

# JEE MAIN (Session 2) 2023 Paper Analysis

**PHYSICS | 6<sup>th</sup> April 2023 \_ Shift-2**



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1256/2994 = **41.95%**

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(2022)

4818/6653 = **72.41%**

(2021)

2994/4087 = **73.25%**



**NITIN VIJAY (NV Sir)**  
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### SECTION - A

31. The temperature of an ideal gas is increased from 200 K to 800 K. If r.m.s. speed of gas at 200 K is  $v_0$ . Then, r.m.s. speed of the gas at 800 K will be:

- (1)  $4v_0$  (2)  $2v_0$  (3)  $v_0$  (4)  $\frac{v_0}{4}$

Sol. (2)

$$\text{using } v_{\text{rms}} = \sqrt{\frac{3RT}{m}}$$

$$v_0 = \sqrt{\frac{3R \times 200}{m}} \quad \dots(1)$$

$$(v') = \sqrt{\frac{3R \times 800}{m}} \quad \dots(2)$$

dividing (2) by (1)

$$\frac{v'}{v_0} = \sqrt{\frac{800}{200}} = \sqrt{4} = 2$$

$$\text{or } v' = 2v_0$$

32. Given below are two statements : one is labelled as assertion A and the other is labelled as Reason R  
**Assertion A :** The phase difference of two light wave change if they travel through different media having same thickness, but different indices of refraction

**Reason R :** The wavelengths of waves are different in different media.

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

- (1) Both A and R are correct and R is the correct explanation of A  
(2) A is not correct but R is correct  
(3) A is correct but R is not correct  
(4) Both A and R are correct but R is NOT the correct explanation of A

Sol. (1)

Both the statements are true

As we know speed of light in a medium

$$v = \frac{c}{\mu} \text{ or } f\lambda = \frac{c}{\mu}$$

$$\text{therefore } \lambda \propto \frac{1}{\mu}$$

when light will travel through two different mediums their phase difference will change

$$\Delta Q = \frac{2\pi}{\lambda} \Delta x$$

and R is correction explanation

33. For an amplitude modulated wave the minimum amplitude is 3 V, while the modulation index is 60%. The maximum amplitude of the modulated wave is :

- (1) 10 V (2) 12 V (3) 15 V (4) 5 V

Sol. (2)

Given, modulation index = 60% = 0.6

$$\frac{A_m}{A_c} = \frac{0.6}{1}$$

Using componendo – dividendo, we can write

$$\frac{A_m + A_c}{A_m - A_c} = \frac{0.6 + 1}{0.6 - 1} = \frac{1.6}{-0.4}$$

$$A_m + A_c = \frac{1.6}{-0.4} \times (A_m - A_c)$$

$$= \frac{1.6}{-0.4} \times (-3) = 12 \text{ V}$$

34. The ratio of speed of sound in hydrogen gas to the speed of sound in oxygen gas at the same temperature is :  
 (1) 1 : 4                      (2) 1 : 2                      (3) 1 : 1                      (4) 4 : 1

Sol. (4)

$$\text{Using } v = \sqrt{\frac{\gamma RT}{m}}$$

$$\frac{v_{H_2}}{v_{O_2}} = \sqrt{\frac{m_{O_2}}{m_{H_2}}} = \sqrt{\frac{32}{2}} = \sqrt{\frac{16}{1}} = 4 : 1$$

(since both hydrogen and oxygen are di-atomic,  $\gamma$  will be same)

35. A dipole comprises of two charged particles of identical magnitude  $q$  and opposite in nature. The mass ' $m$ ' of the positive charged particle is half of the mass of the negative charged particle. The two charges are separated by a distance ' $l$ '. If the dipole is placed in a uniform electric field ' $E$ '; in such a way that dipole axis makes a very small angle with the electric field, ' $E$ '. The angular frequency of the oscillations of the dipole when released is given by :

- (1)  $\sqrt{\frac{4qE}{3ml}}$                       (2)  $\sqrt{\frac{8qE}{ml}}$                       (3)  $\sqrt{\frac{8qE}{3ml}}$                       (4)  $\sqrt{\frac{4qE}{ml}}$

Sol. (1)

In this case, since masses of both charges are not same, therefore, we need to find center of mass (COM), about which dipole will oscillate and then we will find moment of Inertia about this axis, to find torque & hence  $\omega$ .

