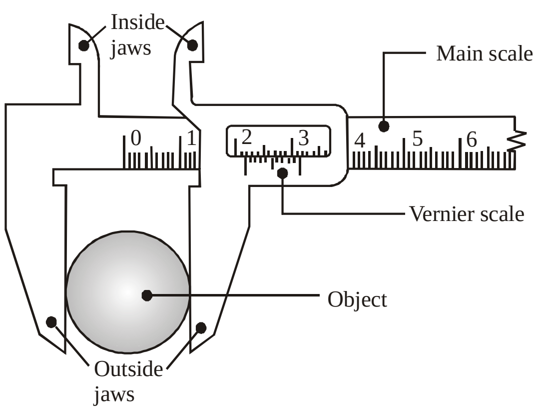
9

PRACTICAL PHYSICS

LEAST COUNT

The smallest value of a physical quantity which can be measured accurately with an instrument is called the least count (L. C.) of the measuring instrument.

Least Count of vernier callipers:



Suppose the size of one main scale division (M.S.D.) is M units and that of one vernier scale division (V. S. D.) is V units. Also let the length of 'a' main scale divisions is equal to the length of 'b' vernier scale divisions.

$$aM = bV \quad \text{or} \quad V = \frac{a}{b}M$$

$$\therefore \quad M - V = M - \frac{a}{b}M \qquad \therefore \quad M - V = \left(\frac{b-a}{b}\right)M$$

The quantity (M – V) is called vernier constant (V. C.) or least count (L. C.) of the vernier callipers.

$$L.C. = M - V = \left(\frac{b-a}{b}\right)M$$

Example 1 :

One cm on the main scale of vernier callipers is divided into ten equal parts. If 20 divisions of vernier scale coincide with 8 small divisions of the main scale. What will be the least count of callipers ?

Sol. 20 division of vernier scale = 8 div. of main scale

$$\Rightarrow \quad 1\,V.S.D. = \left(\frac{8}{20}\right) M.S.D. = \left(\frac{2}{5}\right) M.S.D.$$

$$\text{Least count} = 1\,M.S.D - 1\,V.S.D. = 1\,M.S.D. - \left(\frac{2}{5}\right) M.S.D$$

$$= \left(1 - \frac{2}{5}\right) M.S.D. = \left(\frac{3}{5}\right) M.S.D. = \frac{3}{5} \times 0.1\,cm. = 0.06\,cm.$$

$$(\because\ 1\,M.S.D. = \frac{1}{10}\,cm. = 0.1\,cm.$$

Directly we can use

$$L.C. = M - V = \left(\frac{b-a}{b}\right)M$$

$$= \left(\frac{20-8}{20}\right)\left(\frac{1}{10}\right) cm. = \frac{3}{50} cm. = 0.06\,cm.$$

ZERO ERROR

If there is no object between the jaws (i.e. jaws are in contact), the vernier should give zero reading. But due to some extra material on jaws, even if there is no object between the jaws, it gives some excess reading. This excess reading is called zero error.

Zero correction :

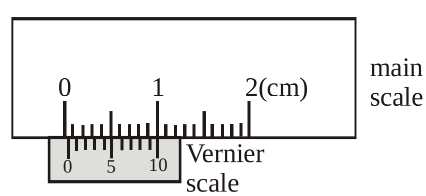
Zero correction is invert of zero error.

Zero correction = – (zero error)

Actual reading = observed reading – excess reading (zero error) = observed reading + zero correction

Example 2 :

The figure shows a situation when the jaws of vernier are touching each other. Each main scale division is of 1 mm. Find zero correction.

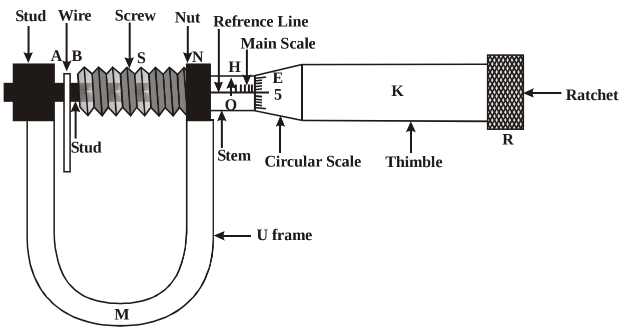


Sol. 5th division of vernier scale coincides with a main scale division.

$$L.C. = \frac{1}{10} = 0.1mm \quad \therefore \text{Zero error} = +5 \times 0.1 = 0.5\,mm$$

This error is to be subtracted from the reading taken for measurement. Also, zero correction = – 0.5 mm.

LEAST COUNT OF SCREW GAUGE



$$\text{Least Count} = \frac{\text{Pitch}}{\text{Total no. of divisions on the circular disc}}$$

where pitch is defined as the distance moved by the screw head when the circular scale is given one complete rotation,i.e.

$$\text{Pitch} = \frac{\text{Distance moved by the screw on the linear scale}}{\text{No. of full rotations given}}$$

Note : With the decrease in the least count of the measuring instrument, the accuracy of the measurement increases and the error in the measurement decreases.

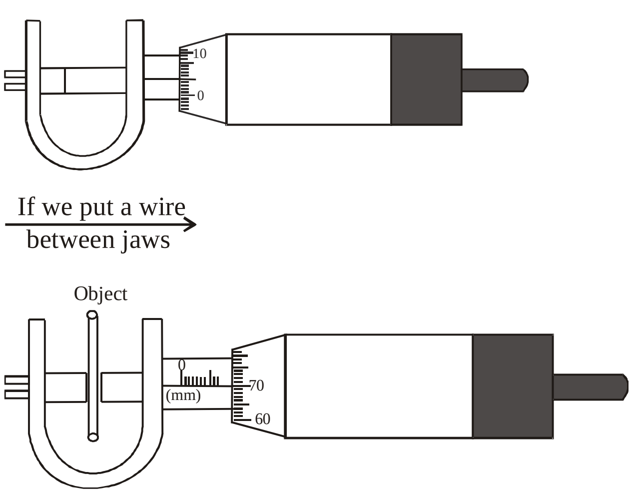
Precision of a measurement : The precision of a measurement is determined by the count of a measuring instrument. The smaller is the least count larger is the precision of the measurement.

Accuracy of a measurement : Accuracy of an instrument represents the closeness of the measured value to actual value.

Zero Error : If there is no object between the jaws (i.e. jaws are in contact), the screw gauge should give zero reading. But due to extra material on jaws, even if there is no object, it gives some excess reading. This excess reading is called zero error.

Example 3 :

Find the thickness of the wire.



Sol. Excess reading (zero error) = 0.03 mm

It is giving 7.67 mm in which there is 0.03 mm excess reading, which has to be removed (substracted) so actual reading

$= 7.67 - 0.03 = 7.64$ mm

SOME IMPORTANT EXPERIMENTS

1. Determination of g using a simple pendulum :

A simple pendulum is an arrangement consisting of a small steel ball with a fine string suspended from a fixed point so that it can swing freely.

The equation for the periodic motion of a simple pendulum as determined by Galileo is $T = 2\pi\sqrt{\frac{\ell}{g}}$,

Here, ℓ is the length of the pendulum, g is acceleration due to gravity and T is time period of periodic motion. To determine g, rearrange the above equation to get,

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

Procedure :

(a) Determine the time for 20 complete swings for six different lengths. (The length means the distance between point of suspension and centre of the ball).

(b) Repeat the time measurement five times for each length, making sure to get consistent readings.

(c) Determine the average time for 20 swings for each length. Then, calculate the time of one swing.

(d) Compute the acc. due to gravity for each pendulum length.

(e) Calculate the mean g and the % error in g for each length.

Precautions :

(i) The oscillations amplitude should be kept small (10° or below) as the formula for time period is applicable for small angular displacements.

(ii) While measuring the length and time periods, an average of several readings should be taken.

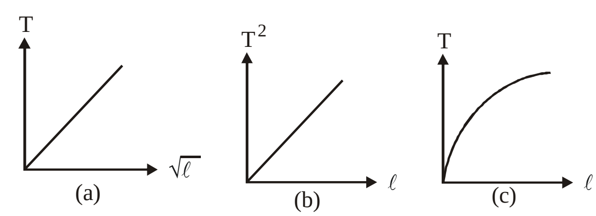
(iii) The instruments used should be checked for zero error.

Factors Affecting the Time Period: The time period of a simple pendulum is affected by following factors.

(i) Time period is clearly a function of the length of pendulum.

