30
Experimental Physics

TOPIC 1
Experiments Related to Units and Measurements

01 In a screw gauge, 5th division of the circular scale coincides with the reference line when the ratchet is closed. There are 50 divisions on the circular scale, and the main scale moves by 0.5 mm on a complete rotation. For a particular observation the reading on the main scale is 5 mm and the 20th division of the circular scale coincides with reference line. Calculate the true reading.

[2021, 26 Aug Shift-I]

(a) 5.00 mm (b) 5.25 mm
(c) 5.15 mm (d) 5.20 mm

Ans. *(c)*

Least count of a screw gauge is given by

$$\text{Least count (LC)} = \frac{\text{Pitch}}{\text{Number of circular scale divisions}}$$

$$\Rightarrow \quad \text{LC} = \frac{0.5}{50} \qquad \ldots(\text{i})$$

The actual reading (true reading)

= Main scale reading + Least count × Circular division − Zero error

$$= 5 + \left(\frac{0.5}{50}\right) \times 20 - \frac{0.5}{50} \times 5$$

[∵ Zero error = Least count × Coinciding division]

$$= 5 + \frac{0.5}{50}(20 - 5)$$

$$= 5 + \frac{0.5}{50}(15) = 5 + \frac{15}{100}$$

$$= \frac{515}{100}\ \text{mm} = 5.15\ \text{mm}$$

02 **Assertion (A)** If in five complete rotations of the circular scale, the distance travelled on main scale of the screw gauge is 5 mm and there are 50 total divisions on circular scale, then least count is 0.001 cm.

Reason (R) Least count

$$= \frac{\text{Pitch}}{\text{Total divisions on circular scale}}$$

In the light of the above statements, choose the most appropriate answer from the options given below.

[2021, 27 July Shift-I]

(a) Both A and R are correct and R is the correct explanation of A.
(b) Both A and R are correct and R is not the correct explanation of A.
(c) A is correct but R is not correct.
(d) A is not correct but R is correct.

Ans. *(d)*

According to question,

In 5 complete rotations of circular scale, distance travelled on the main scale of screw gauge is 5mm, so in one complete rotation of circular scale, distance travelled on the main scale of screw gauge will be

$$= \frac{5\text{mm}}{5} = 1\text{mm}$$

This is the required value of pitch.

∵ Least count

$$= \frac{\text{Pitch}}{\text{Total division on circular scale}}$$

$$\Rightarrow \text{Least count} = \frac{1}{50} = 0.02$$

It means, Assertion is not correct, but Reason is correct.

03 Suppose you have taken a dilute solution of oleic acid in such a way that its concentration becomes $0.01\ \text{cm}^3$ of oleic acid per cm^3 of the solution. Then, you make a thin film of this solution (monomolecular thickness) of area $4\ \text{cm}^2$ by considering 100 spherical drops of radius $\left(\frac{3}{40\pi}\right)^{1/3} \times 10^{-3}\ \text{cm}^2$.

Then, the thickness of oleic acid layer will be $x \times 10^{-14}$ m,

where x is ..... .

[2021, 17 March Shift-II]

Ans. *(25)*

Given, the radius of the spherical drop

$$r = \left(\frac{3}{40\pi}\right)^{1/3} \times 10^{-3}\ \text{cm}$$

The volume of 100 spherical drops,

$$V = 100 \times \frac{4\pi r^3}{3}$$

Substituting the value of the radius in the above equation, we get

$$V = 100 \times \frac{4\pi}{3} \times \frac{3}{40\pi} \times 10^{-9}$$

$$V = 10^{-8}\ \text{cm}^3$$

Now, Volume of the film = Area of the film × Thickness of the film

$\Rightarrow$ Volume of the film $= 4 \times t$

The film is made up of 100 spherical drops.

