SOLVED EXAMPLES

Ex 1. A rectangular plate has a length of (21.3 ± 0.2) cm and a width of (9.8 ± 0.1) cm. Calculate the area of the plate, including its uncertainty.

Sol. Given $L = (21.3 \pm 0.2)$ cm, $b = (9.8 \pm 0.1)$ cm

$\Delta L = 0.2$ cm, $\Delta b = 0.1$ cm

Area $= Lb = (21.3 \pm 0.2) \times (9.8 \pm 0.1) = 21.3 \times 9.8 \pm 0.2 \times 9.8 \pm 0.1 \times 21.3$

$= 208.74 \pm 1.96 \pm 2.13$

Least number of significant figures in the individual quantities is 2. Hence, the final answer should have only two significant figures.

$\therefore$ $A = 208.74 = 209$ cm^2 on rounding

$= 210$ cm^2 on further rounding to two significant figures

$$\text{Relative error} = \frac{\Delta L}{L} + \frac{\Delta b}{b}$$

$$= \frac{0.2}{21.3} + \frac{0.1}{9.8} = 9.39 \times 10^{-3} + 1.02 \times 10^{-2} = 19.59 \times 10^{-3}$$

Percentage error $= 19.59 \times 10^{-3} \times 100 = 1.959\% \; ; \; 2\%$

$\therefore$ actual area $= 210$ cm$^2 \pm 2\%$

Ex 2. How many significant figures are there in each of the following numbers ?

(A) 78.9 ± 0.2 **(B)** 3.788×10^9 **(C)** 2.46×10^{-6} **(D)** 0.0053

(E) 201 **(F)** 2003 **(G)** 0.02

Sol. **(A)** 78.9 ± 0.2 has 3 significant figures.

(B) 3.788×10^9 has 4 significant figures.

(C) 2.46×10^{-6} has 3 significant figures

(D) 0.0053 has 2 significant figures as leading zeros are not significant.

(E) 3 significant figures

(F) 4 significant figures

(G) 1 significant figures

Ex 3. A jeweller inserts a gem weighing 3.47 g into a box weighing 1.8 kg. Find the total weight of the box and the gem to correct number of significant figures.

Sol. Total weight $= 1.8$ kg $+ 0.00347$ kg $= 1.80347$ kg

In finding the sum or difference, the result should have the number of decimal places equal to the smallest number of decimal places in individual quantities.

Therefore, total weight $= 1.8$ kg since only one decimal places should be used.

Ex 4. A long thread of length 1.23 m is cut to obtain a small thread of length 12.3 mm. What is the new length of the long thread ?

Sol. New length = $1.23\ m - 12.3 \times 10^{-3} = 1.2177\ m$

Least number of decimal places in any of the individual quantities is 2.

Hence, new length = 1.22 m.

Ex 5. A rectangular piece of copper is $4.10\ cm \pm 0.01 cm$ long and $0.91\ cm \pm 0.01\ cm$ wide. Find the area of the rectangle and the percentage uncertainty in the area.

Sol. Given $L = 4.10\ cm \pm 0.01\ cm, b = 0.91\ cm \pm 0.01\ cm$

Area $= (L \pm \Delta L)(b \pm \Delta b)$

$= (4.10 \pm 0.01)(0.91 \pm 0.01) = 4.10 \times 0.91 \pm$ percentage error

$= 3.731\ cm^2 \pm$ percentage error

$$\text{Percentage error} = \left(\frac{\Delta L}{L} + \frac{\Delta b}{b}\right) \times 100 = \left(\frac{0.01}{4.1} + \frac{0.01}{0.91}\right) \times 100$$

Percentage error $= (2.439 \times 10^{-3} + 10.99 \times 10^{-3}) \times 100 = 13.429 \times 10^{-1} = 1.343\ \%$

The least number of significant figures in any of the individual quantities is 2. Hence,

Area $= 3.7\ cm^2 \pm 1.3\ \%$

Ex 6. The sides of a rectangle are (18.52 ± 0.2) m and (3.62 ± 0.5) m. Find the perimeter of the rectangle with error limits.

Sol. $L = (1.852 \pm 0.2)$ m and $b = (3.62 \pm 0.5)$ m

Perimeter $= 2(L + b) = 2(1.852 + 3.62) = 10.944$ m

Error in measurement of perimeter,

$\Delta P = (\Delta L + \Delta b) = 2(0.2 + 0.5) = 1.4$ m

$\therefore$ actual perimeter $= (10.94 \pm 1.4)$ m

Ex 7. The length of suspension string in a simple pendulum is $(0.87\ m \pm 0.01\ m)$ and the radius of the bob of the pendulum is $(3.47\ cm \pm 0.01\ cm)$. Find the effective length of the pendulum with error limits and due regard to significant figures.

Sol. $L = 0.87\ m \pm 0.01\ m$

$r = 3.47\ cm \pm 0.01\ cm = (3.47 \pm 0.01)\ 5\ 10^{-2}\ m$

Effective length of the pendulum,

$l = L + r = 0.87 \Rightarrow +0.0347 \Rightarrow = 0.9047\ m \Rightarrow = 0.91\ m$

Error in measurement of effective length,

$\Delta l = \Delta L + \Delta r = 0.01 + 0.0001 = 0.01$ m

Hence, $l = (0.9\ m \pm 0.01\ m)$

Ex 8. The radius of a uniform solid sphere is measured to be (5.60 ± 0.20) cm and its mass is measured to be (8.51 ± 0.02) kg. Determine the density of the sphere in kg m^{-3} and the uncertainity in density.

Sol. Radius, $r = (5.60 \pm 0.20)\,cm$;

mass, $M = (8.51 \pm 0.02)\,kg$

Density, $$\rho = \frac{\text{Mass}}{\text{Volume}} = \frac{M}{\frac{4}{3}\pi r^3} \Rightarrow = \frac{3 \times 8.51 kg}{4 \times \pi \times \left(5.60 \times 10^{-2} m\right)^3}$$

$$= 1.1569 \times 104\,kg\,m^{-3}$$

Uncertainty in density, $$\frac{\Delta\rho}{\rho} = \frac{\Delta M}{M} + 3\frac{\Delta r}{r}$$

$$\frac{0.02}{8.51} + 3 \times \frac{0.20}{5.60} = 2.35 \times 10^{-3} + 107.1 \times 10^{-3}$$

$$= 109.45 \times 10^{-3} = 109.45 \times 10^{-3} \times 100\,\% = 10.945\,\%$$

Least number of significant figures in any of the individual quantities is 3.

Density, $\rho = 1.16 \times 10^4\,kg\,m^{-3} \pm 11\,\%$

Ex 9. A circular park has a radius of $(12.1\ m \pm 0.1 m)$. Find the area of the park with percentage error.

Sol. $r = 12.1\ m \pm 0.1\ m$

$Area = \pi r^2 = \pi (12.1)^2 = 4.6 \times 1.65\,\%$

Percentage error, $$\frac{\Delta A}{A} = 2\frac{\Delta r}{r} = 2 \times \frac{0.1}{12.1} \times 100 = 1.65\,\%$$

$\therefore$ $Area = 460\ m^2 \pm 1.65\,\%$

Ex.10 The circular scale of a micrometer has 200 divisions and pitch of 2mm. Find the measured value of thickness of a thin sheet.

(A) 3.41 mm **(B)** 6.41 mm **(C)** 3.46 mm **(D)** 3.51 mm

Sol. **Ans. (B)**

Least count $= \frac{\text{pitch}}{\text{No. of divisions}} = \frac{2}{200} = 0.01\,mm$; Reading $= 3 \times 2 + (46 - 5)(0.01) = 6.41$ mm

Ex 11. Estimate the percentage error in the determination of density of a material taken in the form of a cylinder with 2 % error in mass measurement, 1 % error in radius measurement and 3 % error in height measurement.

Sol. Density of material of a cylinder, $\rho = \frac{\text{Mass}}{\text{Volume}} = \frac{M}{\pi r^2 h}$

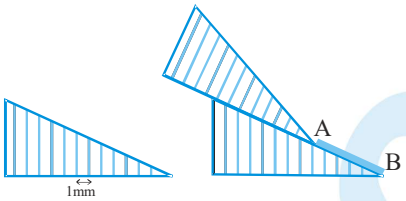
$$\frac{\Delta\rho}{\rho} = \frac{\Delta M}{M} + 2\frac{\Delta r}{r} + \frac{\Delta h}{h} = 2\,\% + 2 \times 1\,\% + 3\,\% = 7\,\%$$

Ex 12. The radius of earth is estimated with an error of 1 %. Estimate the error in the measurement of its volume.