As we know, COM will divide length in the inverse ratio of the masses, therefore, COM will be at a distance of

$$\frac{L}{3} \text{ from } 2m \text{ \& } \frac{2L}{3} \text{ from } m.$$

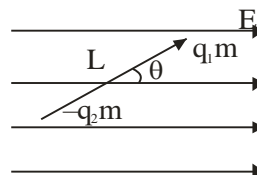
MI about this axis

$$I = 2m\left(\frac{L}{3}\right)^2 + \left(\frac{2L}{3}\right)^2$$

$$\text{Or } I = \frac{2mL^2}{9} + \frac{4mL^2}{9} = \frac{6mL^2}{9} = \frac{2mL^2}{3}$$

$$\text{Using } \omega = \frac{2mL^2}{3} \text{ \& } p = qL$$

$$\omega = \sqrt{\frac{qLE}{\frac{2mL^2}{3}}} = \sqrt{\frac{3qE}{2mL}}$$



None of these given option is correct. **(BONUS)**

36. Given below are two statements: one is labelled as Assertion A and the other is labelled as Reason R  
**Assertion A :** When you squeeze one end of a tube to get toothpaste out from the other end. Pascal's principle is observed.

**Reason R :** A change in the pressure applied to an enclosed incompressible fluid is transmitted undiminished to every portion of the fluid and to the walls of its container.

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

- (1) A is correct but R is not correct  
 (2) Both A and R are correct and R is the correct explanation of A  
 (3) A is not correct but R is correct  
 (4) Both A and R are correct but R is NOT the correct explanation of A

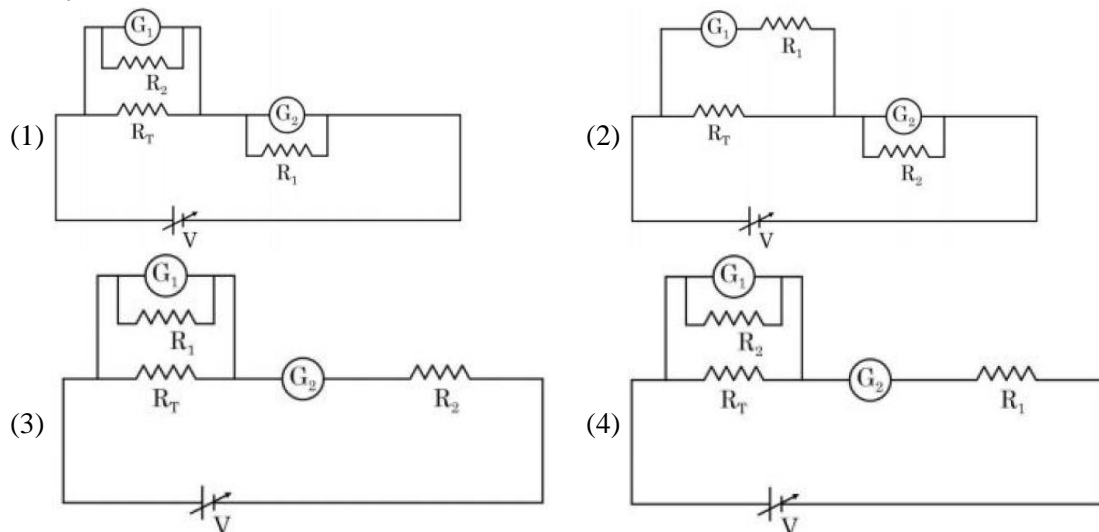
Sol. (2)

As per pascal's law, when we apply pressure to an ideal liquid it is equally distributed in the entire liquid and to the walls as well.

Since due to applied pressure, every morning, the tooth paste does not get compressed and we can safely consider it on incompressible liquid.

Therefore both statements are true and R is correct explanation of A.

37. A student is provided with a variable voltage source  $V$ , a test resistor  $R_T = 10\Omega$ , two identical galvanometers  $G_1$  and  $G_2$  and two additional resistors,  $R_1 = 10M\Omega$  and  $R_2 = 0.001\Omega$ . For conducting an experiment to verify ohm's law, the most suitable circuit is :



**Sol.** (2)

This question is based on the conceptual clarity that we should connect ammeter in series and voltmeter in parallel to measure current and potential difference, respectively

Also, when we use a galvanometer to create an ammeter, shunt resistance should be very small and should be in parallel.