$\therefore$ The volume of the film = Volume of 100 spherical drops

$$4t = 10^{-8} \Rightarrow t = 25 \times 10^{-12}\ \text{m}$$

The thickness of the oleic layer,

$$t_0 = 0.01 \times t = 25 \times 10^{-14}\ \text{m}$$

Comparing with $x \times 10^{-14}$, we get $x = 25$

04 The pitch of the screw gauge is 1 mm and there are 100 divisions on the circular scale. When nothing is put in between the jaws, the zero of the circular scale lies 8 divisions below the reference line. When a wire is placed between the jaws, the first linear scale division is clearly visible while 72nd division on circular scale coincides with the reference line. The radius of the wire is **[2021, 25 Feb Shift-I]**

(a) 1.64 mm (b) 0.82 mm
(c) 1.80 mm (d) 0.90 mm

Ans. *(b)*

Given, pitch of screw gauge, $P = 1$ mm

Number of division, $n = 100$

$\therefore$ Least count (LC) $= \frac{P}{n} = 1/100 = 0.01$ mm

As, zero of circular division lies 8 divisions below.

$\therefore$ Zero error $= 8 \times LC = 8 \times 0.01 = 0.08$ mm

Since, 1st linear scale division coinside with 72nd circular scale division.

$$\therefore \text{Radius } (r) = \frac{[P + (72 \times LC) - \text{Zero error}]}{2}$$

$$= [1 + (72 \times 0.01) - 0.08]/2$$

$$= (1.72 - 0.08)/2 = 1.64/2$$

$$= 0.82 \text{ mm}$$

05 The least count of the main scale of a vernier callipers is 1 mm. Its vernier scale is divided into 10th division and coincide with 9th division of the main scale. When jaws are touching each other, the 7th division of vernier scale coincides with a division of main scale and the zero of vernier scale is lying right side of the zero of main scale. When this vernier is used to measure length of a cylinder the zero of the vernier scale lies between 3.1 cm and 3.2 cm and 4th VSD coincides with a main scale division. The length of the cylinder is (VSD is vernier scale division) **[2020, 2 Sep Shift-I]**

(a) 3.2 cm (b) 2.99 cm
(c) 3.07 cm (d) 3.21 cm

Ans. *(c)*

Given, least count of main scale = 1 main scale division (MSD) = 1 mm

Also, 10 vernier scale divisions = 9 main scale divisions

$\Rightarrow$ 1 vernier scale division (VSD)

$$= \frac{9}{10} \text{MSD} = 0.9 \text{ MSD} = 0.9 \text{ mm}$$

Vernier constant or least count of instrument is,

$$LC = 1 \text{ MSD} - 1 \text{ VSD} = 1 \text{ MSD} - \frac{9}{10} \text{MSD}$$

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

$$= 1 \text{ mm}/10 = 0.1 \text{ mm or } 0.01 \text{ cm}$$

The zero of vernier scale lies to the right of main scale. So, error is positive.

Zero error $= 7 \times LC = 7 \times 0.01$ cm $= 0.07$ cm

Given, main scale reading = 3.1 cm

Vernier scale reading = 4 divisions

$\therefore$ Observed value

$$= \text{MSR} + \text{VSR} \times \text{LC} - \text{Zero error}$$

$$= 3.1 + 4 \times 0.01 - 0.07$$

$$= 3.14 \text{ cm} - 0.07 \text{ cm} = 3.07 \text{ cm}$$

Hence, correct option is (c).

06 Using screw gauge of pitch 0.1 cm and 50 divisions on its circular scale, the thickness of an object is measured. It should correctly be recorded as **[2020, 3 Sep Shift-I]**

(a) 2.121 cm (b) 2.124 cm
(c) 2.125 cm (d) 2.123 cm

Ans. *(b)*

Given, pitch = 0.1 cm

Number of divisions on circular scale = 50

Least count of screw gauge

$$= \frac{\text{Pitch}}{\text{Number of divisions on circular scale}}$$

$$= 0.1/50 = 0.002 \text{ cm}$$

Now, correctly recorded measurement is an integral multiple of LC.

So, amongst the given options, only 2.124 cm is the integral multiple of LC. Thus, it is the correctly recorded value.