Sol. Volume, $V = \frac{4}{3}\pi r^3$

$\therefore$ error in estimation of volume, $\frac{\Delta V}{V} = 3\frac{\Delta r}{r} = 3\ \%$

Ex.13 A brilliant student of Class XII constructed a vernier calipers as shown. He used two identical inclines of inclination 37° and tried to measure the length of line AB. The length of line AB is



(A) $\frac{21}{4}$ mm **(B)** $\frac{25}{4}$ mm **(C)** $\frac{18}{4}$ mm **(D)** None of these

Sol. Least count $= \frac{1}{\cos\theta} - 1 = 1\left(\frac{1}{4/5} - 1\right) = \left(\frac{5}{4} - 1\right) = \frac{1}{4}$ mm

Length AB $= (4)\left(\frac{1}{\cos\theta}\right) + (5)\left(\frac{1}{\cos\theta} - 1\right) = 4\left(\frac{5}{4}\right) + 5\left(\frac{1}{4}\right) = 5 + \frac{5}{4} = \frac{25}{4}$ mm

Ex.14 The length of the string of a simple pendulum is measured with a meter scale to be 63.5 cm, the radius of the bob plus the hook is measured with the help of vernier caliper to be 1.55 cm. Select the incorrect statement :-

(A) Least count of meter scale is 0.1 cm **(B)** Least count of vernier caliper is 0.01 cm

(C) Effective length of pendulum is 65.1 cm **(D)** Effective length of pendulum is 65.2 cm

Sol. From measurements least count of meter scale is 0.1 cm and least count of vernier calliper is 0.01 cm.

Effective length of simple pendulum = 63.5 + 1.55 = 65.15 = 65.2 cm

Ex.15 Two clocks A and B are being tested against a standard clock located in the national laboratory At 10:00 AM by the standard clock, the readings of the two clocks are shown in following table

Day	Clock A	Clock B
Ist	10:00 : 06	8:15:00
IInd	10:01:13	8:15:01
IIIrd	9:59:08	8:15:04
IVth	10:02:15	8:14:58
Vth	9:58:10	8:15:02

If you are doing an experiment that requires precision time interval measurements, which of the two clocks will you prefer?

(A) clock A **(B)** clock B

(C) either clock A or clock B **(D)** Neither clock A nor clock B

Sol. The average reading of clock A is, closure to the standard time and the variation in time is smaller for clock B. As clock's is zero error is not significant for precision work because a zero error can always be easily corrected. Hence clock B is to be preferred.

Ex.16 The side of a cube is (2.00 ± 0.01) cm. The volume and surface area of cube are respectively :–

(A) $(8.00 \pm 0.12)\ cm^3, (24.0 \pm 0.24)\ cm^2$ **(B)** $(8.00 \pm 0.01)\ cm^3, (24.0 \pm 0.01)\ cm^2$

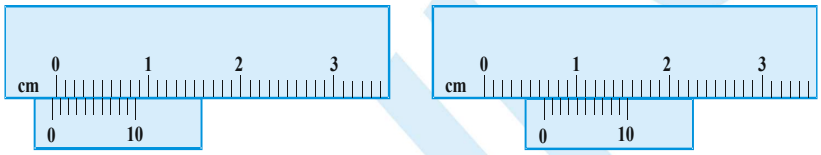
(C) $(8.00 \pm 0.04)\ cm^3, (24.0 \pm 0.06)\ cm^2$ **(D)** $(8.00 \pm 0.03)\ cm^3, (24.0 \pm 0.02)\ cm^2$

Sol. Volume $V=a^3=8\ cm^3$. Also $\frac{\Delta V}{V} = 3\frac{\Delta a}{a} \Rightarrow \Delta V = 3V\left(\frac{\Delta a}{a}\right) = (3)(8)\left(\frac{0.01}{2.00}\right) = 0.12\ cm^3$

Therefore $V = (8.00 \pm 0.12)\ cm^3$; Surface Area $A = 6a^2 = 6\ (2.00)^2 = 24.0\ cm^2$.

Also $\frac{\Delta A}{A} = 2\frac{\Delta a}{a} \Rightarrow \Delta A = 2A\left(\frac{\Delta a}{a}\right) = 2\ (24.0)\left(\frac{0.01}{2.00}\right) = 0.24$. Therefore $A = (24.0 \pm 0.24)\ cm^2$

Ex.17 The main scale of a vernier callipers reads in millimeter and its vernier is divided into 10 divisions which coincides with 9 divisions of the main scale. The reading for shown situation is found to be (x/10) mm. Find the value of x.



Sol. Least count $= \frac{1\,mm}{10} = 0.1$ mm; Zero error $= -(10-6) \times 0.1 = -0.4$ mm

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

Ex.18 Round off the following numbers to 3 significant digits-

(i) 899.68 **(ii)** 987.52 **(iii)** 2.0082 **(iv)** 336.5 **(v)** 335.5

Sol. (i) 900 (ii) 988 (iii) 2.01 (iv) 336 (v) 336

Ex.19 Write number of significant digits

(i) 62.3 cm **(ii)** 6.23×10^1 cm **(iii)** 20.000 **(iv)** 0.02×10^{-19} **(v)** 500.000

(vi) 0.5210 **(vii)** 896.80 **(viii)** 201 **(ix)** 1200 **(x)** 1200 N

Sol. **Ans.** (i) 3 (ii) 3 (iii) 5 (iv) 1 (v) 6 (vi) 4 (vii) 5 (viii) 3 (ix) 2 (x) 4

Ex.20 A scale is calibrated to centimeters and the following measurements are estimated by the scale. Find out the significant digits.

(i) 200 m **(ii)** 92.80 m **(iii)** 80.26 m **(iv)** 8.23 cm

(v) 8.921 mm **(vi)** 6.001 m

Sol. **Ans.** (i) 3 (ii) 4 (iii) 4 (iv) 2 (v) 1 (vi) 4

Ex.21 Solve with regards to significant figure

(i) $908 + 2.76$ **(ii)** $999 - 989$ **(iii)** $4.0 \times 10^{-4} - 2.5 \times 10^{-6}$

(iv) $4.0 \times 10^{-4} - 2.5 \times 10^{-5}$ **(v)** $6.75 \times 10^3 + 4.52 \times 10^2$ **(vi)** $625 \div 125$

Sol. **Ans.** (i) 911 (ii) 10.0 (iii) 4.0×10^{-4} (iv) 3.8×10^{-4} (v) 7.20×10^3 (vi) 5.00

Ex.22 Students I_1, J_1,J_3 and I_2 perform an experiment for measuring the acceleration due to gravity (G) using a simple pendulum. they use different lengths of the pendulum and record time for different number of oscillations. The observations are shown in the table. Least count for length = 0.1 cm, Least count for time = 1s

Students	Length of the pendulum (cm)	No. of oscillations (n)	Time period of pendulum (s)
I_1	100.0	20	20
J_1	400.0	10	40
J_3	100.0	10	20
I_2	400.0	20	40

If P_1,P_2,P_3 and P_4 are the % error in g for students I_1,J_1,J_3 and I_2 respectively then-

(A) $P_1 = P_3$ **(B)** P_3 is maximum **(C)** P_4 is minimum **(D)** $P_2 = P_4$

Sol. $T = 2\pi\sqrt{\frac{l}{g}} \Rightarrow g \propto \bullet T^{-2} = \frac{\Delta g}{g} = \frac{\Delta l}{l} + \frac{2\Delta T}{T}$.

Therefore $P = \left(\frac{\Delta l}{l} + \frac{2\Delta T}{T}\right)100 \Rightarrow P_1 = \left(\frac{0.1}{100} + \frac{2(1)}{400}\right) \times 100 = 0.6\%,\ P_2 = \left(\frac{0.1}{400} + \frac{2(1)}{400}\right) \times 100 = 0.42\%$

$P_3 = \left(\frac{0.1}{100} + \frac{2(1)}{200}\right) \times 100 = 1.1\%,\ P_4 = \left(\frac{0.1}{400} + \frac{2(1)}{800}\right) \times 100 = 0.28\%$

Ex.23 An object covers (16.0 ± 0.4) m distance in (4.0 ± 0.2) s. Find out its speed.

Sol. Speed $v = \frac{\text{distance}}{\text{time}} = \frac{16.0}{4.0} = 4.0$ m/s; Error in speed $\Delta v = \pm\left(\frac{\Delta s}{s} + \frac{\Delta t}{t}\right) v = \left(\frac{0.4}{16.0} + \frac{0.2}{4.0}\right)(4.0) = \pm 0.3$ m/s

Ex.24 The length of a cylinder is measured with a metre rod having least count 0.1 cm. Its diameter is measured with vernier callipers having least count 0.01 cm. Given the length is 5.0 cm and diameter is 2.00 cm. Find the percentage error in the calculated value of volume.