From the formula, it is clear that $T \propto \sqrt{\ell}$ or $T^2 \propto \ell$

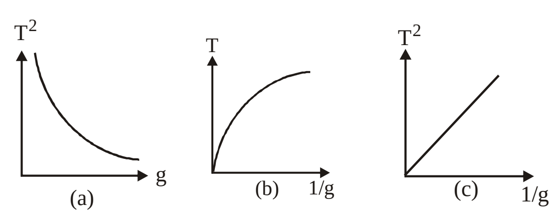
The graphical variation is :



(ii) Time period is a function of acceleration due to gravity.

$$T \propto \frac{1}{\sqrt{g}} \quad \text{or} \quad T^2 \propto \frac{1}{g}$$

Following graphs represent the above variation



(iii) Time period is independent of mass of ball used in the pendulum. A wooden ball or a steel ball will have same time period if other factors are same.

(iv) The time period of a simple pendulum is independent of amplitude (provided amplitude is small). This type of motion is called isochrones motion.

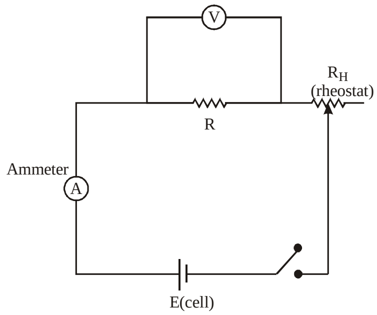
2. Verification of Ohm's law using voltmeter and ammeter:

According to ohm's law, the current flowing through a metallic conductor is directly proportional to the potential difference across the ends of the conductor provided the physical conditions like temperature and mechanical strain etc. are kept constant.

V = IR, where R is a constant called resistance

Arrangement:

The figure shows the arrangement used to verify ohm's law. It consists of a cell of emf E, connected to a fixed resistance R and a variable resistance (rheostat). An ammeter is connected in the circuit to measure current I and a voltmeter is connected across the fixed resistance R to measure potential difference V,



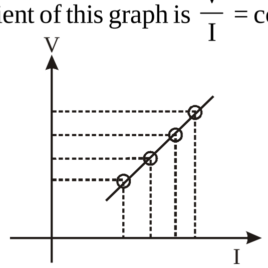
Procedure : Following steps are to be followed.

(a) Close the switch S and note down the readings of voltmeter and ammeter.

(b) Repeat the above process for different values of variable resistance R_H.

(c) Plot a graph between V and I by taking V along y-axis and I along x-axis.

(d) Slope or gradient of this graph is $\frac{V}{I}$ = constant. This shows that $V \propto I$



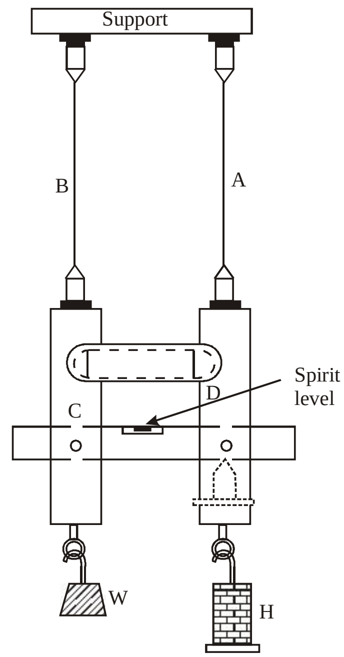
3. Determination of Young's Modulus by Searle's Method :

When a deforming force is applied to deform a body, it shows some opposition. This opposition is called stiffness. Young's modulus is a physical quantity used to describe the stiffness of a body. It is the ratio of stress applied to strain produced, where stress applied is force applied per unit area and strain is the ratio of change in length and original length

$$Y = \left(\frac{F}{A}\right) \div \frac{x}{\ell} = \frac{F\ell}{Ax}$$

Here, F is applied force, A is area of cross-section, ℓ is length and x is increase in length.

Arrangement: The arrangement consists of two wires. One of the wires is a reference wire loaded with a fixed weight. The other wire is the test wire, on which variable load is applied. The reference wire is used to compensate for the thermal expansion of the wire. The extension in the test wire is measured with the help of a spherometer and a spirit level arrangement.



Procedure :

The following steps are required to measure the young's modulus.

(a) Using micrometer determine the radius of the wire.

Using the formula for area of circle = πr^2, calculate the area.

(b) Measure the length of the wire ℓ.

(c) Note down the load applied F and corresponding increase in length x.

(d) Convert load in kg to newton by the formula 1kg=9.81N

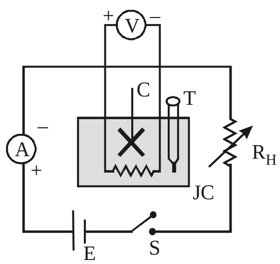
(e) Plot a graph of extension x(along x-axis) against weight (along y-axis).

(f) The slope of this graph is the ratio F/x.

(g) Find Y using the formula $Y = \frac{F\ell}{Ax}$

4. Measurement of specific heat of a liquid using a calorimeter: Specific heat of a substance is the heat required to raise the temperature of unit mass of a substance by unit degree Celsius. It is given by $S = \frac{Q}{m\Delta\theta}$ where Q is the heat supplied, m is the mass of substance and $\Delta\theta$ is the rise in temperature.

Arrangement: The arrangement consists of a joule calorimeter (JC) with a churner C, thermometer, variable resistor R_H, cell of emf E, an ammeter, a voltmeter and a switch.



Procedure: The following steps are required.
(a) Weigh the empty calorimeter with churner C. This is m_c.
(b) Weigh the calorimeter with the liquid in it. The difference in two masses gives the mass of liquid. This is m_ℓ .
(c) Make the set up shown. Keeping the switch open, note the reading of the thermometer θ_1.
(d) Close the switch S for a time t and continuously stir the liquid. At the time of opening the switch, note the reading of thermometer θ_2, voltmeter V and ammeter I.
(e) Calculate heat supplied to the colorimeter using H = VIt.
(f) Calculate rise in temperature using $\Delta\theta = \theta_1 - \theta_2 + d\theta$........
Here dθ is the correction applied for radiation loss. dθ is the fall in temperature when the calorimeter and its contents are left to cool down for time t/2.
(g) Let S_c be the specific heat of calorimeter and S_ℓ be the specific heat of liquid, then the heat supplied is

$$Q = m_\ell S_\ell \Delta\theta + m_c S_c \Delta\theta$$

$$\Rightarrow \quad S_\ell = \frac{Q - m_c S_c \Delta\theta}{m_\ell \Delta\theta} = \frac{1}{m_\ell}\left(\frac{VIt}{\Delta\theta} - m_c S_c\right)$$

Precautions : Following precautions must be taken.
(i) Correction due to radiation loss de must be taken into account.
(ii) The stirring of liquid should be slow.
(iii) While reading voltmeter and ammeter, parallax should be removed.

5. Focal length of a convex lens/concave mirror using u-v method:

When an object is placed at a distance u in front of a convex lens/concave mirror, it forms an image at a distance v from the lens/mirror. The two values u and v are related to each other. For a convex lens, the relationship is $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

For a concave mirror, the relationship is $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

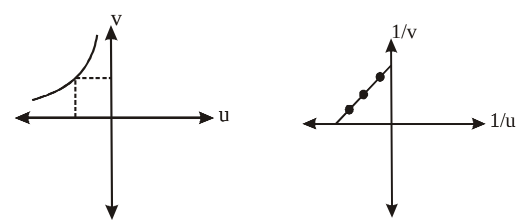
Arrangement: The lens/mirror is fixed on an optical bench with a scale marked on it to measure the distance of object and image. The lens or mirror is fixed. There are two other stands in which two pin shaped objects are fixed. One of these is the object pin. This acts as an object. The other one is called image pin. It is used to locate the image position. When there is no parallax between the image pin and image seen in the lens/mirror, the image pin represents the position of the image.

Procedure: Following steps are to be followed.
(a) Fix the lens on the lens stand.
(b) Place object pin in front of the lens. Measure the distance between the two. The value of u will be negative of the above distance.
(c) Place the image pin on the other side of the lens at such a distance from the lens, so that there is no parallax between image pin and image seen in the lens. The value of v will be the distance between the lens and image pin.
(d) Compute the focal length of the lens using lens formula

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

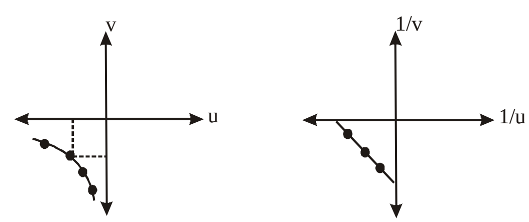
(e) Plot a graph between u and v and $\frac{1}{u}$ and $\frac{1}{v}$.