Hence, option (b) is correct.

07 A screw gauge has 50 divisions on its circular scale. The circular scale is 4 units ahead of the pitch scale marking, prior to use. Upon one complete rotation of the circular scale, a displacement of 0.5 mm is noticed on the pitch scale. The nature of zero error involved and the least count of the screw gauge, are respectively **[2020, 6 Sep Shift-I]**

(a) negative, 2 μm
(b) positive, 10 μm
(c) positive, 0.1 mm
(d) positive, 0.1 μm

Ans. *(b)*

Given that, number of divisions on circular scale = 50

Pitch $= 0.5 \text{ mm} = 5 \times 10^{-4}$ m

Least count of screw gauge

$$= \frac{\text{Pitch}}{\text{Number of divisions on circular scale}}$$

$$= \frac{5 \times 10^{-4}}{50} = 1 \times 10^{-5} \text{ m} = 10 \mu\text{m}$$

Since, circular scale is 4 units ahead of the pitch scale marking which means screw gauge has positive zero error.

08 A student measuring the diameter of a pencil of circular cross-section with the help of a vernier scale records the following four readings; 5.50 mm, 5.55 mm, 5.45 mm and 5.65 mm. The average of these four readings is 5.5375 mm and the standard deviation of the data is 0.07395 mm. The average diameter of the pencil should be therefore recorded as **[2020, 6 Sep Shift-II]**

(a) (5.5375 ± 0.0739) mm
(b) (5.5375 ± 0.0740) mm
(c) (5.538 ± 0.074) mm
(d) (5.54 ± 0.07) mm

Ans. *(d)*

There are three significant figures in the measured value (or readings) whereas there are 5 and 4 significant figures in average readings and standard deviation of the data, respectively. So, answer must be upto three significant figures. After rounding off the uncertain digits and considering least count of vernier scale, i.e. 0.01 mm, average diameter of pencil is recorded as (5.54 ± 0.07) mm.

Hence, option (d) is correct.

09 If the screw on a screw gauge is given six rotations, it moves by 3 mm on the main scale. If there are 50 divisions on the circular scale, the least count of the screw gauge is **[2020, 9 Jan Shift-I]**

(a) 0.001 cm
(b) 0.01 cm
(c) 0.02 cm
(d) 0.001 cm

Ans. *(a)*

Pitch of screw of a screw gauge,

$$\text{pitch} = \frac{\text{distance moved by screw}}{\text{number of rotations}}$$

$$= \frac{3\text{ mm}}{6} = 0.5\text{ mm}$$

and least count of screw gauge,

least count

$$= \frac{\text{pitch}}{\text{number of circular scale divisions}}$$

$$= \frac{0.5\text{ mm}}{50} = 0.01\text{ mm} = 0.001\text{ cm}$$

10 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) 0.75 mm (b) 0.80 mm
(c) 0.70 mm (d) 0.50 mm

Ans. *(a)*

Given that the screw gauge has zero error.

So, least count of a screw gauge

$$= \frac{0.5}{50}\text{ mm.}$$

Thickness of the sheet if the main scale reading is 0.5 mm and the 25th division coincides with the main scale line, we have

$$= 0.50\text{ mm} + (25) \times \frac{0.5}{50}\text{ mm}$$

$$= 0.50\text{ mm} + 0.25\text{ mm}$$

$$= 0.75\text{ mm}$$

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]**

(a) A meter scale
(b) A vernier calliper where the 10 divisions in vernier scale matches with 9 divisions in main scale and main scale has 10 divisions in 1 cm
(c) A screw gauge having 100 divisions in the circular scale and pitch as 1 mm
(d) A screw gauge having 50 divisions in the circular scale and pitch as 1 mm

Ans. *(a)*

If student measures 3.50 cm, it means that there is an uncertainly of order 0.01 cm.