Sol. $V = \pi r^2 h = \frac{\pi D^2 h}{4} \Rightarrow \frac{\Delta V}{V} = \frac{2\Delta D}{D} + \frac{\Delta h}{h}\ \frac{\Delta V}{V} \times 100 = \left[2 \times \left(\frac{0.01}{2.00}\right) + \left(\frac{0.1}{5.0}\right)\right] \times 100 = 3\%$

Exercise # 1 [Single Correct Choice Type Questions]

1. The percentage errors in the measurement of mass and speed are 2% and 3% respectively. How much will be the maximum error in the estimate of kinetic energy obtained by measuring mass and speed ?
(A) 11% **(B)** 8% **(C)** 5% **(D)** 1%

2. Significant figures in 3400 are-
(A) 2 **(B)** 5 **(C)** 6 **(D)** 7

3. The density of a cube is measured by measuring its mass and the length of its side. If the maximum errors in the measurement of mass and length are 4% and 3% respectively, the maximum error in the measurement of the density is -
(A) 9% **(B)** 13% **(C)** 12% **(D)** 7%

4. If error in measuring diameter of a circle is 4%, the error in the radius of the circle would be
(A) 2% **(B)** 8% **(C)** 4% **(D)** 1%

5. An experiment measures quantities a, b and c, and X is calculated from $X = \frac{ab^2}{c^3}$. If the percentage error in a, b and c are ±1%, ±3% and ±2% respectively, the percentage error in X will be –
(A) ±13% **(B)** ±7% **(C)** ±4% **(D)** ±1%

6. While measuring acceleration due to gravity by a simple pendulum a student makes a positive error of 1% in the length of the pendulum and a negative error of 3% in the value of the time period. His percentage error in the measurement of the value of g will be -
(A) 2% **(B)** 4% **(C)** 7% **(D)** 10%

7. The diameter of a wire is measured with a screw gauze having least count 0.01 mm. Which of the following correctly expresses the diameter –
(A) 0.20 cm **(B)** 0.002 m **(C)** 2.00 mm **(D)** 0.2 cm

8. If a, b, c are the percentage errors in the measurement of A, B and C, then percentage error in ABC would be approximately-
(A) abc **(B)** a + b + c **(C)** ab + bc + ac **(D)** $\frac{a}{b}+\frac{b}{c}+\frac{c}{a}$

9. A student measured the diameter of a wire using a screw gauge with least count 0.001 cm and listed the measurements. The correct measurement is –
(A) 5.3 cm **(B)** 5.32 cm **(C)** 5.320 cm **(D)** 5.3200 cm

10. The period of oscillation of a simple pendulum in the experiment is recorded as 2.63s, 2.56s, 2.42s, 2.71s and 2.80s respectively. The average absolute error is
(A) 0.1s **(B)** 0.11s **(C)** 0.01s **(D)** 1.0s

11. The pressure on a square plate is measured by measuring the force on the plate and the length of the sides of the plate. If the maximum error in the measurement of force and length are respectively 4% and 2%, the maximum error in the measurement of pressure is –
(A) 1% **(B)** 2% **(C)** 6% **(D)** 8%

12. When a copper sphere is heated, maximum percentage change will be observed in–
(A) radius **(B)** area **(C)** volume **(D)** none of these

13. A scientist performs an experiment in order to measure a certain physical quantity and takes 100 observations. He repeats the same experiment and takes 400 observations, by doing so
(A) The possible error remains same **(B)** The possible error is doubled
(C) The possible error is halved **(D)** The possible error is reduced to one fourth

14. The significant digits in 200.40 are
(A) 4 **(B)** 5 **(C)** 2 **(D)** 3

15. If error in measuring diameter of a circle is 4 %, the error in circumference of the circle would be :-
(A) 2% **(B)** 8% **(C)** 4% **(D)** 1%

16. A quantity is represented by $X = M^a L^b T^c$. The percentage error in measurement of M, L and T are α%, β % and γ % respectively. The percentage error in X would be
(A) $(\alpha a + \beta b + \gamma c)$ % **(B)** $(\alpha a - \beta b + \gamma c)$ % **(C)** $(\alpha a - \beta b - \gamma c)$ % **(D)** None of these

17. A wire has a mass (0.3±0.003) g, radius (0.5±0.005) mm and length (6 ± 0.06) cm. The maximum percentage error in the measurement of its density is –
(A) 1 **(B)** 2 **(C)** 3 **(D)** 4

18. The volume of a sphere is 1.76 cm^3. The volume of 25 such spheres taking into account the significant figure is-
(A) 0.44×10^2 cm^3 **(B)** 44.0 cm^3 **(C)** 44 cm^3 **(D)** 44.00 cm^3

19. The length of a cylinder is measured with a metre rod having least count 0.1 cm. Its diameter is measured with vernier callipers having least count 0.01 cm. Given the length is 5.0 cm and diameter is 2.00 cm. The percentage error in the calculated value of volume will be –
(A) 2% **(B)** 1% **(C)** 3% **(D)** 4%

20. The resistance is $R = \frac{V}{I}$ where V = 100 ± 5 Volts and I = 10 ± 0.2 amperes. What is the total error in R ?
(A) 5% **(B)** 7% **(C)** 5.2% **(D)** $\left(\frac{5}{2}\right)$%

21. What is the fractional error in g calculated from $T = 2\pi\sqrt{\frac{l}{g}}$? Given that fractional errors in T and ● are ± x and ± y respectively.
(A) x + y **(B)** x – y **(C)** 2x + y **(D)** 2x – y)

22. The external and internal radius of a hollow cylinder are measured to be (4.23 ± 0.01) cm and (3.89 ± 0.01) cm. The thickness of the wall of the cylinder is :-
(A) (0.34 ± 0.02)cm **(B)** (0.17 ± 0.02)cm **(C)** (0.17 ± 0.01)cm **(D)** (0.34 ± 0.01)cm

23. The length, breadth and thickness of a strip are (10.0 ± 0.1)cm, (1.00 ± 0.01) cm and (0.100 ± 0.001) cm respectively. The most probable error in its volume will be
(A) ± 0.03 cm^3 **(B)** ± 0.111 cm^3 **(C)** ± 0.012 cm^3 **(D)** none of these

24. The length ●, breadth b and thickness t of a block of wood were measured with the help of a measuring scale. The results with permissible errors are ● = 15.12 ± 0.01 cm, b = 10.15 ± 0.01 cm, t = 5.28 ± 0.01 cm. The percentage error in volume upto proper significant figures is –
(A) 0.28% **(B)** 0.36% **(C)** 0.48 % **(D)** 0.64%

25. The radius of a disc is 1.2 cm. Its area according to idea of significant figures, will be given by:-
(A) 4.5216 cm^2 **(B)** 4.521 cm^2 **(C)** 4.52 cm^2 **(D)** 4.5 cm^2

26. The following observations were taken for determining surface tension of water by capillary tube method: Diameter of capillary $D = 1.25 \times 10^{-2}$ m Rise of water in capillary, $h = 1.45 \times 10^{-2}$ m. Taking g = 9.80 m/s^2 and using the relation $T = (rhg/2) \times 10^3$ N/m, what is the possible error in surface tension. T–
(A) 0.16% **(B)** 1.6% **(C)** 16% **(D)** 2.4%

27. The area of a rectangle of size 1.23 × 2.345 cm is
(A) 2.88 cm^2 **(B)** 2.884 cm^2 **(C)** 2.9 cm^2 **(C)** 2.88435 cm^2

28. The least count of a stop watch is 1/5 sec. The time of 20 oscillations of a pendulum is measured to be 25 s. What is the maximum percentage error in this measurement
(A) 8% **(B)** 1% **(C)** 0.8% **(D)** 16%

29. The vernier of a circular scale is divided into 30 divisions which coincide against 29 divisions of main scale. Each main scale division is 0.5°. The least count of the instrument is –
(A) 10' **(B)** 0.1' **(C)** 1' **(D)** 30'

30. What is vernier constant
(A) It is the value of the one main scale division by the total number of divisions on the main scale.

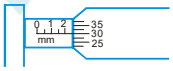
(B) It is the value of one vernier scale division divided by the total number of division on the vernier scale.

(C) It is the difference between value of one main scale division and one vernier scale division

(D) It is not the least count of vernier scale.

31. A vernier callipers having 1 main scale division = 0.1 cm is designed to have a least count of 0.02 cm. If n be the number of divisions on vernier scale and m be the length of vernier scale, then
(A) n= 10, m = 0.5 cm **(B)** n=9, m= 0.4 cm **(C)** n=10, m = 0.8 cm **(D)** n=10, m= 0.2 cm

32. What is the reading of micrometer screw gauge shown in figure



(A) 2.30 mm **(B)** 2.29 mm **(C)** 2.36 mm **(D)** 2.41 mm

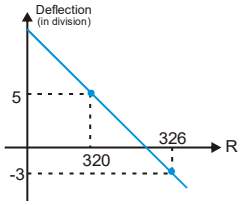
33. In a vernier calliper, N divisions of vernier scale coincide with (N – 1) divisions of main scale (in which 1 division represents 1mm). The least count of the instrument in cm. should be

(A) N **(B)** N – 1 **(C)** $\frac{1}{10N}$ **(D)** $\frac{1}{N-1}$

34. In a vernier callipers the main scale and the vernier scale are made up different materials. When the room temperature increases by ΔT°C, it is found the reading of the instrument remains the same. Earlier it was observed that the front edge of the wooden rod placed for measurement crossed the N^{th} main scale division and N+2 MSD coincided with the 2nd VSD. Initially, 10 VSD coincided with 9 MSD. If coefficient of linear expansion of the main scale is α_1 and that of the vernier scale is α_2 then what is the value of α_1 / α_2? (Ignore the expansion of the rod on heating)
(A) 1.8 /N **(B)** 1.8/ (N+3.8) **(C)** 1.8/ (N–2) **(D)** 1.8/N+2

