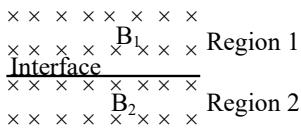




29. Uniform magnetic fields of different strengths ( $B_1$  and  $B_2$ ), both normal to the plane of the paper exist as shown in the figure. A charged particle of mass  $m$  and charge  $q$ , at the interface at an instant, moves into the region 2 with velocity  $v$  and returns to the interface. It continues to move into region 1 and finally reaches the interface. What is the displacement of the particle during this movement along the interface ?



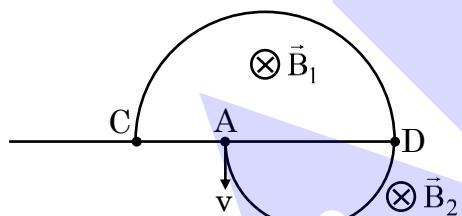
(Consider the velocity of the particle to be normal to the magnetic field and  $B_2 > B_1$ )

- (1)  $\frac{mv}{qB_1} \left(1 - \frac{B_2}{B_1}\right) \times 2$     (2)  $\frac{mv}{qB_1} \left(1 - \frac{B_1}{B_2}\right)$   
 (3)  $\frac{mv}{qB_1} \left(1 - \frac{B_2}{B_1}\right)$     (4)  $\frac{mv}{qB_1} \left(1 - \frac{B_1}{B_2}\right) \times 2$

**Ans. (4)**

**Sol.** As  $\vec{v}$  is  $\perp$  to  $\vec{B}$ , so charge particle will move in circular path, whose radius is given by

$$R = \frac{mv}{qB}$$



Starting point → A

Ending point → C

∴ Net displacement = AC

$$AC = CD - AD$$

$$AC = \frac{2mv}{qB_1} - \frac{2mv}{qB_2}$$

$$AC = \frac{2mv}{qB_1} \left[ 1 - \frac{B_1}{B_2} \right]$$

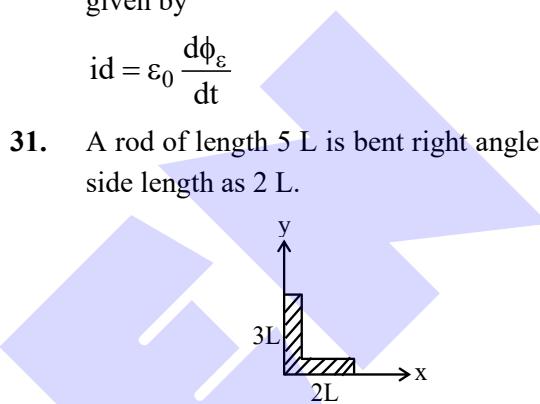


**Ans. (4)**

**Sol.** We know that formula for displacement current is given by

$$\text{id} = \varepsilon_0 \frac{d\phi_\varepsilon}{dt}$$

- 31.** A rod of length  $5 L$  is bent right angle keeping one side length as  $2 L$ .

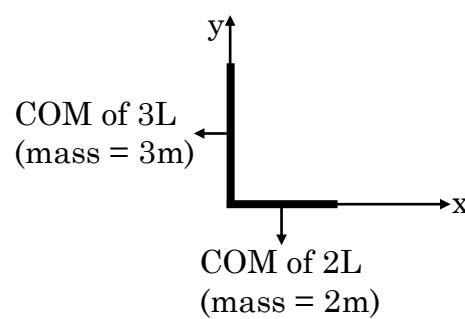


The position of the centre of mass of the system:  
(Consider L = 10 cm)

- (1)  $2\hat{i} + 3\hat{j}$       (2)  $3\hat{i} + 7\hat{j}$   
(3)  $5\hat{i} + 8\hat{j}$       (4)  $4\hat{i} + 9\hat{j}$

**Ans. (4)**

Sol.



$$x_{com} = \frac{2m(10) + 3m(0)}{5m} = 4\text{cm}$$

$$y_{com} = \frac{2m(0) + 3m(15)}{5m} = 9\text{cm}$$

$$\vec{r}_{\text{com}} = 4\hat{i} + 9\hat{j}$$



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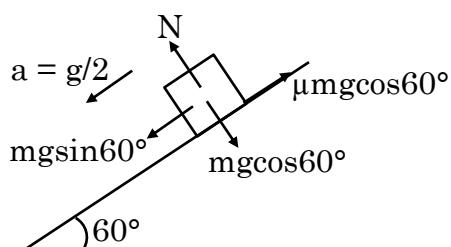