For a convex lens, the shape of graphs obtained are shown.



(a) (b)

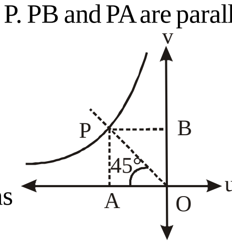
For a concave mirror, the shape of graphs obtained are shown.



(a) (b)

(f) In the u.v curve, we draw a line at 45° as shown in figure. This line intersect the curve at point P. PB and PA are parallel to axes.
Here OA = OB = 2f. So,

focal length f = $\frac{OA}{2}$



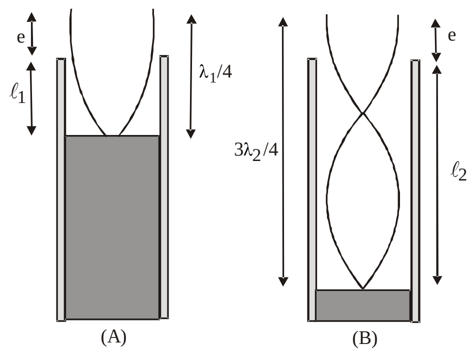
Precaution: Following precautions must be taken.
(i) Both u and v should be measured carefully on the bench.
(ii) While locating the image, parallax should be removed.

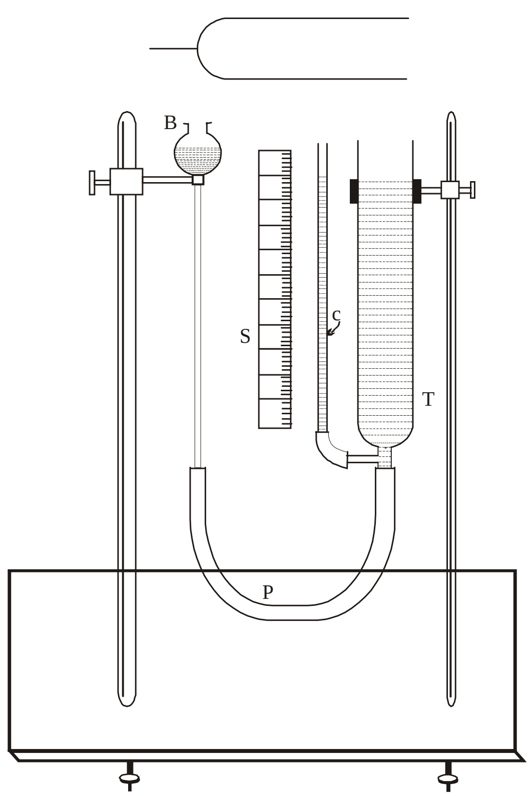
6. Determination of speed of sound using resonance column:

It is a simple apparatus used to measure speed of sound in air with the help of a tuning fork of known frequency. The resonance column is an air column closed at one end. Its length is variable. It is based on the phenomenon of standing waves.

A vibrating tuning fork is held near the open end of the tube which is partially empty. The air-column vibrates with the frequency of tuning fork. As the length of air column is increased from zero onwards, a stage is reached when very intense sound is observed. At this stage the natural frequency of the air-column matches with the frequency of tuning fork. This state is known as resonance. At resonances, the vibration of air column can be like any of the following figures.

Arrangement : The arrangement is shown in the figure. It consists of a metallic tube and a connected glass tube. There is a reservoir containing water. This is connected to the metallic tube by a rubber pipe. Parallel to the glass tube is a scale to measure the length of air-column.





Procedure : Following steps are used in the experiment.
(a) Hold the vibrating tuning fork at the open ,end of the column and start increasing the length of the air column by adjusting the height of reservoir.

(b) Determine the first resonating length ℓ_1. This is the length at which an intense sound is observed.
(c) Determine the second resonating length ℓ_2. This is the length at which an. intense sound is observed again.
(d) Compute the wavelength. It can be calculated as shown. From the figure A and B it is clear that

$$\ell_1 + e = \frac{\lambda}{4} \quad .... (i) \qquad \ell_2 + e = \frac{3\lambda}{4} \quad .... (ii)$$

Here λ is wavelength of sound and e is end correction (height of the antinode above the open end)

Subtracting $\ell_2 - \ell_1 = \frac{\lambda}{2} \quad \therefore \quad \lambda = 2(\ell_2 - \ell_1)$

(e) Using the formula v = f λ, compute the speed of sound.
(f) Compute the end-correction from equation (i) and (ii)

$$\ell_1 + e = \frac{\lambda}{4}, \ \ell_2 + e = \frac{3\lambda}{4}$$

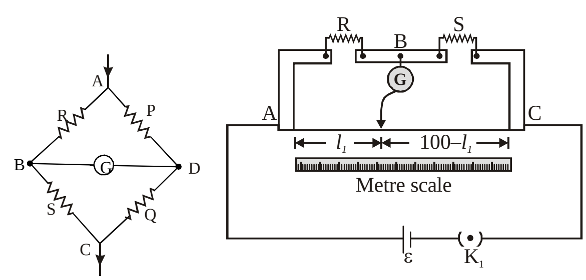
$$\Rightarrow \ \ell_2 - 3\ell_1 - 2e = 0 \Rightarrow e = \left(\frac{\ell_2 - 3\ell_1}{2}\right)$$

(g) Compute the error in end-correction by comparing it with Reyleigh's formula e = 0.6 R. Where R is internal radius of resonance tube.

7. Determination of resistivity of a metal using :
(i) Meter bridge (ii) Post office box

Meter bridge : The resistance of a metal wire depends on its length, area of cross-section and resistivity of-the metal.

The formula is $R = \rho \frac{\ell}{A}$ .Here, ρ is the resistivity.



Its unit is Ω-m (ohm-meter). To measure its resistivity, we use a meter bridge. The working of a meter bridge is based on Wheatstone bridge principle. The circuit shown is called Wheatstone bridge. When $\frac{P}{Q} = \frac{R}{S}$ there is no flow of current in the branch BD. At this state, galvanometer shows zero deflection.

Arrangement : The arrangement consists of a 100cm long wire connected between A and C. It is tapped at point B by a sliding contact called jockey. R is a known resistance. S is the resistance wire whose resistivity is to be determined. A cell and a variable resistance R_H are connected to supply current in the circuit.

Procedure: Following steps are used in the experiment.

(a) Plug the key and slide the jockey on wire AC to locate point B where the galvanometer does not show deflection. Note down the length ℓ.

(b) Compute the resistance S using the formula $\frac{P}{Q} = \frac{R}{S}$

Here, $P = \rho_{wire} \times \frac{\ell}{A}$] $Q = \rho_{wire} \times \frac{100-\ell}{A}$

$\therefore \quad S = R\left(\frac{100-\ell}{\ell}\right)$

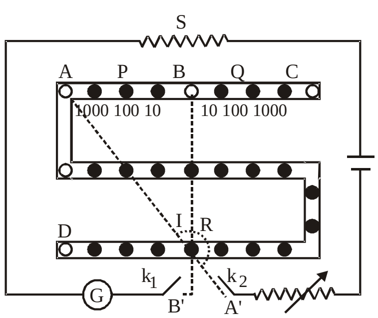
(c) Compute the value of S by determining values of length ℓ. This can be done by using different values of R.

(d) Calculate the percentage error is measurement of S.

(e) Compute the resistivity by measuring length and area of cross-section of resistance wire S using the formula

$S = \frac{\rho\ell}{A}$

(ii) Post office box : This apparatus was initially used in post-offices for measuring the resistance of the telephone or telegraph wires, or for finding the faults in these wires. In post office box, the two arms AB and BC are connected in series. Each of these arms contain resistances 10Ω, 100Ω, and 1000Ω a. In the third arm AD there are resistances from 1Ω to 5000Ω arranged in U shape. In order to insert keys in the arms AC & BD, the point A is connected to a tapping key k_1 & the point B is connected to another tapping key k_2.



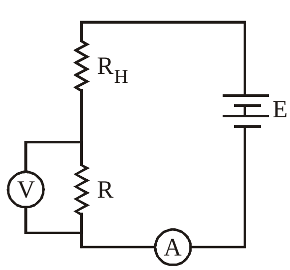
Post-office Box

The wire whose resistance (S) is to be determined is connected in the arm CD. The galvanometer G is connected between Band D through the key k_2 and the cell is connected between A and C through the key k_1.

ADDITIONAL EXAMPLES

Example 1 :

In the circuit shown, voltmeter is ideal and its least count is 0.1 V. The least count of ammeter is 1 mA. Let reading of the voltmeter be 30.3 V and the reading of ammeter is 0.020 A. Calculate the value of resistance R within error limits.