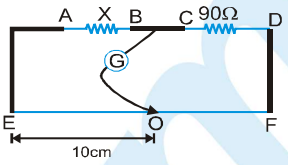
35. In a vernier callipers, N divisions of the main scale coincide with N+m divisions of the vernier scale. What is the value of m for which the instrument has minimum least count?
(A) 1 **(B)** N **(C)** infinity **(D)** N/2

36. For a post office box, the graph of galvanometer deflection versus R (resistance pulled out of RB) for the ratio 100 : 1 is given as shown. A careless student pulls out two non consecutive values R marked in the graph. Find the value of unknown resistance



(A) 3.2 ohm **(B)** 3.24 ohm **(C)** 3.206 ohm **(D)** None

37. Consider the MB shown in the diagram, let the resistance X have temperature coefficient α_1 and the resistance from the RB have the temperature coefficient α_2. Let the reading of the meter scale be 10 cm from the LHS. If the temperature of the two resistance increase by small temperature ΔT then what is the shift in the position of the null point? Neglect all the other changes in the bridge due to temperature rise

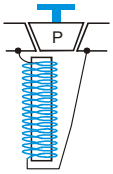


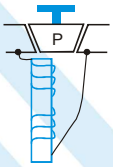
(A) $9(\alpha_1 - \alpha_2)\Delta T$ **(B)** $9(\alpha_1 + \alpha_2)\Delta T$ **(C)** $1/9(\alpha_1 + \alpha_2)\Delta T$ **(D)** $1/9(\alpha_1 - \alpha_2)\Delta T$

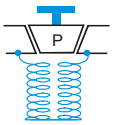
38. In a meter bridge set up, which of the following should be the properties of the one meter long wire?

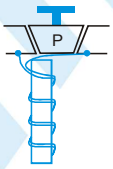
(A) High resistivity and low temperature coefficient
(B) Low resistivity and low temperature coefficient
(C) low resistivity and high temperature coefficient
(D) High resistivity and high temperature coefficient

39. Identify which of the following diagrams represent the internal construction of the coils wound in a resistance box or PO box ?

(A)


(B)


(C)


(D)


Exercise # 2 Part # I [Multiple Correct Choice Type Questions]

1. In the previous question, minimum possible error in area measurement can be -

(A) $\pm 0.02\ cm^2$ (B) $\pm 0.01\ cm^2$ (C) $\pm 0.03\ cm^2$ (D) Zero

2. The length of a rectangular plate is measured by a meter scale and is found to be 10.0 cm. Its width is measured by vernier callipers as 1.00 cm. The least count of the meter scale and vernier callipers are 0.1 cm and 0.01 cm respectively (Obviously). Maximum permissible error in area measurement is -

(A) $\pm 0.2\ cm^2$ (B) $\pm 0.1\ cm^2$ (C) $\pm 0.3\ cm^2$ (D) Zero

3. For a cubical block, error in measurement of sides is $\pm$ 1% and error in measurement of mass is $\pm$ 2%, then maximum possible error in density is -

(A) 1% (B) 5% (C) 3% (D) 7%

4. The least count of a stop watch is 0.2 second. The time of 20 oscillations of a pendulum is measured to be 25 seconds. The percentage error in the time period is

(A) 16% (B) 0.8 % (C) 1.8 % (D) 8 %

5. To estimate 'g' (from $g = 4p^2 \frac{L}{T^2}$), error in measurement of L is $\pm$ 2% and error in measurement of T is $\pm$ 3%. The error in estimated 'g' will be -

(A) $\pm$ 8% (B) $\pm$ 6% (C) $\pm$ 3% (D) $\pm$ 5%

6. Two resistors R_1 (24 ± 0.5) W and R_2 (8 ± 0.3) W are joined in series. The equivalent resistance is

(A) 32 ± 0.33 W (B) 32 ± 0.8 W (C) 32 ± 0.2 W (D) 32 ± 0.5 W

7. The mass of a ball is 1.76 kg. The mass of 25 such balls is

(A) 0.44×10^3 kg (B) 44.0 kg (C) 44 kg (D) 44.00 kg

8. The dimensions of a rectangular block measured with a vernier callipers having least count of 0.1 mm is 5 mm × 10 mm × 5 mm. The maximum percentage error in measurement of volume of the block is

(A) 5 % (B) 10 % (C) 15 % (D) 20 %

9. The pitch of a screw gauge is 0.5 mm and there are 100 divisions on it circular scale. The instrument reads +2 circular scale divisions when nothing is put in-between its jaws. In measuring the diameter of a wire, there are 8 divisions on the main scale and 83rd circular scale division coincides with the reference line. Then the diameter of the wire is

(A) 4.05 mm (B) 4.405 mm (C) 3.05 mm (D) 1.25 mm

10. In the Searle's experiment, after every step of loading, why should we wait for two minutes before taking the readings? (More than one correct)

(A) So that the wire can have its desired change in length

(B) So that the wire an attain room temperature

(C) So that vertical oscillations can get subsided

(D) So that the wire has no change in its radius

11. The pitch of a screw gauge is 1 mm and there are 50 divisions on its circular scale. When the two jaws of the screw gauge are in contact with each other, the zero of the circular scale lies 6 division below the line of graduation. When a wire is placed between the jaws, 3 main scale divisions are clearly visible while 31st division on the circular scale coincide with the reference line. The diameter of the wire is :

(A) 3.62 mm (B) 3.50 mm (C) 3.5 mm (D) 3.74 mm

12. The smallest division on the main scale of a vernier callipers is 1 mm, and 10 vernier divisions coincide with 9 main scale divisions. While measuring the diameter of a sphere, the zero mark of the vernier scale lies between 20 and 21 mm and the fifth division of the vernier scale coincide with a main scale division. Then diameter of the sphere is

(A) 20.5 mm **(B)** 21.5 mm **(C)** 21.50 mm **(D)** 20.50 mm

Part # II [Assertion & Reason Type Questions]

In each of the following questions, a statement of Assertion **(A)** is given followed by a corresponding statement of Reason **(R)** just below it . Of the statements mark the correct answer as

(A) Statement–1 is True, Statement–2 is True ; Statement–2 is a correct explanation for Statement–1

(B) Statement–1 is True, Statement–2 is True ; Statement–2 is NOT a correct explanation for Statement–1

(C) Statement–1 is True, Statement–2 is False.

(D) Statement–1 is False, Statement–2 is True.

1. **Statement I :** If the error in measurement of mass is 2 % and that in measurement of velocity is 5 %, then the error in measurement of kinetic energy is 6 %.

Statement II : Error in kinetic energy is $\frac{\Delta K}{K} = \left(\frac{\Delta m}{m} + 2\frac{\Delta v}{v}\right)$

2. **Statement -I :** The number of significant figures in 0.001 is 1, while in 0.100 it is 3.

Statement - II : Zeros before a non- zero significant digit are not counted while zeros after a non-zero significant digit are counted.

Exercise # 3 Part # I [Matrix Match Type Questions]

1. Match the columns.

	Column I		Column II
i	Backlash error	A	Always subtracted
ii	Zero error	B	Least count = 1 MSD – 1 VSD
iii	Vernier callipers	C	May be negative or positive
iv	Error in screw gauge	D	Due to loose fitting

2. There are four vernier scales, whose specification are given in Column I and the least count is given in Column II. Match the Columns I and II with correct specification and corresponding least count (s = value of main scale division, n = number of marks on vernier). Assume (n – 1) main scale divisions are equal to n vernier divisions.

	Column I		Column II
i	s = 1 mm , n = 10	A	0.05 mm
ii	s = 0.5 mm, n = 10	B	0.01 mm
iii	s = 0.5 mm, n = 20	C	0.1 mm
iv	s = 1 mm, n = 100	D	0.025 mm

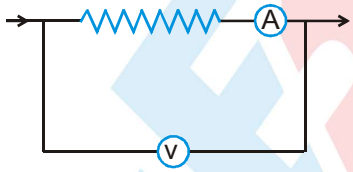
3. Using significant figures, match the following

	Column I		Column II
i	0.12345	A	5
ii	0.12100 cm	B	4
iii	47.23 ÷ 2.3	C	1
iv	3×10^8	D	2

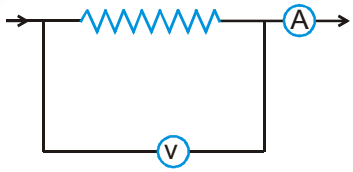
Part # II [Comprehension Type Questions]

Comprehension # 1

In the, Ohm's law experiment, to find resistance of unknown resistor R, following two arrangements **(A)** and **(B)** are possible.