When we create a voltmeter shunt should be large and in series with galvanometer.

All these criteria are satisfied in option (2)

38. A body cools in 7 minutes from  $60^\circ\text{C}$  to  $40^\circ\text{C}$ . The temperature of the surrounding is  $10^\circ\text{C}$ . The temperature of the body after the next 7 minutes

- (1)  $30^\circ\text{C}$  (2)  $34^\circ\text{C}$  (3)  $32^\circ\text{C}$  (4)  $28^\circ\text{C}$

**Sol.** (4)

### Method-1

Using exact law of cooling

$$T - T_s = (T_0 - T_s) e^{-Kt}$$

Case-I:  $(40 - 10) = (60 - 10) e^{-7K}$

$$30 = 50e^{-7K} \quad \dots(1)$$

Case-II:  $(T - 10) = (40 - 10) e^{-7K}$  or  $T - 10 = 30 e^{-7K}$

Dividing (2) by (1)

$$\frac{T - 10}{30} = \frac{30}{50}$$

$$\Rightarrow T - 10 = \frac{30 \times 30}{50} = 18$$

$$\text{or } T = 28^\circ\text{C}$$

### Method-2

Using newton's average law of cooling

$$\frac{T_i - T_f}{t} = k \left( \frac{T_i + T_f}{2} - T_s \right)$$

Case-I:-  $\frac{60 - 40}{7} = R \left[ \frac{60 + 40}{2} - 10 \right] \Rightarrow \frac{20}{7} = k [40] \quad \dots(i)$

Case-II:-  $\frac{40 - T}{7} = R \left[ \frac{40 + T}{2} - 10 \right] \quad \dots(2)$

Dividing (2) by (1)

$$\frac{40 - T}{20} = \frac{20 + T}{80}$$

$$160 - 4T = 20 + T$$

$$5T = 140$$

$$T = 28^\circ\text{C}$$

- 39.** The energy density associated with electric field  $\vec{E}$  and magnetic field  $\vec{B}$  of an electromagnetic wave in free space is given by ( $\epsilon_0$  – permittivity of free space,  $\mu_0$  – permeability of free space)

$$(1) U_E = \frac{\epsilon_0 E^2}{2}, U_B = \frac{B^2}{2\mu_0}$$

$$(2) U_E = \frac{E^2}{2\epsilon_0}, U_B = \frac{\mu_0 B^2}{2}$$

$$(3) U_E = \frac{E^2}{2\epsilon_0}, U_B = \frac{B^2}{2\mu_0}$$

$$(4) U_E = \frac{\epsilon_0 E^2}{2}, U_B = \frac{\mu_0 B^2}{2}$$

**Sol.** (1)  
By theory of electromagnetic waves

$$U_E = \frac{1}{2} \epsilon_0 E^2 \text{ and}$$

$$U_B = \frac{1}{2} \frac{B^2}{\mu_0}$$

- 40.** The weight of a body on the surface of the earth is 100 N. The gravitational force on it when taken at a height, from the surface of earth, equal to one-fourth the radius of the earth is :

$$(1) 64 \text{ N}$$

$$(2) 25 \text{ N}$$

$$(3) 100 \text{ N}$$

$$(4) 50 \text{ N}$$

**Sol.** (1)

using newton's formula  $F = \frac{GMm}{r^2}$

at surface of earth,  $100 = \frac{GM_e m}{R_e^2} \dots (1)$

at  $r = R_e + \frac{R_e}{4} = \frac{5}{4} R_e$

$$F' = \frac{GM_e m}{\left(\frac{5}{4} R_e\right)^2} = \frac{16}{25} \times \frac{GM_e m}{R_e^2}$$

$$F' = \frac{16}{25} \times 100 = 64 \text{ N}$$

- 41.** A capacitor of capacitance  $150.0 \mu\text{F}$  is connected to an alternating source of emf given by  $E = 36 \sin(120\pi t) \text{ V}$ . The maximum value of current in the circuit is approximatively equal to :

$$(1) \sqrt{2} \text{ A}$$

$$(2) 2\sqrt{2} \text{ A}$$

$$(3) \frac{1}{\sqrt{2}} \text{ A}$$

$$(4) 2 \text{ A}$$

**Sol.** (4)

Given alternating AC source  $E = 36 \sin(120\pi t) \text{ v}$  & capacitor  $C = 150 \mu\text{F}$