Sol. $V = 30.0,\ I = 0.020\,A,\quad R = \frac{V}{I} = \frac{30.0}{0.020} = 1.50\ k\Omega$

Error : As $R = \frac{V}{I} \quad \therefore \frac{\Delta R}{R} = \frac{\Delta V}{V} + \frac{\Delta I}{I}$

$\Rightarrow \Delta R = 1.50 \times 10^3\left(\frac{0.1}{30.0} + \frac{0.001}{0.020}\right) = 0.080\ k\Omega$

Example 2 :

In an experiment for measurement of young's modulus, following readings are taken. Load = 3.00 kg, length = 2.820 m, diameter = 0.041 cm and extension = 0.87. Determine the percentage error in measurement of Y.

Sol. If Y = Young's modulus of wire, M = mass of wire, g = acceleration due to gravity, x = extension in the wire, A= Area of cross-section of the wire, ℓ = length of the wire.

$$Y = \frac{Mgx}{A\ell} \Rightarrow \frac{\Delta Y}{Y} = \frac{\Delta M}{M} + \frac{\Delta x}{x} + \frac{\Delta A}{A} + \frac{\Delta \ell}{\ell}$$

$$\Rightarrow \frac{\Delta Y}{Y} = \frac{0.01}{3.00} + \frac{0.01}{0.87} + \frac{2 \times 0.001}{0.041} + \frac{0.001}{2.820} = 0.065$$

$$\text{or} \quad \frac{\Delta Y}{Y} \times 100 = \pm\ 6.5\%$$

Example 3 :

In an experiment to measure the focal length of concave mirror, it was found that for an object distance of 0.30 m, the image distance come out to be 0.60m. Determine the focal length.

Sol. By mirror formula,

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{f} = \frac{-1}{0.30} - \frac{1}{0.60} \Rightarrow f = \frac{-3.0}{0.60} \Rightarrow f = 0.20m$$

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

$$\Rightarrow df = (0.20)^2\left[\frac{0.01}{(0.60)^2} + \frac{0.01}{(0.30)^2}\right] \Rightarrow df = 0.0055 \approx 0.01m$$

$\Rightarrow$ Focal length $f = (0.20 \pm 0.01)$ m

Example 4 :

The internal radius of a 1m long resonance tube is measured as 3 cm. A tuning fork of frequency 2000 Hz is used. The first resonating length is measured as 4.6 cm and the second resonating length is measured as 14.0 cm. Calculate the following

(i) Maximum percentage error in measurement of e.

(ii) Speed of sound at the room temperature.

(iii) End correction.

(iv) Percentage error in the calculation of e.

Sol. (i) Max. % error in e, as given by Reyleigh's formula.

(Given error is measurement of radius is 0.1 cm)

$\Delta e = 0.6\,\Delta R = 0.6 \times 0.1 = 0.06$ cm.

Percentage error = $\frac{\Delta e}{e} \times 100 = \frac{0.06}{0.6 \times 3} \times 100 = 3.33\%$

(ii) Speed of sound at the room temperature.

$\ell_1 = 4.6$ cm, $\ell_2 = 14.0$ cm., $\lambda = 2(\ell_2 - \ell_1) = 18.8$ cm.

$$v = f\lambda = 2000 \times \frac{18.8}{100} = 376 \text{ m/s}$$

(iii) End correction $e = \frac{\ell_2 - 3\ell_1}{2} = \frac{14.0 - 3 \times 4.6}{2} = 0.1$ cm.

(iv) % error in e with respect to theoretical value.

Percentage error $= \frac{0.1 - 0.6 \times 3}{1.8} \times 100 = 94.44\%$

Example 5 :

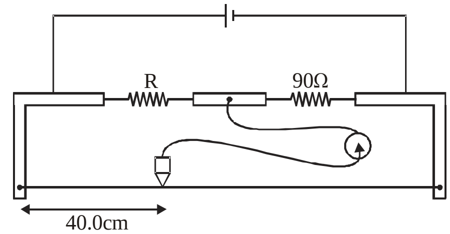
During Searle's experiment, zero of the Vernier scale lies between 3.20×10^{-2}m and 3.25×10^{-2}m of the main scale. The 20th division of the Vernier scale exactly coincides with one of the main scale divisions. When an additional load of 2 kg is applied to the wire, the zero of the Vernier scale still lies between 3.20×10^{-2}m and 3.25×10^{-2} m of the main scale but now the 45^{th} division of Vernier scale coincides with one of the main scale divisions. The length of the thin metallic wire is 2m and its cross-sectional area is 8×10^{-7} m^2. The least count of the Vernier scale is 1.0×10^{-5} m. The maximum percentage error in the Young's modulus of the wire is –

Sol. **4.** $Y = \frac{F/A}{\Delta\ell/\ell}$; $\Delta\ell = 25 \times 10^{-5}$ m ; $Y = \frac{F}{A} \cdot \frac{\ell}{\Delta\ell}$

$$\frac{\Delta Y}{Y} \times 100 = \frac{10^{-5}}{25 \times 10^{-5}} \times 100 = 4\%$$

Example 6 :

During an experiment with a metre bridge, the galvanometer shows a null point when the jockey is pressed at 40.0 cm using a standard resistance of 90 Ω, as shown in the figure. The least count of the scale used in the metre bridge is 1mm. The unknown resistance is



(A) $60 \pm 0.15\,\Omega$
(B) $135 \pm 0.56\,\Omega$
(C) $60 \pm 0.25\,\Omega$
(D) $135 \pm 0.23\,\Omega$

Sol. **(C).** $\frac{R_1}{x} = \frac{R_2}{(100 - x)}$ (Balanced Wheatstone)

For R, $\frac{R}{40} = \frac{90}{60} \Rightarrow R = \frac{90 \times 40}{60}$; $\frac{R}{90} = \frac{x}{100 - x}$

For ΔR, $\ln R = \ln x + \ln(100 - x)$

$$\frac{\Delta R}{R} = \frac{\Delta x}{x} + \frac{\Delta(100 - x)}{(100 - x)} ; \frac{\Delta R}{R} = \frac{\Delta x}{x} + \frac{\Delta x}{(100 - x)} ;$$

$$\Delta R = \left(\frac{0.1}{40} + \frac{0.1}{60}\right) 60$$

$\Delta R = 0.25\Omega \Rightarrow R = 60 \pm 0.25\,\Omega$

QUESTION BANK

CHAPTER 9 : PRACTICAL PHYSICS

EXERCISE - 1

Choose one correct response for each question.

Q.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 estimation of the kinetic energy obtained by measuring mass and speed
(A) 11% (B) 8%
(C) 5% (D) 1%

Q.2 What is the number of significant figures in 0.310×10^3
(A) 2 (B) 3
(C) 4 (D) 6

Q.3 The mean time period of second's pendulum is 2.00s and mean absolute error in the time period is 0.05s. To express maximum estimate of error, the time period should be written as
(A) (2.00 ± 0.01) s (B) $(2.00 + 0.025)$ s
(C) (2.00 ± 0.05) s (D) (2.00 ± 0.10) s

Q.4 A body travels uniformly a distance of (13.8 ± 0.2) m in a time (4.0 ± 0.3) s. The velocity of the body within error limits is
(A) (3.45 ± 0.2) ms^{-1} (B) (3.45 ± 0.3) ms^{-1}
(C) (3.45 ± 0.4) ms^{-1} (D) (3.45 ± 0.5) ms^{-1}

Q.5 In the context of accuracy of measurement and significant figures in expressing results of experiment, which of the following is/are correct
(A) Out of the two measurements 50.14 cm and 0.00025 ampere, the first one has greater accuracy
(B) If one travels 478 km by rail and 397 m. by road, the total distance travelled is 478 km.
(A) Only (A) is correct (B) Only (B) is correct
(C) Both are correct (D) None of them is correct.