(a)



(b)

The resistance measured is given by

$$R_{measured} = \frac{V}{i}$$

V = voltage reading of voltmeter, i = current Reading of ammeter.
But unfortunately the ammeters and voltmeter used are not ideal, but having resistance R_A and R_v respectively.

1. For arrangement **(A)**, the measured resistance is

(A) $R + R_v$ **(B)** $R + R_A$ **(C)** $\frac{RR_v}{R+R_v}$ **(D)** $\frac{RR_v}{R+R_v} + R_A$

2. For arrangement **(B)**, the measured resistance is

(A) $R + R_v$ **(B)** $R + R_A$ **(C)** $\frac{RR_v}{R+R_v}$ **(D)** $\frac{RR_v}{R+R_v} + R_A$

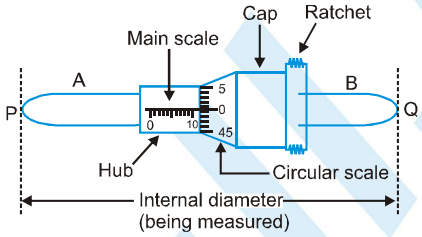
3. You are given two unknown resistors X and Y. These resistances are to be determined, using an ammeter of $R_A = 0.5\ \Omega$ and a voltmeter of $R_v = 20\ k\Omega$. It is known that X is in range of a few ohms and Y is in the range of several kilo ohm's. Which circuit is preferable to measure X and Y :

Resistor	Circuit
x	(A)
y	(B)

(A) x → **(A)**, y → **(B)** **(B)** x → **(B)**, y → **(A)**
(C) x → **(A)**, y → **(A)** **(D)** x → **(B)**, y → **(B)**

Comprehension # 2

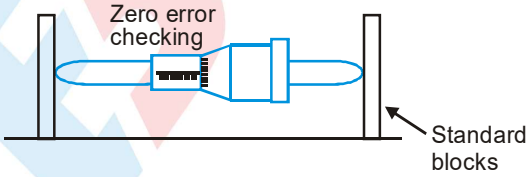
Internal micrometer is a measuring instrument used to measure internal diameter (ID) of a large cylinder bore with high accuracy. Construction is shown in figure. There is one fixed rod B (to the right in figure) and one moving rod A (to the left in figure). It is based on the principle of advancement of a screw when it is rotated in a nut with internal threads. Main scale reading can be directly seen on the hub which is fixed with respect to rod B. When the cap is rotated, rod A moves in or out depending on direction of rotation. The circular scale reading is seen by checking which division of circular scale coincides with the reference line.



This is to be multiplied by LC to get circular scale reading.

$$\text{Least count} = \text{value of 1 circular scale division} = \frac{\text{pitch}}{\text{number of division on circular scale}}$$

Length of rod A is chosen to match the ID (PQ) to be measured. Zero error is checked by taking reading between standard blocks fixed at nominal value of ID to be measured. Zero error is positive if cap end is on the right side of the main scale and negative it is on the left side.



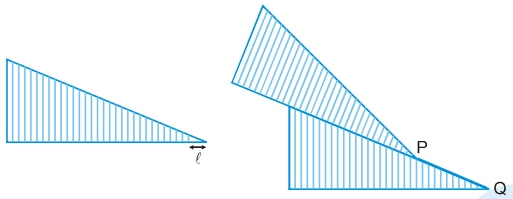
1. In an internal micrometer, main scale division is of 0.5 mm and there are 50 divisions in circular scale. The least count of the instrument is -
(A) 0.005 mm **(B)** 0.001 mm **(C)** 0.05 mm **(D)** 0.01 mm

2. In the above instrument, while measuring an internal diameter. ID is set of 321 mm with no zero error. If cap end is after 7^{th} division and 17^{th} division of main scale coincides with the reference line, the ID is-
(A) 321.717 mm **(B)** 321.87 mm **(C)** 328.17 mm **(D)** 324.67 mm

3. During zero setting of the above instrument, the end of the cap is on left side of the zero of main scale (i.e. zero of main scale is not visible) and 41^{st} division of circular scale coincides with the reference line, the zero error is-
(A) –0.09 mm **(B)** +0.41 mm **(C)** –0.41 mm **(D)** +0.09 mm

Exercise # 4 [Subjective Type Questions]

1. Consider a home made vernier scale as shown in the figure. In this diagram, we are interested in measuring the length of the line PQ. If both the inclines are identical and their angles are equal to θ then what is the least count of the instrument.



2. In a given slide callipers 10 division of its vernier coincides with its 9 main scale divisions. If one main scale division is equal to 0.5 mm then find its least count.

3. The pitch of a screw gauge is 1 mm and there are 50 divisions on its cap. When nothing is put in between the studs, 44th division of the circular scale coincides with the reference line zero of the main scale is not visible. When a glass plate is placed between the studs, the main scale reads three divisions and the circular scale reads 26 divisions. Calculate the thickness of the plate.

4. A glass prism of angle A = 60° gives minimum angle of deviation $\theta = 30°$ with the maximum error of 1° when a beam of parallel light passed through the prism during an experiment. Find the permissible error in the measurement of refractive index μ of the material of the prism.

5. A short circuit occurs in a telephone cable having a resistance of 0.45 Ωm^{-1} . The circuit is tested with a Wheatstone bridge. The two resistors in the ratio arms of the Wheatstone bridge network have values of 100Ω and 1110 Ω respectively. A balance condition is found when the variable resistor has a value of 400Ω. Calculate the distance down the cable, where the short has occurred.

6. In a given optical bench, a needle of length 10 cm is used to estimate bench error. The object needle, image needle & lens holder have their reading as shown. $x_0 = 1.1$ cm; $x_1 = 0.8$ cm; $x_L = 10.9$ cm

Estimate the bench errors which are present in image needle holder and object needle holder. Also find the focal length of the convex lens when $x_0 = 0.6$ cm ; $x_I = 22.5$ cm; $x_L = 11.4$ cm

7. Consider $S = x \cos(\theta)$ for $x = (2.0 \pm 0.2)$ cm, $\theta = 53 \pm 2°$. Find S.

8. Using screw gauge, the observation of the diameter of a wire are 1.324, 1.326, 1.334, 1.336 cm respectively. Find the average diameter, the mean error, the relative error and % error.

9. Find significant figures in the following observations -

(i) 0.007 gm **(ii)** 2.64×10^{24} kg **(iii)** 0.2370 gm/cm^3 **(iv)** 6.320 J/K

(v) 6.032 N/m^2 **(vi)** 0.0006032 K^{-1}

10. If a tuning fork of frequency (f_0) 340 Hz and tolerance $\pm$ 1% is used in resonance column method [$v = 2f_0 (l_2 - l_1)$], the first and the second resonance are measured at $l_1 = 24.0$ cm and $l_2 = 74.0$ cm. Find max. permissible error in speed of sound.

11. Round off the following numbers within three significant figures -

(i) 0.03927 kg **(ii)** 4.085×10^8 sec **(iii)** 5.2354 m **(iv)** 4.735×10^{-6} kg

Exercise # 5 Part # I [Previous Year Questions] [AIEEE/JEE-MAIN]

1. The 'rad' is the correct unit used to report the measurement of : **[AIEEE - 2006]**

(1) the ability of a beam of gamma ray photons to produce ions in a target
(2) the energy delivered by radiation to a target
(3) the biological effect of radiation
(4) the rate of decay of a radioactive source

2. An experiment is performed to find the refractive index of glass using a travelling microscope. In this experiment distances are meausred by **[AIEEE - 2008]**

(1) a vernier scale provided on the microscope **(2)** a stanard laboratory scale
(3) a meter scale provided on the microscope **(4)** a screw gauge provided on the microscope

3. Two full turns of the circular scale of gauge cover a diastance of 1 mm on scale. The total number of divisions on circular scale is 50. Further, it is found that screw gauge has a zero error of -0.03 mm. While measuring the diameter of a thin wire a student notes the main scale reading of 3 mm and the number of circular scale division in line, with the main scale as 35. The diameter of the wire is **[AIEEE - 2008]**

(1) 3.32 mm **(2)** 3.73 mm **(3)** 3.67 mm **(4)** 3.38 mm

4. In an experiment the angles are required to be measured using an instrument 29 divisions of the main scale exactly coincide with the 30 divisions of the vernier scale. If the smallest division of the main scale is half-a-degree (=0.5°), then the least count of the instrument is :- **[AIEEE - 2009]**

(1) One degree **(2)** Half degree **(3)** One minute **(4)** Half minute

5. In an optics experiment, with the position of the object fixed, a student varies the position of a convex lens and for each position, the screen is adjusted to get a clear image of the object. A graph between the object distance u and the image distance v, from the lens, is plotted using the same scale for the two axes. A straight line passing through the origin and making an angle of 45° with the x-axis meets the experimental curve at P. The coordinates of P will be **[AIEEE - 2009]**

(1) (f, f) **(2)** $(4f, 4f)$ **(3)** $(2f, 2f)$ **(4)** $\left(\frac{f}{2}, \frac{f}{2}\right)$

