\frac{\Delta d}{d} + \frac{\Delta x}{x}$

$m = 20.0$ kg $\Rightarrow \Delta m = 0.1$ kg

$\ell = 125$ m $\Rightarrow \Delta\ell = 1$ cm

$d = 0.050$ cm $\Rightarrow \Delta d = 0.001$ cm

$x = 0.100$ cm $\Rightarrow \Delta x = 0.001$ cm

$\left(\frac{dY}{Y}\right)_{max} = \left(\frac{0.1\text{kg}}{20.0\text{kg}} + \frac{1\text{cm}}{125\text{cm}} + \frac{0.001\text{cm}}{0.05\text{cm}} + \frac{0.001\text{cm}}{0.100\text{cm}}\right) \times 100\,\%$

$= 4.3\,\%$

16. For any mirror

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

$f = \frac{uv}{u+v} \Rightarrow \ln f = \ln u + \ln v - \ln(u+v)$

$\left(\frac{df}{f}\right) = \frac{du}{u} + \frac{dv}{v} - \frac{d(u+v)}{u+v}$

$\left(\frac{\Delta f}{f}\right) = \pm\frac{\Delta u}{u} \pm \frac{\Delta v}{v} + \frac{m\Delta u m\Delta v}{u+v}$

$\left(\frac{\Delta f}{f}\right)_{max} = \frac{\Delta u}{|u|} + \frac{\Delta v}{|v|} + \frac{\Delta u + \Delta v}{|u+v|}$ m

$\left(\frac{df}{f}\right)_{max} = \left(\frac{0.1\text{cm}}{10.0\text{cm}} + \frac{0.1\text{cm}}{40.0\text{cm}} + \frac{0.1\text{cm} + 0.1\text{cm}}{10.0\text{cm} + 40.0\text{ cm}}\right) \times 100\,\%$

$= 1 + 0.25 + 0.4\,\% = 1.65\,\%$

17. $\frac{\Delta x}{x} = \pm\left[2\frac{\Delta a}{a} + 3\frac{\Delta b}{b} + \frac{\Delta c}{c} + \frac{1}{2}\frac{\Delta d}{d}\right]$

$\therefore \quad \frac{\Delta x}{x} \times 100 = \pm\,(2\times 2\% + 3\times 1\% + 3\% + \tfrac{1}{2}\times 4\%)$

$= \pm(4\% + 3\% + 3\% + 2\%) = \pm 12\%$

18. We have $\rho = \frac{(\pi r^2)R}{l}$

$= \frac{3.14\times(2.00)^2\times 10^{-6}\times 4.25}{(200.0\times 10^{-2})}$

$= 26.8\times 10^{-6}\,\Omega$m.