Q.6 The resistance R = 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) 5/2%

Q.7 The length of a cylinder is measured with a meter rod having least count 0.1 cm. Its diameter is measured with vernier calipers having least count 0.01 cm. Given that length is 5.0 cm. and radius is 2.0 cm. The percentage error in the calculated value of the volume will be
(A) 1% (B) 2%
(C) 3% (D) 4%

Q.8 According to Joule's law of heating, heat produced $H = I^2Rt$, where I is current, R is resistance and t is time. If the errors in the measurement of I, R and t are 3%, 4% & 6% respectively then error in the measurement of H is
(A) ± 17% (B) ± 16%
(C) ± 19% (D) ± 25%

Q.9 A physical quantity P is given by $P = \dfrac{A^3B^{1/2}}{C^{-4}D^{3/2}}$.
The quantity which brings in the maximum percentage error in P is
(A) A (B) B
(C) C (D) D

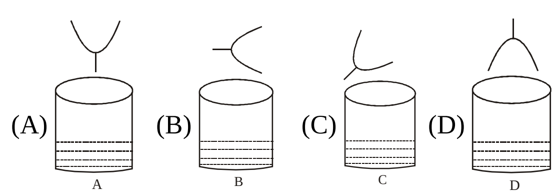
Q.10 The number of significant figures in all the given numbers 25.12, 2009, 4.156 and 1.217×10^{-4} is
(A) 1 (B) 2
(C) 3 (D) 4

Q.11 A physical quantity A is related to four observable a, b, c and d as follows, $A = \dfrac{a^2b^3}{c\sqrt{d}}$, the percentage errors of measurement in a, b, c and d are 1%,3%,2% and 2% respectively. What is the % error in the quantity A
(A) 12% (B) 7%
(C) 5% (D) 14%

Q.12 In an experiment with NPN transistor amplifier in common emitter configuration, the current gain of the transistor is 100. If the conductor current changes by 1mA, what will be the change in emitter current –
(A) 1.1 mA (B) 1.01 mA
(C) 0.01 mA (D) 10 mA

Q.13 The pitch of a screw gauge is 1mm and there are 50 divisions on its cap. 44th division of the circular scale coincide with the reference line. When the studs are in contact, then the correction would be –
(A) + 44/50 (B) – 44/50
(C) + 6/50 (D) –6/50

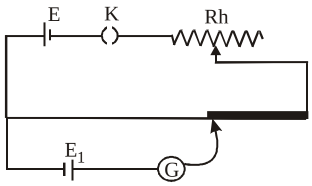
Q.14 Which is the correct method for performing the experiment to determine the speed of sound –



Q.15 To measure the Young's modulus of a copper wire, the extension of length is measured by –
(A) Vernier scale provided in searle's apparatus
(B) Screw gauge provided in searle's apparatus
(C) Spherometer provided in searle's apparatus
(D) Vernier provided with travelling microscope

Q.16 The least count of vernier calliper is 0.1mm. The main scale reading before the zero of the vernier scale is 10 and zeroth division of the vernier scale coincides with the main scale division. Given that each main scale division is 1mm. The radius is –
(A) 0.01 cm. (B) 0.1 cm.
(C) 0.5 cm. (D) 0.05 cm.

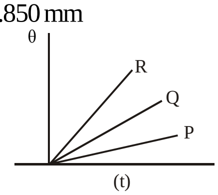
Q.17 A student performs experiment to find the emf of unknown cell by using potentiometer and arranges the circuit as shown. What must be his mistake as he is not getting correct reading –



(A) E is connected correctly but not E_1
(B) E_1 is connected correctly but not E
(C) Wire is not having uniform throughout
(D) R_h and K are not connected in series

Q.18 In a screw gauge, there are 8 divisions in a distance of 2mm on linear scale. The total number of divisions on circular scale is 250. While measuring the diameter of a wire the linear scale reads 15 divisions and 100^{th} division of circular scale coincides with reference line of linear scale. The observed value of diameter of the wire is –
(A) 15.100 mm (B) 30.1 mm
(C) 3.75 mm (D) 3.850 mm

Q.19 Three different materials are studied by plotting temperature (θ) v/s time (t) graph. Which one will be least preferred for the use as coolant –



(A) P (B) Q
(C) R (D) any of these, it does not matter

Q.20 When the jaws of vernier callipers are in contact the zero of the vernier scale lies left of the first division of the main scale and fourths division coincides with main scale. The minimum reading which this instrument can give is 0.1mm. A cylinder's diameter is measured by this then it reads 1cm. on the main scale and 5^{th} division of the vernier coincides with the 15^{th} division of the main scale. The radius is –
(A) 10.1 mm (B) 10.5 mm
(C) 10.15 mm (D) 5.05 mm

Q.21 Two students perform the experiment of resonance to find the speed of sound one does with cooler tuning fork. The resonance length comes as ℓ_1. If the second one does it with slightly hotter tuning fork the resonance length ℓ_2 will be –
(A) equal to ℓ_1 (B) Less than ℓ_1
(C) more than ℓ_1 (D) twice of the ℓ_1

Q.22 While measuring acceleration due to gravity by a simple pendulum, a student makes a positive error of 2% in the length of the pendulum and a positive error of 1% in the value of time period. His actual percentage error in the measurement of the value of g will be –
(A) 3% (B) 4%
(C) 2% (D) 5%

Q.23 If a tunning fork of frequency (f_0) 340 Hz tolerance ± 1% is used in resonance column method [$v = 2f_0(\ell_2 - \ell_1)$], the first and the second resonance are measured at ℓ_1 = 24.0 cm. and ℓ_2 = 74.0 cm. The max. permissible error in speed of sound is –
(A) 1.4 % (B) 1.8%
(C) 1% (D) 0.8%

Q.24 In Searle's experiment to find Young's modulus the diameter of wire is measured as d = 0.05cm, length of wire is ℓ = 125cm 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).

Use : $Y = \dfrac{mg\ell}{(\pi/4)\, d^2 x}$

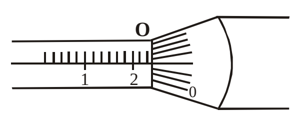
(A) 6.3% (B) 5.3%
(C) 2.3% (D) 1%

Q.25 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 cm. The maximum error in the location of the image can be 0.2 cm. 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 cannot come from experiment and is (are) incorrectly recorded, is (are)
(A) (42, 56) (B) (48, 48)
(C) (66, 33) (D) (78, 39)

Q.26 The density of a solid ball is to be determined in an experiment. The diameter of the ball is measured with a screw gauge, whose pitch is 0.5 mm and there are 50 divisions on the circular scale. The reading on the main scale is 2.5 mm and that on the circular scale is 20 divisions. If the measured mass of the ball has a relative error of 2%, the relative percentage error in the density is
(A) 0.9% (B) 2.4%
(C) 3.1% (D) 4.2%

Q.27 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 & 47^{th} division on the circular scale coincides with the reference line. The length of the wire is 5.6 cm. The curved surface area (in cm^2) of the wire in appropriate number of significant figures -
(A) 2.4 (B) 2.5
(C) 2.6 (D) 2.7

Q.28 Zero correction as per given figure of a standard screw gauge is -

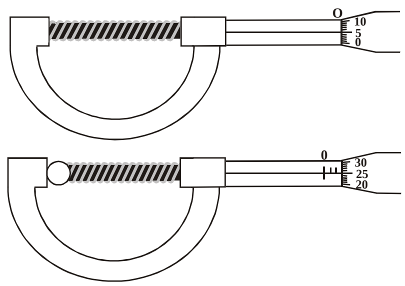


(A) 0.002 cm (B) – 0.002 cm
(C) – 0.003 cm (D) 0.003 cm

Q.29 The pitch of a screw gauge is 1 mm and there are 100 divisions on the cap. When nothing is placed in between its jaws, it reads –5 divisions. When a wire is held there, the reading on the main scale is 2 mm and 69 division on its cap. If the length of wire is 20 cm, the volume in mm^3 will be

(A) 2.74×10^3 (B) 2.69×10^3
(C) 1.18×10^3 (D) 1.88×10^3

Q.30 The circular divisions of shown screw gauge are 50. It moves 0.5 mm on main scale in one rotation. The diameter of the ball is -



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

Q.31 The pitch of a screw gauge is 0.5 mm and there are 50 divisions on circular scale. When there is nothing between the two ends (studs) of screw gauge, 45th division of circular scale is coinciding with screw gauge, and in this situation zero of main scale is not visible. When a wire is placed between the studs, the linear scale reads 2 divisions and 20th division of circular scale coincides with reference line. For this situation mark the correct statement(s) -

(A) Least count of the instrument is 0.01 mm
(B) Zero correction for the instrument is + 0.45 mm
(C) Thickness of wire is 1.65 mm
(D) All of the above

Q.32 An object is weighed on a balance whose pans are not equal in masses when placed in the left pan, the object appears to weigh 10.30 g but when placed is the right pan, it appears to weigh 12.62 g. The correct mass of the object is -

(A) 10.30 g (B) 12.62 g
(C) 11.46 g (C) 12.40 g

Q.33 The air bubble in sprit level in Searle's apparatus is at centre. With increase in length of experimental wire towards your right hand, the air bubble will shift towards your -

(A) right towards experimental wire
(B) towards compensating wire
(C) towards either of them
(D) does not shift