6. The respective number of significant figures for the numbers 23.023, 0.0003 and 2.1×10^{-3} are:- **[AIEEE - 2010]**

(1) 4, 4, 2 **(2)** 5, 1, 2 **(3)** 5, 1, 5 **(4)** 5, 5, 2

7 . A screw gauge gives the following reading when used to measure the diameter of a wire. **[AIEEE - 2011]**
Main scale reading : 0 mm.
Circular scale reading : 52 divisions
Given that 1 mm on main scale corresponds to 100 divisions of the circular scale.
The diameter of wire from the above data is :-

(1) 0.026 cm **(2)** 0.005 cm **(3)** 0.52 cm **(4)** 0.052 cm

8. A spectrometer gives the following reading when used to measure the angle of a prism. **[AIEEE - 2012]**
Main scale reading : 58.5 degree
Vernier scale reading : 09 divisions
Given that 1 division on main scale corresponds to 0.5 degree. Total divisions on the vernier scale is 30 and match with 29 divisions of the main scale. The angle of the prism from the above data : **[AIEEE - 2012]**

(1) 59 degree **(2)** 58.59 degree **(3)** 58.77 degree **(4)** 58.65 degree

9. Resistance of a given wire is obtained by measuring the current flowing in it and the voltage difference applied across it. If the percentage errors in the measurement of the current and the voltage difference are 3% each, then error in the value of resistance of the wire is :- **[AIEEE - 2012]**

(1) 3% **(2)** 6% **(3)** zero **(4)** 1%

10. The current voltage relation of diode is given by $I = \left(e^{1000V/T} - 1\right)$ mA, where the applied voltage V is in volts and the temperature T is in degree Kelvin. If a student makes an error measuring ± 0.01 V while measuring the current of 5 mA at 300 K, what will be the error in the value of current in mA ? **[JEE (Main) - 2014]**

(1) 0.5 mA **(2)** 0.05 mA **(3)** 0.2 mA **(4)** 0.02 mA

11. A student measured the length of a rod and wrote it as 3.50 cm. Which instrument did he use to measure it? **[JEE (Main) - 2014]**

(1) A screw gauge having 100 divisions in the circular scale and pitch as 1 mm.

(2) A screw gauge having 50 divisions in the circular scale and pitch as 1 mm.

(3) A meter scale.

(4) A vernier calliper where the 10 divisions in vernier scale matches with 9 division in main scale and main scale has 10 divisions in 1 cm.

12. Match List-I (fundamental Experiment) with List –II (its conclusion) and select the correct option from the choice given below the list: **[JEE (Main) - 2015]**

	List–I		List–II
(A)	Franck–Hertz Experiment	**(i)**	Particle nature of Experiment light
(B)	Photo-electric experiment	**(ii)**	Discrete energy levels of atom
(C)	Davison-Germer Experiment.	**(iii)**	Wave nature of electron
		(iv)	Structure of atom

(1) A → ii ; B → i ; C → iii

(2) A → iv ; B → iii ; C → ii

(3) A → i ; B → iv ; C → iii

(4) A → ii ; B → iv ; C → iii

13. In an experiment for determination of refractive index of glass of a prism by i -δ, plot, it was found that a ray incident at angle 35°, suffers a deviation of 40° and that it emerges at angle 79°. In that case which of the following is closest to the maximum possible value of the refractive index ? **[JEE (Main) - 2016]**

(1) 1.6 **(2)** 1.7 **(3)** 1.8 **(4)** 1.5

14. A screw gauge with a pitch of 0.5 mm and a circular scale with 50 divisions is used to measure the thickness of a thin sheet of Aluminium. Before starting the measurement, it is found that when the two jaws of the screw gauge are brought in contact, the 45th division coincides with the main scale line and that the zero of the main scale is barely visible. What is the thickness of the sheet if the main scale reading is 0.5 mm and the 25th division coincides with the main scale line? **[JEE (Main) - 2016]**

(1) 0.80 mm **(2)** 0.70 mm **(3)** 0.50 mm **(4)** 0.75 mm

Part # II [Previous Year Questions][IIT-JEE ADVANCED]

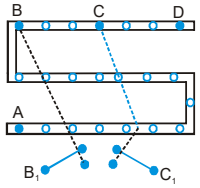
1. The edge of a cube is a = 1.2×10^{-2} m. Then its volume will be recorded as [IIT-JEE 2003]

(A) 1.7×10^{-6} m^3 (B) 1.70×10^{-6} m^3 (C) 1.70×10^{-7} m^3 (D) 1.78×10^{-6} m^3

2. A wire has a mass (0.3 ± 0.003)g, radius (0.5 ± 0.005) mm and length (6 ± 0.06) cm. The maximum percentage error in the measurement of its density is – [IIT-JEE 2004]

(A) 1 (B) 2 (C) 3 (D) 4

3. For the post office box arrangement to determine the value of unknown resistance, the unknown resistance should be connected between [IIT-JEE 2004]

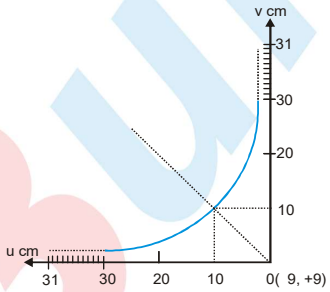


(A) B and C (B) C and D (C) A and D (D) B_1 and C_1

4. In a resonance column method, resonance occurs at two successive level of ℓ_1 = 30.7 cm and ℓ_2 = 63.2 cm using a tuning fork of f = 512 Hz. What is the maximum error in measuring speed of sound using relations v = fλ & λ = 2 (ℓ_2 – ℓ_1). [IIT-JEE 2005]

(A) 256 cm/sec (B) 92 cm/sec (C) 102.4 cm/sec (D) 204.8 cm/sec

5. Graph of position of image vs position of point object from a convex lens is shown. Then, focal length of the lens is [IIT-JEE 2006]



(A) 0.50 ± 0.05 cm (B) 0.50 ± 0.10 cm (C) 5.00 ± 0.05 cm (D) 5.00 ± 0.10 cm

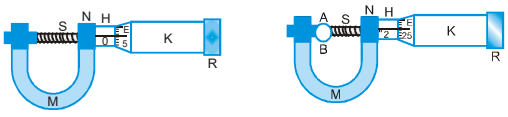
6. A student performs an experiment for determination of $\left(g = \frac{4\pi^2 l}{T^2}\right)$, $\ell \approx 1$m, and he commits an error of $\Delta\ell$.

For T he takes the time of n oscillations with the stop watch of least count ΔT and he commits a human error of 0.1 s. For which of the following data, the measurement of g will be most accurate ?

(A) $\Delta L = 0.5, \Delta T = 0.1, n = 20$ (B) $\Delta L = 0.5, \Delta T = 0.1, n = 50$ [IIT-JEE 2006]

(C) $\Delta L = 0.5, \Delta T = 0.01, n = 20$ (D) $\Delta L = 0.1, \Delta T = 0.05, n = 50$

7. The circular scale of a screw gauge has 50 divisions and pitch of 0.5 mm. Find the diameter of sphere. Main scale reading is 2 – [IIT-JEE 2006]



(A) 1.2 (B) 1.25 (C) 2.207 (D) 2.25

8. A student performs an experiment to determine the Young's modulus of a wire, exactly 2m long, by Searle's method. In a particular reading, the student measures the extension in the length of the wire to be 0.8 mm with an uncertainty of ± 0.05 mm at a load of exactly 1.0 kg. The student also measures the diameter of the wire to be 0.4 mm with an uncertainty of ± 0.01 mm. Take g = 9.8 m/s^2 (exact). The Young's modulus obtained from the reading is – **[IIT-JEE 2007]**

(A) $(2.0 \pm 0.3) \times 10^{11}$ N/m^2 **(B)** $(2.0 \pm 0.2) \times 10^{11}$ N/m^2

(C) $(2.0 \pm 0.1) \times 10^{11}$ N/m^2 **(D)** $(2.0 \pm 0.05) \times 10^{11}$ N/m^2

9. In the experiment to determine the speed of sound using a resonance column – **[IIT-JEE 2007]**

(A) prongs of the tuning fork are kept in a vertical plane.

(B) prongs of the tuning fork are kept in a horizontal plane.