39. A cubic block of mass  $m$  is sliding down on an inclined plane at  $60^\circ$  with an acceleration of  $\frac{g}{2}$ , the value of coefficient of kinetic friction is

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

**Ans.** (1)

**Sol.**



$$mgsin60^\circ - \mu mgcos60^\circ = ma$$

$$g \sin 60 - \mu g \cos 60 = \frac{g}{2}$$

$$\frac{\sqrt{3}}{2} - \frac{\mu}{2} = \frac{1}{2}$$

$$\mu = \sqrt{3} - 1$$

40. In a hydrogen like ion, the energy difference between the 2<sup>nd</sup> excitation energy state and ground is 108.8 eV. The atomic number of the ion is  
 (1) 4      (2) 2      (3) 1      (4) 3

**Allen Ans.** (4)

**NTA Ans.** (2)

$$\text{Sol. } \Delta E = 13.6z^2 \left[ \frac{1}{n_1^2} - \frac{1}{n_2^2} \right]$$

$$(13.6)z^2 \left[ \frac{1}{1} - \frac{1}{9} \right] = 108.8$$

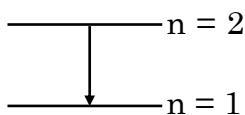
$$\frac{(13.6)(8)}{9} (z^2) = 108.8$$

$$z = 3$$

41. For a hydrogen atom, the ratio of the largest wavelength of Lyman series to that of the Balmer series is.  
 (1) 5 : 36      (2) 5 : 27  
 (3) 3 : 4      (4) 27 : 5

**Ans.** (2)

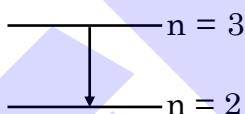
**Sol.** **Lyman**



$$\frac{1}{\lambda_1} = R \left[ \frac{1}{1} - \frac{1}{4} \right] = \frac{3R}{4}$$

$$\lambda_1 = \frac{4}{3R} \quad \dots(1)$$

and **Balmer**

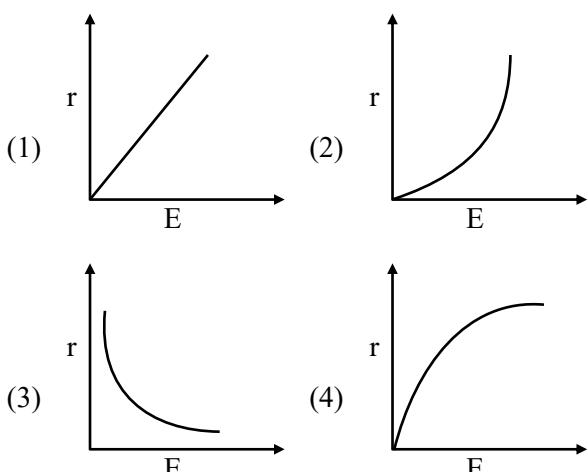


$$\frac{1}{\lambda_2} = R \left[ \frac{1}{4} - \frac{1}{9} \right] = \frac{5R}{36}$$

$$\lambda_2 = \frac{36}{5R}$$

$$\text{Then, } \frac{\lambda_1}{\lambda_2} = \frac{5}{27}$$

42. A particle of charge  $q$ , mass  $m$  and kinetic energy  $E$  enters in magnetic field perpendicular to its velocity and undergoes a circular arc of radius( $r$ ). Which of the following curves represents the variation of  $r$  with  $E$ ?



**Ans.** (4)



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Sol.

$$\frac{mv^2}{r} = qvB$$

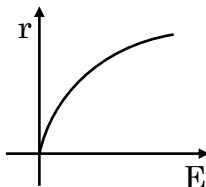
$$mv = qBr$$

$$E = \frac{1}{2}mv^2$$

$$E = \frac{1}{2}m\left(\frac{q^2B^2r^2}{m^2}\right) = \frac{q^2B^2r^2}{2m}$$

$$E = \left(\frac{q^2B^2}{2m}\right)r^2$$

$$r^2 \propto E$$



43. An object of mass 1000 g experiences a time dependent force  $\vec{F} = (2t\hat{i} + 3t^2\hat{j})N$ . The power generated by the force at time t is :
- (1)  $(2t^2 + 3t^3)W$       (2)  $(2t^2 + 18t^3)W$   
 (3)  $(3t^3 + 5t^5)W$       (4)  $(2t^3 + 3t^5)W$

Ans. (4)