For vernier scale with 1 MSD = 1 mm

and 9 MSD = 10 VSD

LC of vernier calliper = 1MSD – 1VSD

$$= \frac{1}{10}\left(1 - \frac{9}{10}\right) = \frac{1}{100}\text{ cm}$$

12 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 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 **[AIEEE 2011]**

(a) 0.052 cm (b) 0.026 cm
(c) 0.005 cm (d) 0.52 cm

Ans. *(a)*

Diameter of wire,

$$d = \text{MSR} + (\text{CSR} \times \text{LC}) \quad \left[\because \text{LC} = \frac{1}{100}\right]$$

$$= 0 + 52 \times \frac{1}{100} = 0.52\text{ mm}$$

$$= 0.052\text{ cm}$$

13 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 divisions 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) 3.32 mm (b) 3.72 mm
(c) 3.67 mm (d) 3.38 mm

Ans. *(d)*

Diameter = Main scale reading + Circular scale reading × LC + Zero error

$$z = 3 + 35 \times \frac{1}{2 \times 50} + 0.03 = 3.38\text{ mm}$$

TOPIC 2

Experiments Related to Oscillations

14 A student is performing the experiment of resonance column. The diameter of the column tube is 6 cm. The frequency of the tuning fork is 504 Hz. Speed of the sound at the given temperature is 336 m/s. The zero of the meter scale coincides with the top end of the resonance column tube. The reading of the water level in the column when the first resonance occurs is **[2021, 25 Feb Shift-I]**

(a) 13 cm (b) 16.6 cm
(c) 18.4 cm (d) 14.8 cm

Ans. *(d)*

Given, diameter of the column tube,

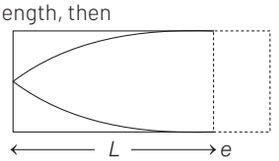
$d = 6\text{ cm} = 6 \times 10^{-2}\text{ m}$

Frequency of tuning fork, $f = 504\text{ Hz}$

Speed of sound at given temperature, $v = 336\text{ ms}^{-1}$

As, this is a closed organ pipe.

Let L be the length of tube and λ be the wavelength, then



$$L + e = \lambda/4 = v/4f \qquad \left(\because \lambda = \frac{v}{f}\right)$$

and $e = 0.6 \times d/2$

$$= \frac{6}{10} \times \frac{6 \times 10^{-2}}{2} = 0.018$$

$$\Rightarrow \quad L + e = \frac{v}{4f} = \frac{336}{4 \times 504}$$

$$\Rightarrow \quad L = \frac{336}{2016} - 0.018 = 0.1667 - 0.018$$

$$= 0.1487\text{ m} = 14.87\text{ cm} \simeq 14.8\text{ cm}$$

15 A simple pendulum is being used to determine the value of gravitational acceleration g at a certain place. The length of the pendulum is 25.0 cm and a stop watch with 1s resolution measures the time taken for 40 oscillations to be 50 s. The accuracy in g is **[2020, 8 Jan Shift-II]**

(a) 2.40% (b) 5.40%
(c) 4.40% (d) 3.40%

Ans. *(c)*

Given, length of pendulum, $l = 25.0$ cm
So, there is an uncertainty of 0.1 cm in measurement of length.

Resolution of stopwatch is 1s. So, uncertainty in measurement of time is 1s.

Now using, $T = 2\pi\sqrt{\frac{l}{g}}$ or $g = \frac{4\pi^2 l}{T^2}$

We have, $\frac{\Delta g}{g} = \frac{\Delta l}{l} + \frac{2\Delta T}{T} \Rightarrow \frac{\Delta g}{g} \times 100\%$

$$= \left(\frac{\Delta l}{l} + \frac{2\Delta T}{T}\right) \times 100\%$$

Accuracy in measurement of g is

$$\frac{\Delta g}{g} \times 100\% = \left(\frac{0.1}{25} + \frac{2 \times 1}{50}\right) \times 100\%$$

$$= (0.004 + 0.04) \times 100\ \%$$

$$= 4.40\%$$

TOPIC 3

Experiments Related to Current Electricity

16 In the experiment of Ohm's law, a potential difference of 5.0 V is applied across the end of a conductor of length 10.0 cm and diameter of 5.00 mm. The measured current in the conductor is 2.00 A. The maximum permissible percentage error in the resistivity of the conductor is