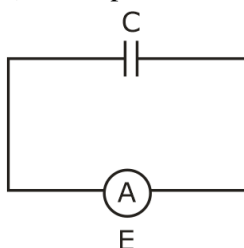
using  $Q = CV$

we can write  $Q = (CE_0 \sin \omega t)$

$$\text{Current } i = \frac{dQ}{dt} = (CE_0 \omega \cos \omega t)$$

max. value of current  $i_0 = CE_0 \omega$

$$\text{or } i_0 = 150 \times 10^{-6} \times 36 \times 120\pi = 2.03 \text{ A}$$



42. A 2 meter long scale with least count of 0.2 cm is used to measure the locations of objects on an optical bench. While measuring the focal length of a convex lens, the object pin and the convex lens are placed at 80 cm mark and 1 m mark., respectively. The image of the object pin on the other side of lens coincides with image pin that is kept at 180 cm mark. The % error in the estimation of focal length is :

(1) 0.51 (2) 1.02 (3) 0.85 (4) 1.70

Sol. (4)

Based on the data provided

$$U = 100 - 80 = 20 \text{ cm}$$

$$V = 180 - 100 = 80 \text{ cm}$$

$$\text{Using } \frac{1}{f} = \frac{1}{v} + \frac{1}{u} \text{ or } f = \frac{uv}{u+v} = \frac{20 \times 80}{20+80} \text{ or } f = 16 \text{ cm}$$

For error analysis,

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

Differentiating

$$-\frac{Df}{f^2} = -\frac{Dv}{v^2} - \frac{\Delta u}{u^2}$$

To calculate  $\Delta u$  &  $\Delta v$

$$U = (100 \pm 2) - (80 \pm 0.2) = (20 \pm 0.4) \text{ cm}$$

Therefore  $\Delta u = 0.4 \text{ cm}$ ,

Similarly  $\Delta v = 0.4 \text{ cm}$ .

$$\text{Now } \frac{\Delta f}{f} = f \left[ \frac{\Delta v}{v^2} + \frac{\Delta u}{u^2} \right]$$

$$\frac{\Delta f}{f} = 16 \left[ \frac{0.4}{(80)^2} + \frac{0.4}{(20)^2} \right]$$

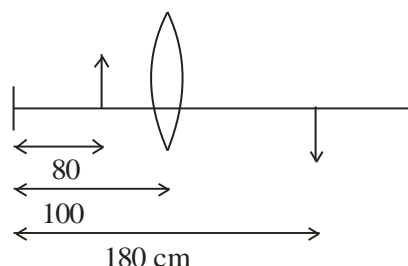
(Note: every data is in cm)

$$\frac{\Delta f}{f} = \frac{16 \times 0.4}{(20)^2} \left[ \frac{1}{4^2} + 1 \right]$$

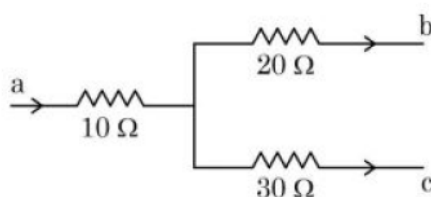
$$= \frac{16 \times 0.4}{20^2} \times \frac{17}{16} = \frac{17 \times 0.4}{400}$$

$$\% \text{ Error : } \frac{\Delta f}{f} \times 100 = \frac{17 \times 0.4}{400} \times 1000$$

$$= 1.7$$



43. Figure shows a part of an electric circuit. The potentials at points a, b and c are 30 V, 12 V and 2 V respectively. The current through the 20  $\Omega$  resistor will be



(1) 1.0 A (2) 0.2 A (3) 0.4 A (4) 0.6 A

Sol. (3)

Let potential of the junction be x volts

using junction law  $i_1 + i_2 + i_3 = 0$

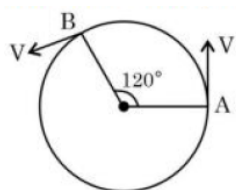
$$\text{or } \frac{x-30}{10} + \frac{x-12}{20} + \frac{x-2}{30} = 0$$