Q.34 To observe, how is the surface tension of water affected on dissolving a detergent in it experimentally, student must observe that -

(A) pure water rises to a higher level in the same capillary tube whereas detergent solution rises to a lesser height.
(B) the height of detergent solution is more than the rise of water in an identical capillary tube.
(C) same rise of water & detergent solution in both the tubes.
(D) water rises in the capillary tube but detergent solution depressed in the tube

Q.35 A student performs Newton's law of cooling experiment with hot metallic spheres of radius r. It's rate of cooling should be -

(A) Independent of r (B) Proportional to r
(C) Proportional to r^2 (D) Proportional to 1/r

Q.36 In the experiment to determine the speed of sound using a resonance column -

(A) prongs of the tuning fork are kept in vertical plane
(B) prongs of the tuning fork are kept in horizontal plane
(C) in one of the two resonances observed, the length of the resonating air column is close to the wavelength of sound in air
(D) in one of the two resonances observed, the length of the resonating air column is close to half of the wavelength of sound in air

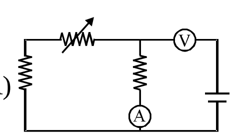
Q.37 A tuning fork of frequency 340 sec^{-1} vibrates just above a cylindrical tube. Height of tube is 120 cm. If the velocity of the sound is 340 m/sec. What should be the minimum height to which the water should be filled in the tube to perform experiment ?

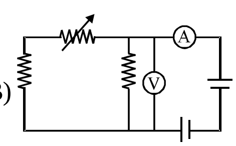
(A) 52 cm (B) 25 cm (C) 54 cm (D) 45 cm

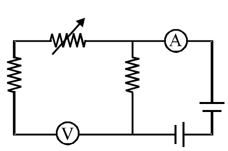
Q.38 A student performed the experiment to measure the speed of sound in air using resonance air-column method. Two resonances in the air-column were obtained by lowering the water level. The resonance with the shorter air-column is the first resonance and that with the longer air-column is the second resonance. Then -

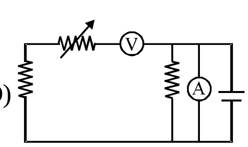
(A) the intensity of the sound heard at the first resonance was more than that at the second resonance
(B) the prongs of the tuning fork were kept in a horizontal plane above the resonance tube
(C) the amplitude of vibration of the ends of the prongs is typically around 1 cm
(D) the length of the air-column at the first resonance was somewhat shorter than $1/4^{th}$ of the wavelength of the sound in air

Q.39 Which of the following circuit is correct for verification of Ohm's law ?

(A)


(B)


(C)


(D)


Q.40 By mistake a student connects a voltmeter in series and an ammeter in parallel with a resistance in an electrical circuit. Then -
(A) voltmeter will be damaged, ammeter will not be damaged.
(B) ammeter will be damaged, voltmeter will not be damaged.
(C) both will be damaged
(D) none will be damaged

Q.41 A student in an experiment gets following observations.
Reading for the bottom of an empty beaker = 12.324 cm.
Reading for the bottom of the beaker when partially filled with the liquid = 12.802 cm.
Reading for the liquid surface = 13.895 cm.
The refractive index would be -
(A) 1.232 (B) 1.389 (C) 1.280 (D) 1.437

Q.42 A student is given a transister. He is asked to find out the terminals of p-n-p transistor as emitter, base and collector. He is told that the terminal marked with red dot is emitter. He touches red probe with known terminal as emitter and marks other two lead wires as A and B. He measures resistance between emitter and lead A. Then measured resistance between emitter and lead B and finds that resistance increases. This shows –
(A) A is base and B is collector
(B) A is collector and B is base
(C) either can be collector or base
(D) multimeter cannot be used to test the terminals

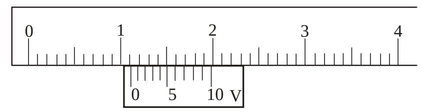
Q.43 What is the value of least count of commonly available vernier callipers.
(A) 0.1 cm (B) 0.01 cm
(C) 0.001 cm (D) 0.0001 cm

Q.44 Zero error is positive of vernier when -
(A) Zero mark of vernier coincides with zero of main scale.
(B) Zero mark of vernier lies towards left of zero of main scale.
(C) Zero mark of vernier lies towards right of zero main scale.
(D) None

Q.45 n division of veriner scale of a vernier callipers coincide with (n – 1) divisions main scale. What is the least count of the instrument if the length of one main scale division is 1mm -
(A) 10 n cm (B) $\frac{1}{10n}$ cm (C) n cm (D) $\frac{1}{100n}$ cm

Q.46 The main scale of a spectrometer is divided into 720 division in all. If the vernier scale consists of 30 divisions the least count of the instrument is - (30 division of vernier scale coincide with 29 division of main scale)
(A) 0.1° (B) $1''$
(C) $1'$ (D) $0.1''$

Q.47 What is reading of vernier callipers as shown in figure below ?



(A) 1.05 cm (B) 1.055 cm
(C) 1.05 mm (D) 1.55 mm

Directions : Assertion-Reason type questions.
(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

Q.48 **Statement 1 :** Absolute error may be negative or positive.
Statement 2 : Absolute error in the difference between the measured value and real value of a physical quantity.

Passage (Q.49-Q.51)
The smallest division on the main scale of a vernier callipers is 1 mm and 10th vernier division coincides with 9th main scale division. When two jaws of the instrument are touched with each other, zero of vernier scale coincides with zero of the main scale.

Q.49 The least count of the vernier callipers is -
(A) 0.01 mm (B) 0.1 mm
(C) 0.1 cm (D) 0.1 m

Q.50 The side of a cube, when measured with the given instrument, gives 10 divisions on main scale and first division of vernier scale coincides with main scale division. The side length of the cube is -
(A) 10 mm (B) 1 mm
(C) 10.1 mm (D) 10.1 cm

Q.51 The volume of the cube, in correct number of significant figures, is -
(A) 0.03 cm^3 (B) 1.03 cm^3
(C) 1.1 cm^3 (D) 1.031 cm^3

EXERCISE - 2 [PREVIOUS YEARS AIEEE / JEE MAIN QUESTIONS]

Choose one correct response for each question.

Q.1 While measuring the speed of sound by performing a resonance column experiment, a student get's the first resonance condition at a column length of 18 cm during winter. Repeating the same experiment during summer, she measures the column length to be x cm for the second resonance. Then - **[AIEEE 2008]**

(A) $x > 54$ (B) $54 > x > 36$
(C) $36 > x > 18$ (D) $18 > x$

Q.2 A working transistor with its three legs marked P, Q and R is tested using a multimeter. No conduction is found between P and Q. By connecting the common (negative) terminal of the multimeter to R and the other (positive) terminal to P or Q, some resistance is seen on the multimeter, which of the following is true for the transistor? **[AIEEE 2008]**

(A) it is an n-p-n transistor with R as base
(B) it is a p-n-p transistor with R as collector
(C) it is a p-n-p transistor with R as emitter
(D) it is an n-p-n transistor with R as collector

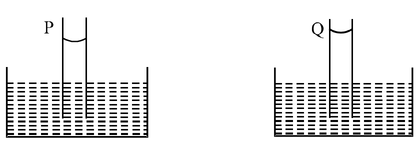
Q.3 An experiment is performed to find the refractive index of glass using a travelling microscope in this experiment distances are measured by - **[AIEEE 2008]**

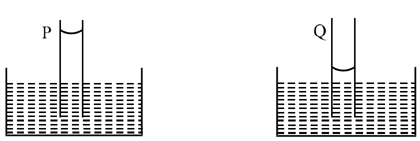
(A) a standard laboratory scale
(B) a meter scale provided on the microscope
(C) a screw gauge provided on the microscope
(D) a vernier scale provided on the microscope

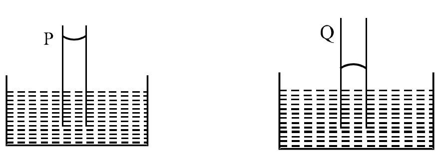
Q.4 Two full turns of the circular scale of a screw gauge cover a distance of 1 mm on its main scale. The total number of division on the circular scale is 50. Further it is found that the screw gauge has a zero error of – 0.03 mm. While measuring the diameter of a thin wire, a student notes the main scale reading of 3 mm and the number of circular scale divisions in line with the main scale as 35. The diameter of the wire is - **[AIEEE 2008]**

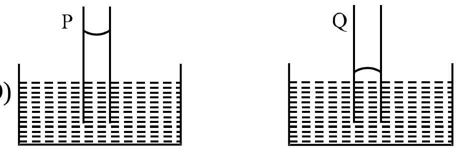
(A) 3.73 mm (B) 3.67 mm
(C) 3.38 mm (D) 3.32 mm