[2021, 18 March Shift-I]

(a) 3.9 (b) 8.4 (c) 7.5 (d) 3.0

Ans. *(a)*

Given, the potential difference applied across the ends of the conductor, $V = 5$ V

The length of the conductor, $L = 10$ cm

The measured value of the current in the conductor, $I = 2$ A

The diameter of the conductor, $d = 5$ mm

As we know that, $R = \frac{\rho l}{A}$

Using Ohm's law,

$$V = IR \Rightarrow R = V/I$$

$$\frac{\rho l}{A} = \frac{V}{I} \Rightarrow \rho = \frac{V}{Il}\left(\frac{\pi d^2}{4}\right)$$

In error form,

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

$$\Rightarrow \quad \frac{\Delta\rho}{\rho} = \frac{0.1}{5} + \frac{0.01}{2} + \frac{0.1}{10} + 2\frac{(0.01)}{(5)}$$

$$\Rightarrow \quad \frac{\Delta\rho}{\rho} = 0.039 \Rightarrow \frac{\Delta\rho}{\rho} \times 100 = 3.9\%$$

The maximum permissible percentage error in the resistivity of the conductor is 3.9%.

17 Which of the following will not be observed when a multimeter (operating in resistance measuring mode) probes connected across a component, are just reversed?

[2020, 3 Sep Shift-II]

(a) Multimeter shows no deflection in both cases, i.e. before and after reversing the probes if the chosen component is metal wire.

(b) Multimeter shows an equal deflection in both cases, i.e. before and after reversing the probes if the chosen component is resistor.

(c) Multimeter shows no deflection in both cases, i.e. before and after reversing the probes if the chosen component is capacitor.

(d) Multimeter shows a deflection, accompanied by a splash of light out of connected component in one direction and no deflection on reversing the probes if the chosen component is LED.

Ans. *(c)*

If a capacitor is put between probes of a multimeter, then during charging, a current flows in circuit, so there is a deflection which becomes soon zero.

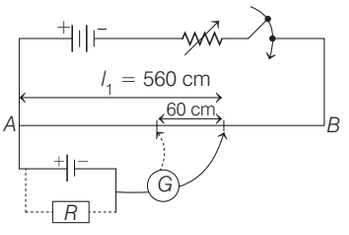
∴Statement in option (c) is not correct.

18 The balancing length for a cell is 560 cm in a potentiometer experiment. When an external resistance of 10Ω is connected in parallel to the cell, the balancing length changes by 60 cm. If the internal resistance of the cell is $\frac{N}{10}\Omega$, where N is an integer, then value of N is ..... .

[2020, 7 Jan Shift-II]

Ans. *(12)*

In experiment of finding internal resistance,



Balancing length with only cell,

$$l_1 = 560 \text{ cm}.$$

Balancing length with cell and resistance, $l_2 = 560\text{ cm} - 60\text{ cm} = 500$ cm

External resistance, $R = 10\ \Omega$

Now using

$$r = R\left(\frac{E}{V} - 1\right) = R\left(\frac{l_1}{l_2} - 1\right), \text{ we get}$$

$$r = 10\left(\frac{560}{500} - 1\right) = \frac{6}{5}\Omega$$

Now given,

$$r = \frac{N}{10} \Rightarrow \frac{6}{5} = \frac{N}{10}$$

$$\Rightarrow \quad N = 60/5 = 12$$

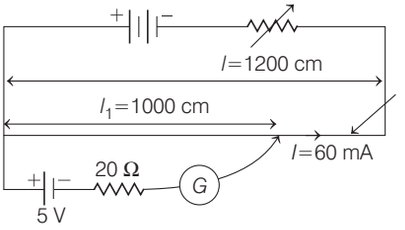
19 The length of a potentiometer wire is 1200 cm and it carries a current of 60 mA. For a cell of emf 5 V and internal resistance of 20 Ω, the null point on it is found to be at 1000 cm. The resistance of whole wire is

[2020, 9 Jan Shift-II]

(a) 80 Ω (b) 100 Ω
(c) 60 Ω (d) 120 Ω

Ans. *(b)*

The given situation is as shown below.