**Sol. (1)**  
 Given,  $m = 5\text{ kg}$ ,  $R = 2\text{ m}$   
 time  $t$  for 1 rev = 3.14 sec or  $\pi$  sec  
 $\theta$  for 1 rev =  $2\pi$  rad  
 Therefore  $\omega = \frac{\theta}{t} = \frac{2\pi}{\pi} = 2\text{ rad/s}$   
 centrifugal force  $F = mR\omega^2$   
 or  $F = 5 \times 2 \times 2^2 = 40\text{ N}$

**48.** As shown in the figure, a particle is moving with constant speed  $\pi\text{ m/s}$ . Considering its motion from A to B, the magnitude of the average velocity is :



- (1)  $\pi\text{ m/s}$                       (2)  $2\sqrt{3}\text{ m/s}$                       (3)  $\sqrt{3}\text{ m/s}$                       (4)  $1.5\sqrt{3}\text{ m/s}$

**Sol. (4)**  
 Given speed  $v = \pi\text{ m/s}$   
 or  $R\omega = \pi$   
 or  $\omega = \frac{\pi}{R}\text{ rad/s}$   
 angular displacement  $\theta = 120^\circ$  or  $\frac{2\pi}{3}$   
 using  $\theta = \omega t$   
 $t = \frac{\theta}{\omega} = \frac{2\pi/3}{\pi/R} = \frac{2R}{3}$   
 linear displacement  $d = 2R \sin(\theta/2)$   
 $d = 2R \sin\left(\frac{120}{2}\right)$   
 $= 2R \times \sin 60 = 2R \times \frac{\sqrt{3}}{2}$   
 $= R\sqrt{3}$   
 average velocity =  $\frac{d}{t} = \frac{R\sqrt{3}}{2R/3} = \frac{3\sqrt{3}}{2}$

**49.** The work functions of Aluminium and Gold are 4.1 eV and 5.1 eV respectively. The ratio of the slope of the stopping potential versus frequency plot for Gold to that of Aluminium is

- (1) 1                      (2) 2                      (3) 1.24                      (4) 1.5

**Sol. (1)**  
 Using  $KE_{\max} = eV_s = hf - \phi_0$   
 where  $\phi_0$  is work function,  $V_s$  is stopping potential and  $f$  is frequency  
 or  $V_s = \frac{h}{e}f - \frac{\phi_0}{e}$   
 therefore the slope  $m$  will be same for all graphs and will be independent of  $\phi_0$ .

50. A particle starts with an initial velocity of  $10.0 \text{ ms}^{-1}$  along x-direction and accelerates uniformly at the rate of  $2.0 \text{ ms}^{-2}$ . The time taken by the particle to reach the velocity of  $60.0 \text{ ms}^{-1}$  is \_\_\_\_\_.  
 (1) 3s (2) 6s (3) 25s (4) 30s

Sol. (3)  
 Using 1<sup>st</sup> equation of motion

$$t = \frac{v - u}{a}$$

$$t = \frac{60 - 10}{2} = \frac{50}{2} = 25 \text{ sec}$$

### SECTION - B

51. A simple pendulum with length 100 cm and bob of mass 250 g is executing S.H.M. of amplitude 10 cm. The maximum tension in the string is found to be  $\frac{x}{40} \text{ N}$ . The value of x is \_\_\_\_\_.

Sol. (99)

For pendulum

$$T_{\max} = mg + \frac{mv^2}{L} \quad \dots(1)$$

$$\text{Given } m = \frac{1}{4} \text{ kg, } L = 1 \text{ m, } g = 9.8 \text{ m/s}^2$$

$$\text{and amplitude } A = \frac{1}{10} \text{ m}$$

$$\text{For SHM, } KE_{\max} = \frac{1}{2} mv^2 = \frac{1}{2} m\omega^2 A^2$$

$$\text{using } \omega = \sqrt{\frac{g}{L}}$$

$$mv^2 = m \left( \sqrt{\frac{g}{L}} \right)^2 A^2 = \frac{mgA^2}{L} \quad \dots(2)$$

using (2) in (1)

$$T_{\max} = 2mg + \frac{mgA^2}{L^2}$$

$$= mg \left[ 1 + \frac{1}{10^2} \right] = \frac{1}{4} \times 9.8 \times \frac{101}{100}$$

$$\text{or } T_{\max} = \frac{98.98}{40}$$

Therefore x = 99

52. Experimentally it is found that 12.8 eV energy is required to separate a hydrogen atom into a proton and an electron. So the orbital radius of the electron in a hydrogen atom is  $\frac{9}{x} \times 10^{-10} \text{ m}$ . The value of the x is : \_\_\_\_\_.