Q.5 A capillary tube (P) is dipped in water. Another identical tube Q is dipped in a soap-water solution which of the following shows the relative nature of the liquid column in the two tubes ? **[AIEEE 2008]**

(A) 

(B) 

(C) 

(D) 

Q.6 In an experiment the angles are required to be measured using an instrument 29 divisions of the main scale exactly concides 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]**

(A) half minute (B) one degree
(C) half degree (D) one minute

Q.7 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]**

(A) (4f, 4f) (B) (2f, 2f)
(C) (f/2, f/2) (D) (f, f)

Q.8 The respective number of significant figures for the numbers 23.023, 0.0003 and 2.1×10^{-3} are –

(A) 5, 1, 2 (B) 5, 1, 5 **[AIEEE 2010]**
(C) 5, 5, 2 (D) 4, 4, 2

Q.9 A screw gauge gives the following reading when used to measure the diameter of a wire.
Main scale reading : 0 mm
Circular scale reading : 52 division
Given that 1 mm on main scale corresponds to 100 divisions of the circular scale. **[AIEEE 2011]**
The diameter of wire from the above data is :

(A) 0.52 cm (B) 0.052 cm
(C) 0.026 cm (D) 0.005 cm

Q.10 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 –

(A) 6% (B) zero **[AIEEE 2012]**
(C) 1% (D) 3%

Q.11 A spectrometer gives the following reading when used to measure the angle of a prism.
Main scale reading : 58.5 degree
Vernier scale reading : 09 divisions **[AIEEE 2012]**
Given that 1 division onmain 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 :

(A) 58.59 degree (B) 58.77 degree
(C) 58.65 degree (D) 59 degree

Q.12 The current voltage relation of diode is given by $I = (e^{1000V/T} - 1)$ 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]**

(A) 0.5 mA (C) 0.05 mA
(C) 0.2 mA (D) 0.02 mA

Q.13 A student measured the length of a rod and wrote it as 3.50cm. Which instrument did he use to measure it?

(A) A screw gauge having 100 divisions in the circular scale and pitch as 1 mm. **[JEE MAIN 2014]**
(B) A screw gauge having 50 divisions in the circular scale and pitch as 1 mm.
(C) A meter scale.
(D) 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.

Q.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]**

(A) 0.80 mm (B) 0.70 mm
(C) 0.50 mm (D) 0.75 mm

Q.15 The following observations were taken for determining surface tension T of water by capillary method:
Diameter of capillary, $D = 1.25 \times 10^{-2}$ m rise of water, $h = 1.45 \times 10^{-2}$ m. Using $g = 9.80$ m/s^2 and the simplified relation $T = \frac{rhg}{2} \times 10^3$ N/m, the possible error in surface tension is closest to: **[JEE MAIN 2017]**

(A) 1.5% (B) 2.4%
(C) 10% (D) 0.15%

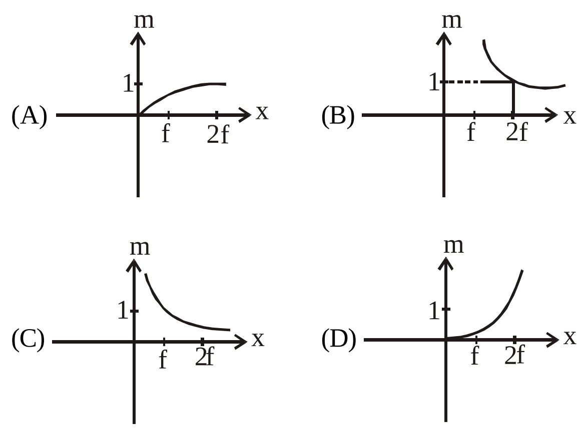
Q.16 The density of a material in the shape of a cube is determined by measuring three sides of the cube and its mass. If the relative errors in measuring the mass and length are respectively 1.5% and 1%, the maximum error in determining the density is: **[JEE MAIN 2018]**

(A) 4.5% (B) 6%
(C) 2.5% (D) 3.5%

Q.17 The pitch and the number of divisions, on the circular scale, for a given screw gauge are 0.5 mm and 100 respectively. When the screw gauge is fully tightened without any object, the zero of its circular scale lies 3 divisions below the mean line. The readings of the main scale and the circular scale, for a thin sheet, are 5.5 mm and 48 respectively, the thickness of this sheet is : **[JEE MAIN 2019 (JAN)]**

(A) 5.755 m (B) 5.725 mm
(C) 5.740 m (D) 5.950 mm

Q.18 An object is gradually moving away from the focal point of a concave mirror along the axis of the mirror. The graphical representation of the magnitude of linear magnification (m) versus distance of the object from the mirror (x) is correctly given by : (Graphs are drawn schematically and are not to scale) **[JEE MAIN 2020 (JAN)]**



ANSWER KEY

EXERCISE - 1

Q	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
A	B	B	C	B	C	B	C	B	C	D	D	B	C	B	C	C	C	D	C	D	B	B	A	A	CD	C
Q	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	
A	C	C	C	C	D	C	B	A	D	A	D	AD	B	D	D	A	B	C	B	C	A	A	B	C	B	

EXERCISE - 2

Q	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
A	A	B	D	C	B	D	B	A	B	A	C	C	D	A	A	A	B	B

CHAPTER- 9 : PRACTICAL PHYSICS
EXERCISE-1

(1) **(B).** $\therefore E = \frac{1}{2}mv^2$

$\therefore$% Error in K.E. = % error in mass + 2 × % error in velocity

$= 2 + 2 \times 3 = 8\,\%$

(2) **(B).** Number of significant figures are 3, because 10^3 is decimal multiplier.

(3) **(C).** Mean time period T = 2.00 sec

& Mean absolute error = ΔT = 0.05 sec.

To express maximum estimate of error, the time period should be written as (2.00 ± 0.05) sec

(4) **(B).** Here, $S = (13.8 \pm 0.2)$ m

and $t = (4.0 \pm 0.3)$ sec

Expressing it in percentage error, we have,

$$S = 13.8 \pm \frac{0.2}{13.8} \times 100\% = 13.8 \pm 1.4\%$$

$$\text{and } t = 4.0 \pm \frac{0.3}{4} \times 100\% = 4 \pm 7.5\%$$

$$\because V = \frac{s}{t} = \frac{13.8 \pm 1.4}{4 \pm 7.5} = (3.45 \pm 0.3)\text{ m/s.}$$

(5) **(C).** Since for 50.14 cm, significant number = 4 and for 0.00025, significant numbers = 2

(6) **(B).** $\therefore \left(\frac{\Delta R}{R} \times 100\right)_{max} = \frac{\Delta V}{V} \times 100 + \frac{\Delta I}{I} \times 100$

$$= \frac{5}{100} \times 100 + \frac{0.2}{10} \times 100 = (5 + 2)\% = 7\%$$

(7) **(C).** Volume of cylinder $V = \pi r^2 \ell$

Percentage error in volume

$$\frac{\Delta V}{V} \times 100 = \frac{2\Delta r}{r} \times 100 + \frac{\Delta \ell}{\ell} \times 100$$

$$= \left(2 \times \frac{0.01}{2.0} \times 100 + \frac{0.1}{5.0} \times 100\right) = (1 + 2)\% = 3\%$$

(8) **(B).** $H = I^2Rt$

$$\therefore \frac{\Delta H}{H} \times 100 = \left(\frac{2\Delta I}{I} + \frac{\Delta R}{R} + \frac{\Delta t}{t}\right) \times 100$$

$$= (2 \times 3 + 4 + 6)\% = 16\%$$

(9) **(C).** Quantity C has maximum power. So it brings maximum error in P.

(10) **(D).** The number of significant figures in all of the given number is 4.

(11) **(D).** Percentage error in A

$$= \left(2 \times 1 + 3 \times 3 + 1 \times 2 + \frac{1}{2} \times 2\right)\% = 14\%$$

(12) **(B).** $\beta = \frac{\Delta i_c}{\Delta i_b}$, so $\Delta i_b = \frac{1 \times 10^{-3}}{100} = 0.01$ mA

$\Delta i_e = \Delta i_b + \Delta i_c = 0.01 + 1 = 1.01$ mA

(13) **(C).** Error $= 6 \times LC = 6 \times \frac{1}{50}$; Correction $= 6 \times \frac{1}{50} = \frac{6}{50}$

(14) **(B).** Tuning fork should be handled in vertical plane.