(C) In one of the two resonance observed, the length of the resonating air column is close to the wavelength of sound in air

(D) In one of the two resonance observed, the length of the resonating air column is close to half of the wavelength of sound in air

10. In an experiment to determine the focal length (f) of a concave mirror by the u-v method, a student placed the object pin A on the principal axis at a distance x from the pole P. The student looks at the pin and its inverted image from a distance keeping his/her eye in line with PA. When the student shift his/her eye towards left, the image appears to the right of the object pin. Then- **[IIT-JEE 2007]**

(A) $x < f$ **(B)** $f < x < 2f$ **(C)** $x = 2f$ **(D)** $x > 2f$

11. The diameter of a cylinder is measured using a Vernier callipers with no zero error. It is found that the zero of the Vernier scale lies between 5.10 cm and 5.15 cm of the main scale. The Vernier scale has 50 divisions equivalent to 2.45 cm. The 24th division of the Vernier scale exactly coincides with one of the main scale divisions. The diameter of the cylinder is :- **[JEE Advanced 2013]**

(A) 5.112 cm **(B)** 5.124 cm **(C)** 5.136 cm **(D)** 5.148 cm

12. Using the expression $2d \sin \theta = \lambda$, one calculates the values of d by measuring the corresponding angles θ in the range 0 to 90°. The wavelength λ is exactly known and the error in θ is constant for all values of θ. As θ increases from 0° :- **[JEE Advanced 2013]**

(A) the absolute error in d remains constant **(B)** the absolute error in d increases

(C) the fractional error in d remains constant **(D)** the fractional error in d decreases

13. There are two Vernier calipers both of which have 1 cm divided into 10 equal divisions on the main scale. The vernier scale of one of the calipers (C_1) has 10 eaul divisions the correspond to 9 main scale divisions. The vernier scale of the other caliper (C_2) has 10 equal divisions that correspond to 11 main scale divisions. The readings of the two calipers a shown in the figure. The measured values (in cm) by calipers C_1 and C_2, respectively are **[IIT-JEE 2016]**

(A) 2.85 and 2.82 **(B)** 2.87 and 2.83 **(C)** 2.87 and 2.86 **(D)** 2.87 and 2.87

Multiple Choice Questions

1. A student performed the experiment of determination of focal length of a concave mirror by u-v method using an optical bench of length 1.5 meter. The focal length of the mirror used is 24 m. The maximum error in the location of the image can 0.2 m. The 5 sets of (u, v) values recorded by the student (in cm) are : (42, 56), (48, 48),(60, 40), (66, 33), (78, 39). The data set(s) that connot come from experiment and is (are) incorrectly recorded is (are) **[IIT-JEE 2009]**

(A) (42, 56) **(B)** (48, 48) **(C)** (66, 33) **(D)** (78, 39)

2. A student performed the experiment to measure the speed of sound in air using resonance air-column method. Two resonances in the air-column were obtained by resonance and that with the longer air-column is the second resonance. Then, [IIT-JEE 2009]

(A) The intensity of the sound heard at the first resonance was more than that at the second resonance

(B) the prongs of the tuning fork were kept in a horizontal plane above the resonance tube

(C) the amplitude of vibration of the ends of the prongs is typically around 1 cm

(D) the length of the air-column at the first resonance was somewhat shorter than 1/4th of the wavelength of the sound in air

3. Consider two identical galvanometers and two identical resistors with resistance R. If the internal resistance of the galvanometers Rc < R/2, which of the following statement(s) about any one of the galvanometer is(are) true?

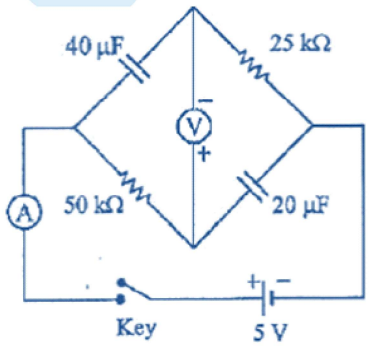
(A) The maximum voltage range is obtained when all the components are connected in series [IIT-JEE 2016]

(B) The maximum voltage range is obtained when the two resistors and one galvanometer are connected in series, and the second galvanometer is connected in parallel to the first galvanometer

(C) The maximum current range is obtained when all the components are connected in parallel

(D) The maximum current range is obtained when the two galvanometers are connected in series and the combina tion is connected parallel with both the resistors

4. In the circuit shown below, the key is pressed at time t = 0.



Which of the following statement(s) is(are) true?

(A) The voltmeter displays - 5 V as soon as the key is pressed, and displays +5 V after a long time [IIT-JEE 2016]

(B) The voltmeter will display 0 V at time t = ln 2 seconds

(C) The current in the ammeter becomes 1/e of the initial value after 1 second

(D) The current in the ammeter becomes zero after a long time

Subjective Questions

1. In a vernier callipers, n divisions of its main scale match with (n + 1) divisions on its vernier scale. Each division of the main scale is a units. Using the vernier principle, calculate its least count. [IIT-JEE 2003]

2. In a Searle's experiment, the diameter of the wire as measured by a screw gauge of least count 0.001 cm is 0.050 cm. The length, measured by a scale of least count 0.1 cm, is 110.0 cm. When a weight of 50N is suspended from the wire, the extension is measured to be 0.125 cm by a micrometer of least count 0.001 cm. Find the maximum error in the measurement of Young's modulus of the material of the wire from these data. [IIT-JEE 2004]

3. Draw the circuit for experimental verification of Ohm's law using a source of variable D.C. voltage, a main resistance of 100 Ω, two galvanometers and two resistance of values 10^6 Ω and 10^{-3} Ω respectively. Clearly show the positions of the voltmeter and the ammeter. [IIT-JEE 2004]

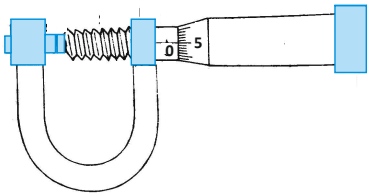
4. The pitch of a screw gauge is 1 mm and there are 100 divisions on the circular scale. While measuring the diameter of a wire, the linear scale reads 1 mm and 47^{th} division on the circular scale coincides with the reference line. The length of the wire is 5.6 cm. Find the curved surface area (in cm^2) of the wire in appropriate number of significant figures. [IIT-JEE 2004]

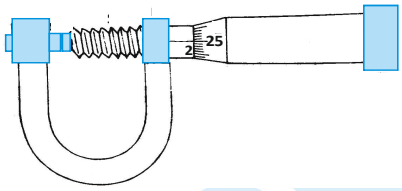
5. The edge of a cube is measured using a vernier calliper. (9 divisions of the main scale is equal to 10 divisions of vernier scale and 1 main scale division is 1 mm). The main scale division reading is 10 and 1 division of vernier scale was found to be coinciding with the main scale. The mass of the cube is 2.736 g. Calculate the density in g/cm^3 upto correct significant figures. [IIT-JEE 2005]

MOCK TEST

SECTION - I : STRAIGHT OBJECTIVE TYPE

1. The number of circular divisions on the shown screw gauge is 50. It moves 0.5 mm on main scale for one complete rotation and main scale has 1/2 mm marks . The diameter of the ball is :





(A) 2.25 mm **(B)** 2.20 mm **(C)** 1.20 mm **(D)** 1.25 mm

2. If a tuning fork of frequency (f_0) 340Hz tolerance $\pm$ 1% is used in resonance column method [$v = 2f_0(\ell_2 - \ell_1)$], the first and the second resonance are measured at $\ell_1 = 24.0$ cm and $\ell_2 = 74.0$ cm. The max. permissible error in speed of sound is :

(A) 1.4 % **(B)** 1.8 % **(C)** 1% **(D)** 0.8 %

3. To find the value of 'g' using simple pendulum. T = 2.00 sec; $\ell = 50.0$ cm was measured. The maximum permissible error in 'g' is :

(A) 1.4 % **(B)** 1.1 % **(C)** 1.5 % **(D)** 1.2%

4. The values of kinetic energy 'K' and potential energy 'U' are measured as follows :

$K = 100.0 \pm 2.0$ J

$U = 200.0 \pm 1.0$ J

Then the percentage error in the measurement of mechanical energy is :

(A) 2.5% **(B)** 1% **(C)** 0.5% **(D)** 1.5%

5. Let $y = \ell^2 - \frac{\lambda^3}{z}$ where $\ell = 2.0 \pm 0.1$, $z = 1.0 \pm 0.1$ then the value of y is given by :

(A) $+2 \pm 0.8$ **(B)** -4 ± 1.6 **(C)** -4 ± 0.8 **(D)** none of these

6. Two masses M_A & M_B ($M_A < M_B$) are weighed using same weighing machine. Absolute error and relative error in two measurements are [Assume only systematic errors are involved]

(A) Absolute error same for both, relative error greater for M_A and lesser for M_B.

(B) Absolute error same for both, relative error greater for M_B and lesser for M_A.

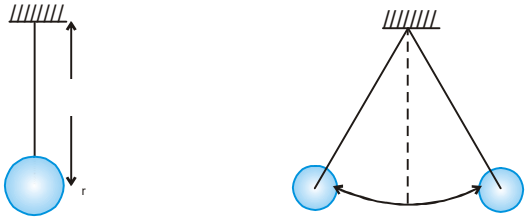
(C) Relative error same for both, absolute error greater for M_A and lesser for M_B.

(D) Relative error same for both, absolute error greater for M_B and lesser for M_A.

SECTION - II : COMPREHENSION TYPE

Comprehension # 1

Determining the value of 'g' using a simple pendulum



In this experiment. a small spherical bob is hanged with a cotton thread. This arrangement is called sample pendulum. The bob is displaced slightly and allowed to oscillate. To find time period, time taken for 50 oscillations is noted using a stop watch.