$$(1 \text{ eV} = 1.6 \times 10^{-19} \text{ J, } \frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \text{ Nm}^2 / \text{C}^2 \text{ and electronic charge} = 1.6 \times 10^{-19} \text{ C})$$

**Sol. (16)**

$$\text{Using } E = \frac{ke^2}{2r}$$

$$r = \frac{Re^2}{2E}$$

$$\text{Given } E = 12.8 \text{ eV} = 12.8 \times e \text{ Joule}$$

$$r = \frac{9 \times 10^9 e^2}{2 \times 12.8e} = \frac{9 \times 10^9 \times 1.6 \times 10^{-19}}{2 \times 12.8}$$

$$r = \frac{9 \times 10^{-10}}{(2 \times 12.8 / 1.6)} = \frac{9 \times 10^{-10}}{10} \text{ m}$$

Therefore  $x = 16$

- 53.** A beam of light consisting of two wavelengths  $7000 \text{ \AA}$  and  $5500 \text{ \AA}$  is used to obtain interference pattern in Young's double slit experiment. The distance between the slits is  $2.5 \text{ mm}$  and the distance between the place of slits and the screen is  $150 \text{ cm}$ . The least distance from the central fringe, where the bright fringes due to both the wavelengths coincide, is  $n \times 10^{-5} \text{ m}$ . The value of  $n$  is \_\_\_\_\_.

**Sol. (462)**

Let  $n_1$  maxima of  $7000 \text{ \AA}$  coincides with  $n_2$  maxima of  $5500 \text{ \AA}$

therefore  $n_1 \beta_1 = n_2 \beta_2$

$$\text{or } \frac{n_1}{n_2} = \frac{\lambda_2}{\lambda_1} = \frac{5500}{7000} = \frac{11}{14}$$

therefore  $11^{\text{th}}$  maxima of  $7000 \text{ \AA}$  will coincide with  $14^{\text{th}}$  maximum of  $5500 \text{ \AA}$

To find the least distance of this

$$y = n_1 \beta_1$$

$$\text{or } y = \frac{n_1 \lambda_1 D}{d} = \frac{11 \times 7000 \times 10^{-10} \times 150 \times 10^{-2}}{2.5 \times 10^{-3}}$$

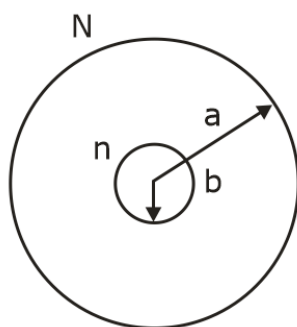
$$= \frac{11 \times 7 \times 5}{2.5} \times 10^{-5} \text{ m}$$

$$\text{or } y = 462 \times 10^{-5} \text{ m}$$

therefore  $n = 462$

- 54.** Two concentric circular coils with radii  $1 \text{ cm}$  and  $1000 \text{ cm}$ , and number of turns  $10$  and  $200$  respectively are placed coaxially with centers coinciding. The mutual inductance of this arrangement will be \_\_\_\_\_  $\times 10^{-8} \text{ H}$ . (Take,  $\pi^2 = 10$ )

**Sol. (4)**



Given

$$a = 1000 \text{ cm}$$

$$b = 1 \text{ cm}$$

$$\text{or } b \ll a$$

we will take larger coil as primary

$$B = \frac{\mu_0 i_p N}{2a}$$

$$\text{flux } \phi_s = BA = \frac{\mu_0 i_p N}{2a} \times \pi b^2 \times n$$

$$\text{Mutual inductance } M = \frac{\phi_s}{i_p}$$

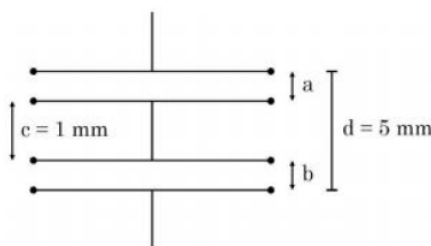
$$M = \frac{\mu_0 N n \pi b^2}{2 \times a}$$