At null point, a length of 1000 cm balances emf of 5 V.

So, potential drop across 1000 cm of wire is equal to emf of cell,

$$E = l_1 \cdot x \cdot I$$

$$\Rightarrow \quad 5 = 1000 \times x \times 60 \times 10^{-3}$$

where, x = resistance per centimetre length of potentiometer wire.

$$\Rightarrow \quad x = \frac{5}{1000 \times 60 \times 10^{-3}}$$

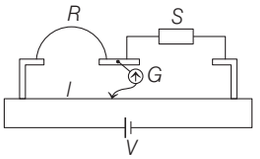
$$\text{or} \quad x = \frac{1}{12}\ \Omega\ \text{cm}^{-1}$$

So, resistance of 1200 cm length of wire,

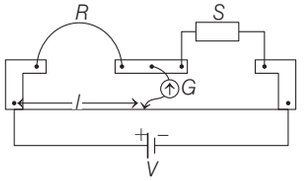
$$R = I \cdot x = 1200 \times \frac{1}{12} = 100\ \Omega$$

20 In a meter bridge experiment, S is a standard resistance, R is a resistance wire. It is found that balancing length is $l = 25$ cm. If R is replaced by a wire of half length

and half diameter that of R of same material, then the balancing distance l' (in cm) will now be ..... **[2020, 9 Jan Shift-II]**



Ans. *(40)*



Given, balance length, $l = 25$ cm

At balance point, $\frac{R}{l} = \frac{S}{100 - l}$

$\Rightarrow \quad \frac{R}{25} = \frac{S}{75}$

$\Rightarrow \quad R = \frac{S}{3}\Omega$ ....(i)

When R is replaced by some other resistance of half length and half diameter, then resistance in left gap,

$$R' = \frac{\rho\frac{l}{2}}{\frac{\pi}{4}\left(\frac{d}{2}\right)^2} = 2\left\{\frac{\rho l}{\left(\frac{\pi}{4}d^2\right)}\right\}$$

$\Rightarrow \quad R' = 2R$

Now, if balance is obtained at length l', then

$$\frac{R'}{l'} = \frac{S}{(100 - l')}$$

$\Rightarrow \quad \frac{2R}{l'} = \frac{S}{100 - l'}$

Substituting for S from Eq. (i), we get

$$\frac{2R}{l'} = \frac{3R}{100 - l'}$$

$\Rightarrow \quad 200 - 2l' = 3l'$

or $\quad l' = 40$ cm

TOPIC 4

Experiments Related to Electronics Devices

21 A common transistor radio set requires 12 V (DC) for its operation. The DC source is constructed by using a transformer and a rectifier circuit, which are operated at 220 V (AC) on standard domestic AC supply. The number of turns of secondary coil are 24, then the number of turns of primary are ..... . **[2021, 24 Feb Shift-I]**

Ans. *(440)*

In a transformer,

$$\frac{N_p}{N_s} = \frac{V_p}{V_s}$$

where, N_p = number of turns in primary circuit,

N_s = number of turns in secondary circuit = 24,

V_p = potential of primary circuit = 220 V

and V_s = potential of secondary circuit = 12 V

$\Rightarrow \quad \frac{N_p}{24} = \frac{220}{12}$

$\Rightarrow \quad N_p = 440$

TOPIC 5

Experiment Related to Optics

22 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 vernier scale provided on the microscope

(b) a standard laboratory scale

(c) a meter scale provided on the microscope

(d) a screw gauge provided on the microscope

Ans. *(a)*

If an experiment is performed to find the refractive index of glass using a travelling microscope, distances are measured by a vernier scale which is provided on the microscope.