(15) **(C).** Spherometer provided in searle's apparatus

(16) **(C).** $2r = 10 \times 1 + 0 \times LC$

2r = 10mm = 1 cm.

so r = 0.5 cm.

(17) **(C).** Wire is not having uniform throughout

(18) **(D).** Pitch= $\frac{2mm}{8} = 0.25mm$

$$L.C. = \frac{0.25mm}{250} = 0.001mm$$

Observed diameter = MSR + (Coinciding division× L.C.)

$= (15 \times 0.25\text{ mm}) + (100 \times 0.001\text{ mm})$

$= 3.75\text{mm} + 0.100\text{mm} = 3.850\text{ mm}$

(19) **(C).** Slope $\uparrow$, S $\downarrow$

so least preferred.

(20) **(D).** LC = 0.1 mm ; MSR = 1cm = 10 mm

VSR = 5 × 0.1 = 0.5 mm ; Error = +4 × 0.1 = 0.4 mm

So, 2r = 10 + 0.5 – 0.4 = 10.1 mm ; r = 5.05 mm

(21) **(B).** Temp. $\uparrow$, frequency $\downarrow$; so resonance length $\downarrow$

(22) **(B).** $T = 2\pi\sqrt{\frac{L}{g}}$ or $T^2 = 4\pi^2 \frac{L}{g}$

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

$$\text{Actual \% error in } g = \frac{\Delta L}{L} \times 100 + 2\frac{\Delta T}{T} \times 100$$

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

(23) **(A).** $\left(\frac{dv}{v}\right)_{max} = \frac{\Delta f_0}{f_0} + \frac{\Delta \ell + \Delta \ell}{\ell_2 - \ell_1}$

$$= \frac{1}{100} + \frac{0.1 + 0.1}{74 - 24} = \left(\frac{1}{100} + \frac{0.2}{50}\right) \times 100\% = 1.4\%$$

(24) **(A).** $Y = \frac{mg\ell}{(\pi/4)\, d^2 x}$ .... (1)

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

m = 20.0 kg $\Rightarrow$ Δm = 0.1 kg

ℓ = 125cm $\Rightarrow$ $\Delta \ell$ = 1 cm.

d = 0.050 cm. $\Rightarrow$ Δd = 0.001 cm

x = 0.100 cm. $\Rightarrow$ Δx = 0.001 cm.

$$\left(\frac{dY}{Y}\right)_{max} = \left(\frac{0.1kg}{20.0kg} + \frac{1cm}{125cm} + 2\times\frac{0.001cm}{0.05cm} + \frac{0.001cm}{0.100cm}\right)\times 100\% = 6.3\%$$

(25) **(CD).** $\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$ or $\frac{1}{-|v|}+\frac{1}{-|u|}=\frac{1}{-|f|}$

$\Rightarrow |v| = \frac{|u||f|}{|u|-|f|}$

For $|u| = 42, |f| = 24 ; |v| = \frac{(42)(24)}{42-24} = 56$ cm
so (42, 56) is correct observation.
For $|u| = 48$ or $|u| = 2f$ or $|v| = 2f$
so (48, 48) is correct observation

For $|u| = 66$ cm ; $|f| = 24$ cm, $|v| = \frac{(66)(24)}{66-24} \approx 36$cm
which is not in the permissible limit so (66, 33), is incorrect recorded. For $|u| = 78, |f| = 24$ cm

$|v| = \frac{(78)(24)}{78-24} \approx 32$cm, which is also not in the permissible limit so (78, 39), is incorrect recorded.

(26) **(C).** Least count $= \frac{0.5}{50} = 0.01$ mm
Diameter of ball D = 2.5 mm + (20)(0.01) = 2.7 mm

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

$\left(\frac{\Delta\rho}{\rho}\right)_{max} = 2\% + 3\left(\frac{0.01}{2.7}\right)\times 100\%$; $\frac{\Delta\rho}{\rho} = 3.1\%$

(27) (C)	**(28)** (C)	**(29)** (C)
(30) (C)	**(31)** (D)	**(32)** (C)
(33) (B)	**(34)** (A)	**(35)** (D)
(36) (A)	**(37)** (D)	**(38)** (AB)
(39) (B)	**(40)** (D)	**(41)** (D)
(42) (A)	**(43)** (B)	**(44)** (C)
(45) (B)	**(46)** (C)	**(47)** (A)

(48) **(A).** Absolute error in the difference between the measured value and real value of a physical quantity.
$x = x_0 \pm \Delta x$

(49) (B)	**(50)** (C)	**(51)** (B)

EXERCISE-2

(1) **(A).** $n = \frac{1}{4x}\sqrt{\frac{\gamma RT}{M}}$; $xn = \frac{1}{x}\sqrt{\frac{\gamma RT}{M}}$; $x \propto \sqrt{T}$

(2) **(B).** It is a pnp transistor with R as collector

(3) **(D).** A vernier scale provided on the microscope

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

(5) **(B).** Capillary rise $h = \frac{2T\cos\theta}{\rho gr}$.
As soap solution has lower T, h will be low.

(6) **(D).** Least count = 1 MSD – 1 VSD = 1MSD – $\frac{29}{30}$MSD

$= \frac{1}{30}$MSD $= \frac{0.5°}{30} = \frac{30 \text{ minutes}}{30}$ = one minute

(7) **(B).** $\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$; $\frac{1}{|v|}+\frac{1}{|u|}=\frac{1}{f}$
$|v| = |u| = 2f$
Coordinates are (2f, 2f)

(8) **(A).** 5, 1, 2

(9) **(B).** Least count of screw gauge $= \frac{1}{100}$ mm = 0.01 mn
Diameter = Divisions on cirular scale × least count + main scale reading $= 52\times\frac{1}{100} + 0 = 0.52$ mm
Diameter = 0.052 cm

(10) **(A).** $R = \frac{V}{I} \Rightarrow \pm\frac{\Delta R}{R} = \pm\frac{\Delta V}{V} \pm \frac{\Delta I}{I} = 3 + 3 = 6\%$

(11) **(C).** 30 V.S.D. → 29 M.S.D.

1 V.S.D. → $\frac{29}{30}$ M.S.D. $= \frac{29}{30}\times 0.5$
Least count of vernier = 1 M.S.D. – 1 V.S.D.

$= 0.5° - \frac{29}{30}\times 0.5° = \frac{0.5°}{30}$

Reading of vernier
= M.S. reading + V.S reading × least count

$= 58.5° + 9\times\frac{0.5°}{30} = 58.65$

(12) **(C).** $5 = e^{1000\frac{V}{T}} - 1 \Rightarrow e^{1000\frac{V}{T}} = 6$ ..... (1)

Again, $I = e^{1000\frac{V}{T}} - 1$

$\frac{dI}{dV} = e^{\frac{1000V}{T}}\frac{1000}{T}$; $dI = \frac{1000}{T}e^{\frac{1000V}{T}}dV$
Using eq. (1),

$\Delta I = \frac{1000}{T}\times 6\times 0.01 = \frac{60}{T} = \frac{60}{300} = 0.2$ mA

(13) **(D).** Least count of vernier calliper is

$\frac{1}{10}$ mm = 0.1 mm = 0.01 cm

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

Zero error = – 0.5 + 45 × 0.01 = – 0.05mm

Measured reading = 0.5 + 25 × 0.01 = 0.75 mm

Actual reading = Measured reading – Z.E.

$= 0.75\text{mm} - (0.05) = 0.80$ mm

(15) (A). $T = \frac{rhg}{2} \times 10^3 \frac{N}{m} = \frac{dhg}{4} \times 10^3 \frac{N}{m}$

% error $\frac{\Delta T}{T} = \frac{\Delta d}{d} + \frac{\Delta h}{h}$

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

= 0.8% + 0.7% = 1.5 %

(There is no error in g because its value is not calculated through experiments)

(16) (A). $\rho = \frac{M}{V} = \frac{M}{L^3}$

$$\frac{\Delta \rho}{\rho} = \frac{\Delta M}{M} + 3\frac{\Delta L}{L}$$

∴ Maximum % error in density = 1.5% + 3 (1%) = 4.5%

(17) (B). $LC = \frac{\text{Pitch}}{\text{No. of division}}$

$LC = 0.5 \times 10^{-2}$ mm

+ve error = $3 \times 0.5 \times 10^{-2}$ mm = 1.5×10^{-2} mm

= 0.015 mm

Reading = MSR + CSR – (+ve error)

= 5.5 mm + $(48 \times 0.5 \times 10^{-2})$ – 0.015

= 5.5 + 0.24 – 0.015 = 5.725 mm

(18) (B). $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

At focus $m = \infty$, $x = f$

At centre $m = -1$, $x = 2f$