$$\text{or } M = \frac{4\pi \times 10^{-7} \times 200 \times 10 \times \pi \times 1 \times 10^{-4}}{2 \times 1000 \times 10^{-2}}$$

$$= 4\pi^2 \times 10^{-9}$$

$$\text{or } M = 4 \times 10^{-8} \text{ (using } \pi^2 = 10)$$

55. As shown in the figure, two parallel plate capacitors having equal plate area of  $200 \text{ cm}^2$  are joined in such a way that  $a \neq b$ . The equivalent capacitance of the combination is  $x \epsilon_0 \text{ F}$ . The value of  $x$  is \_\_\_\_\_.



Sol. (5)

As per the arrangement given, distance between the capacitor plates are  $a$  and  $b$  and  $a \neq b$  using the diagram we can write

$$b = 5 - a - 1 = (4 - a) \text{ in mm}$$

$$\text{as we know capacitance of capacitor } C = \frac{\epsilon_0 A}{d}$$

and in series arrangement

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$$

$$\frac{1}{C_{eq}} = \frac{a}{\epsilon_0 A} + \frac{4-a}{\epsilon_0 A} = \frac{4(\text{in mm})}{\epsilon_0 A}$$

$$\text{or } C_{eq} = \frac{\epsilon_0 A}{4(\text{mm})}$$

$$\text{Given } A = 200 \text{ cm}^2$$

$$C_{eq} = \frac{\epsilon_0 \times 200 \times 10^{-4}}{4 \times 10^{-3}}$$

$$= \epsilon_0 50 \times 10^{-1}$$

$$\text{or } C_{eq} = 5\epsilon_0 \text{ farad}$$

$$\text{therefore } n = 5$$

56. A proton with a kinetic energy of  $2.0 \text{ eV}$  moves into a region of uniform magnetic field of magnitude  $\frac{\pi}{2} \times 10^{-3} \text{ T}$ .

The angle between the direction of magnetic field and velocity of proton is  $60^\circ$ . The pitch of the helical path taken by the proton is \_\_\_\_\_ cm.

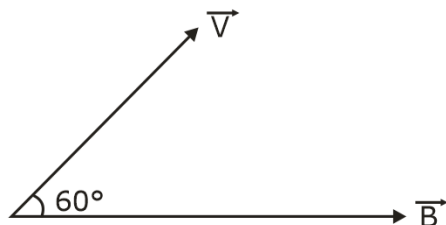
(Take, mass of proton =  $1.6 \times 10^{-27} \text{ kg}$  and Charge on proton =  $1.6 \times 10^{-19} \text{ C}$ ).

**Sol. (40)**

$$B = \frac{\pi}{2} \times 10^{-3}$$

$$\text{K.E.} = \frac{1}{2} mV^2$$

$$\Rightarrow V = \sqrt{\frac{2KE}{m}}$$



Pitch =  $v \cos 60^\circ \times$  time period of one rotation

$$= v \cos 60^\circ \times \frac{2\pi m}{eB}$$

$$= \sqrt{\frac{2 \times 2 \times 1.6 \times 10^{-9}}{1.6 \times 10^{-27}}} \times \cos 60^\circ \times \frac{2\pi \times 1.6 \times 10^{-27}}{1.6 \times 10^{-19} \times \frac{\pi}{2} \times 10^{-3}}$$

$$= 2 \times 10^4 \times \frac{1}{2} \times 4 \times 10^{-5}$$

$$= 4 \times 10^{-1} \text{ m} = 40 \text{ cm}$$

- 57.** A body is dropped on ground from a height ' $h_1$ ' and after hitting the ground, it rebounds to a height ' $h_2$ '. If the ratio of velocities of the body just before and after hitting ground is 4, then percentage loss in kinetic energy of the body is  $\frac{x}{4}$ . The value of  $x$  is \_\_\_\_\_.