Theoretically $T = 2\pi\sqrt{\frac{L}{g}} \Rightarrow g = 4\pi^2 \frac{L}{T^2}$ .....(1)

where L = Equivalent length of pendulum = length of thread (●) + radius (R) of bob,
T = time period of the simple pendulum
So 'g' can be easily determined by equation ...(1).

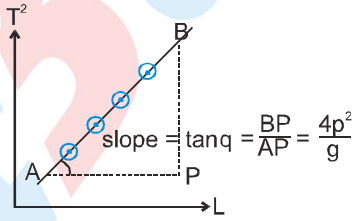
Graphical method to find 'g' :

$$T^2 = \left(\frac{4\pi^2}{g}\right)L \quad \text{.....(2)} \qquad \text{So, } T^2 \propto L$$

* Find T for different values of L.

* Plot T^2 v/s L curve. From equation (2), it should be a straight line, with slope = $\left(\frac{4\pi^2}{g}\right)$.

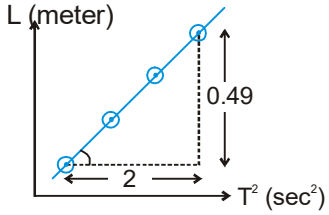
Find slope of T^2 v/s L graph and equate it to $\left(\frac{4\pi^2}{g}\right)$ and get 'g' .



7. In certain observation we got ● = 23.2 cm, r = 1.32 cm and time taken for 10 oscillation was 10.0 sec. Estimate the value of 'g' in proper significant figure. (take $\pi^2 = 10$)

(A) 9.8 m/s² **(B)** 9.80 m/s² **(C)** 9.800 m/s² **(D)** none of these

8. For different values of L, we get different values of 'T'. The curve between L v/s T^2 is shown. Estimate 'g' from this curve. (take $\pi^2 = 10$)



(A) 9.7 m/s² **(B)** 9.6 m/s² **(C)** 9.8 m/s² **(D)** 10 m/s²

Comprehension # 2

Working : Resonance tube is a 100 cm tube. Initially it is filled with water. To increase the length of air column in the tube, water level is lowered. The air column is forced with a tuning fork of frequency f_0. Let at length ℓ_1, we get a first resonance (loud voice) then

$$\ell_{eq_1} = \frac{V}{4f_0}$$

$$\Rightarrow \quad \ell_1 + \varepsilon = \frac{V}{4f_0} \qquad \text{.....(i)}$$

where ε is end correction

If we further lower the water level, the noise becomes moderate. But at ℓ_2. We, again get a loud noise (second resonance) then

$$\ell_{eq_2} = \frac{3V}{4f_0}$$

$$\Rightarrow \quad \ell_2 + \varepsilon = \frac{3V}{4f_0} \qquad \text{.....(ii)}$$

From (i) and (ii)

$$V = 2f_0 (\ell_2 - \ell_1)$$

Observation table :

Room temperature is 27°C

		Position of water level (cm)			
Freq. of tuning fork in (Hz) (f_0)	Resonance	Water level is falling	Water level is rising	Mean resonant length	Speed of sound $V = 2f_0(l_2 - l_1)$
330 Hz	1st Resonance	23.9	24.1	l_1 = ...	V = ...
	2nd Resonance	73.9	74.1	l_2 = ...	

9. Speed of sound calculated is roughly

(A) 340 m/sec **(B)** 380 m/sec **(C)** 430 m/sec **(D)** 330 m/s

10. In the previous question, speed of sound at 0°C is roughly

(A) 324 m/sec **(B)** 380 m/sec **(C)** 430 m/sec **(D)** 314 m/s

11. What should be minimum length of tube, so that third resonance can also be heard.

(A) $\ell_3 = 421$ cm **(B)** $\ell_3 = 214$ cm **(C)** $\ell_3 = 124$ cm **(D)** None of these

12. From equation (i) and (ii) end correction can be calcualted. Estimate the diameter of the tube using imparical formula ($\varepsilon \approx 0.3d$)

(A) 2.5 cm **(B)** 3.3 cm **(C)** 5.2 cm **(D)** None of these

SECTION - III : INTEGER TYPE

13. In some observations, value of 'g' are coming as

9.81, 9.80, 9.82, 9.79, 9.78, 9.84, 9.79, 9.78, 9.79 and 9.80 m/s^2. Calculate absolute errors and percentage error in g. is $\frac{x}{100}\%$ then x is.

14. From Meter Bridge, resistivity of a wire comes from

$$\rho = \frac{\pi D^2 s}{4L}\ \frac{l}{100-l}$$

where ● is balance length, D is diameter of wire, S is resistance, L is total length of wire. Find the value of ● corresponding to max. permissible error in ρ.(in cm)

15. In Searle's experiment to find Young's modulus the diameter of wire is measured as d = 0.05 cm, length of wire is ● = 125 cm and when a weight, m = 20.0 kg is put, extension in wire was found to be 0.100 cm. Find maximum permissible error in Young's modulus (Y). is $\frac{x}{10}\%$ then x is (Use : $Y = \frac{mg\lambda}{(\pi/4)\, d^2 x}$.)

16. In u – v method to find focus distance of a concave mirror, if object distance was found to be 10.0 cm and image distance was found to be 40.0 cm then the max - permissible error in f is $\frac{165}{x}\%$, due to error is u and v measurement. Then x is

17. A physical quantity x is calculated from the relation $x = \frac{a^2 b^3}{c\sqrt{d}}$. If % error in a, b, c and d are 2%, 1%, 3% and 4% respectively, what is the percentage error in x.

18. If the length of wire is (200.0 cm) and radius of wire as measured from screw gauge is (2.00 mm). Its resistance is 4.25 Ω. If find specific resistance of wire material is $X \times 10^{-7}$ Ω – m then x is.

ANSWER KEY

EXERCISE - 1

1. B **2.** A **3.** B **4.** C **5.** A **6.** C **7.** C **8.** B **9.** C **10.** B **11.** D **12.** C **13.** D
14. B **15.** C **16.** A **17.** D **18.** D **19.** C **20.** B **21.** C **22.** A **23.** A **24.** B **25.** D **26.** B
27. A **28.** C **29.** C **30.** C **31.** C **32.** A **33.** C **34.** B **35.** A **36.** B **37.** A **38.** A **39.** D

EXERCISE - 2 : PART # I

1. D **2.** A **3.** B **4.** B **5.** A **6.** B **7.** B **8.** A **9.** B **10.** ABC **11.** D **12.** A

PART # II

1. D **2.** A

EXERCISE - 3 : PART # I

1. i → D ; ii. → A,C iii. → B, iv → C, D **2.** i → C, ii. → A, iii. → D, iv → B. **3.** i → A ; ii. → A ; iii. → D; iv → C.

PART # II

Comprehension #1: **1.** B **2.** C **3.** B **Comprehension #2:** **1.** D **2.** D **3.** A

EXERCISE - 4

1. $LC = l\left[\frac{1-\cos\theta}{\cos\theta}\right]$ **2.** 0.05 mm **3.** $R_t = 3.64$ mm **4.** $\frac{5\pi}{18}\%$ **5.** 40m

6. $\overline{D} = 1.330\,cm$, $\overline{\Delta D} = 0.005\,cm$, Relative error = $\pm$ 0.004 %, error = 0.4% **7.** S = (1.2 ± 0.18) cm

8. 5.5 ± 0.05 cm **9.** **(i)** 1 **(ii)** 3 **(iii)** 4 **(iv)** 4 **(v)** 4 **(vi)** 4 **10.** 1.4%

11. **(i)** 0.0393 kg **(ii)** 4.08 x 10^8 sec **(iii)** 5.24 m **(iv)** 4.74 x 10^{-6} kg

EXERCISE - 5 : PART # I

1. 3 **2.** 1 **3.** 4 **4.** 3 **5.** 3 **6.** 2 **7.** 4 **8.** 4 **9.** 2 **10.** 3 **11.** 4 **12.** 1 **13.** 4
14. 1

PART # II

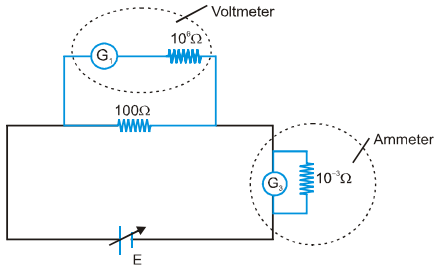
Single Choice Questions :

1. A **2.** D **3.** C **4.** D **5.** C **6.** D **7.** A **8.** B **9.** A **10.** B **11.** B **12.** D **13.** B

Multiple Choice Questions

1. C, D **2.** A, D **3.** B,C **4.** A,B,C,D

Subjective Questions : **1.** $\frac{a}{n+1}$ **2.** 4.89% **3.**



4. 2.6 cm^2 **5.** 2.66 g/cm^3

MOCK TEST

1. C **2.** A **3.** D **4.** B **5.** B **6.** A **7.** B **8.** C **9.** D **10.** D **11.** C **12.** B **13.** 14
14. 50 **15.** 43 **16.** 100 **17.** 12 **18.** 268