**Sol. (375)**

Let  $u$  and  $v$  be speeds, just before and after body strikes the ground.

$$\text{Given } \frac{u}{v} = \frac{4}{1}$$

$$\text{loss in KE: } \Delta KE = \frac{\frac{1}{2} mu^2 - \frac{1}{2} mv^2}{\frac{1}{2} mu^2}$$

$$\Delta KE = 1 - \left(\frac{v}{u}\right)^2 = 1 - \frac{1}{16} = \frac{15}{16}$$

$$\text{Percentage loss} = \frac{15}{16} \times 100 = 375$$

- 58.** A ring and a solid sphere rotating about an axis passing through their centers have same radii of gyration. The axis of rotation is perpendicular to plane of ring. The ratio of radius of ring to that of sphere is  $\sqrt{\frac{2}{x}}$ . The value of  $x$  is \_\_\_\_\_.



**Sol. (5)**

Given radius of gyration is same for ring and solid sphere

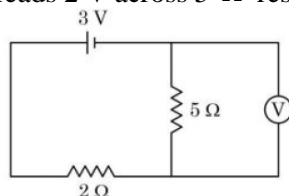
$$K_R = K_{ss}$$

$$R_R = \sqrt{\frac{2}{5}} R_{ss}$$

$$\text{or } \frac{R_R}{R_{ss}} = \sqrt{\frac{2}{5}}$$

therefore  $x = 5$

**59.** As shown in the figure, the voltmeter reads 2 V across  $5\ \Omega$  resistor. The resistance of the voltmeter is  $\_\_\_\ \Omega$ .



**Sol. (20)**

**Method-I:**

$$R_{eq} = 2 + \frac{5R}{5+R} = \frac{10+7R}{5+R}$$

$$i = \frac{3}{R_{eq}} = \frac{3(5+R)}{10+7R}$$

$$i_1 = \frac{2}{5}, i_2 = \frac{2}{R}$$

$$i = i_1 + i_2$$

$$\frac{3(5+R)}{10+7R} = \frac{2}{5} + \frac{2}{R} = \frac{2(5+R)}{5R}$$

$$15R(5+R) = 2(5+R)(10+7R)$$

$$75R + 15R^2 = 2(50 + 35R + 10R + 7R^2)$$

$$15R^2 + 75R = 14R^2 + 90R + 100$$

$$R^2 - 15R - 100 = 0$$

$$R = \frac{15 \pm \sqrt{225 + 400}}{2}$$

$$= \frac{15 \pm \sqrt{625}}{2} = \frac{15 \pm 25}{2}$$

$$R = 20\ \Omega$$

**Method-II:**

Given potential across  $5\Omega$  and voltmeter is 2V. To find resistance R of voltmeter.

Let current in  $5\Omega$  be  $i_1$ , and in R  $i_2$ .

$$i_1 = \frac{2}{5} \text{ and } i_2 = \frac{2}{R}$$

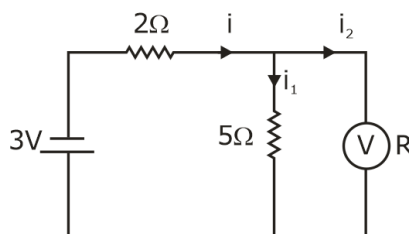
V across  $2\Omega$  will be 1 volt and  $i = \frac{1}{2}$  A.

Using junction law:  $i = i_1 + i_2$

$$\frac{1}{2} = \frac{2}{5} + \frac{2}{R}$$

$$\frac{2}{R} = \frac{1}{2} - \frac{2}{5} = \frac{1}{10}$$

$$R = 20\Omega$$



- 60.** A metal block of mass  $m$  is suspended from a rigid support through a metal wire of diameter 14 mm. The tensile stress developed in the wire under equilibrium state is  $7 \times 10^5 \text{ Nm}^{-2}$ . The value of mass  $m$  is \_\_\_\_\_ kg.

(Take,  $g = 9.8 \text{ ms}^{-2}$  and  $\pi = \frac{22}{7}$ )

**Sol.** 11

$$\text{Using stress} = \frac{\text{force}}{\text{area}} = \frac{mg}{A}$$

$$\Rightarrow m = \frac{S \times A}{g} = \frac{7 \times 10^5 \times \pi R^2}{g}$$

$$= \frac{7 \times 10^5 \times \frac{22}{7} \times (7 \times 10^{-3})^2}{9.8} \quad (\text{Note: 14 mm is diameter})$$

$$= 11 \text{ kg}$$

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