Sol.  $\vec{F} = (2t\hat{i} + 3t^2\hat{j})N$

$$m = 1000 \text{ gm} = 1 \text{ kg}$$

$$\vec{F} = m\vec{a}, \vec{a} = 2t\hat{i} + 3t^2\hat{j}$$

$$\frac{d\vec{v}}{dt} = 2t\hat{i} + 3t^2\hat{j}$$

$$\vec{v} = t^2\hat{i} + t^3\hat{j}$$

$$\text{Power, } P = \vec{F} \cdot \vec{v}$$

$$P = (2t\hat{i} + 3t^2\hat{j}) \cdot (t^2\hat{i} + t^3\hat{j})$$

$$P = (2t^3 + 3t^5)W$$

44. Two wires A and B are made of same material having ratio of lengths  $\frac{L_A}{L_B} = \frac{1}{3}$  and their diameters ratio  $\frac{d_A}{d_B} = 2$ . If both the wires are stretched using same force, what would be the ratio of their respective elongations?
- (1) 1 : 6      (2) 1 : 12  
 (3) 3 : 4      (4) 1 : 3

Ans. (2)

Sol.  $\frac{L_A}{L_B} = \frac{1}{3}$  and  $\frac{d_A}{d_B} = 2$

$$\Delta L_A = \frac{F_A L_A}{A_A Y_A} \text{ and } \Delta L_B = \frac{F_B L_B}{A_B Y_B}$$

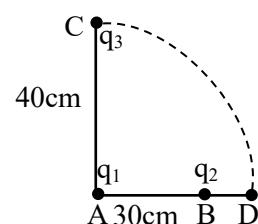
$$\text{Given, } F_A = F_B \text{ and } Y_A = Y_B$$

$$\frac{\Delta L_A}{\Delta L_B} = \frac{\frac{F_A L_A}{A_A Y_A}}{\frac{F_B L_B}{A_B Y_B}} = \left(\frac{L_A}{L_B}\right) \left(\frac{A_B}{A_A}\right)$$

$$\frac{\Delta L_A}{\Delta L_B} = \left(\frac{L_A}{L_B}\right) \left(\frac{\frac{\pi}{4} d_B^2}{\frac{\pi}{4} d_A^2}\right) = \left(\frac{L_A}{L_B}\right) \left(\frac{d_B}{d_A}\right)^2$$

$$\frac{\Delta L_A}{\Delta L_B} = \left(\frac{1}{3}\right) \left(\frac{1}{2}\right)^2 = \frac{1}{12}$$

45. Two charges  $q_1$  and  $q_2$  are separated by a distance of 30 cm. A third charge  $q_3$  initially at 'C' as shown in the figure, is moved along the circular path of radius 40 cm from C to D. If the difference in potential energy due to movement of  $q_3$  from C to D is given by  $\frac{q_3 K}{4\pi \epsilon_0}$ , the value of K is :



- (1)  $8q_2$       (2)  $6q_2$   
 (3)  $8q_1$       (4)  $6q_1$

Ans. (1)



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**Sol.** Potential at C

$$V_C = \frac{kq_1}{0.4} + \frac{kq_2}{0.5}$$

Potential at D

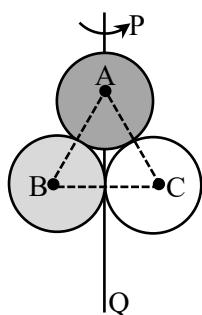
$$V_D = \frac{kq_1}{0.4} + \frac{kq_2}{0.1}$$

$$\Delta U = (V_D - V_C)(q_3) = \left( \frac{kq_2}{0.1} - \frac{kq_2}{0.5} \right)(q_3)$$

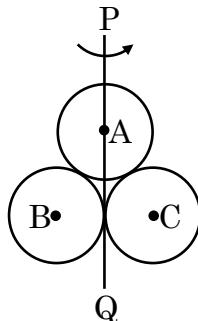
$$\Delta U = 8kq_2q_3 = \frac{8q_2q_3}{4\pi\epsilon_0}$$

### SECTION-B

46. A, B and C are disc, solid sphere and spherical shell respectively with same radii and masses. These masses are placed as shown in figure.



The moment of inertia of the given system about PQ is  $\frac{x}{15}I$ , where I is the moment of inertia of the disc about its diameter. The value of x is \_\_\_\_\_.  
**Ans. (199)**



**Sol.**

All bodies have same mass and same radius.

A → Disc

B → Solid sphere

C → Spherical shell

$$\text{and, } I = \frac{MR^2}{4}$$

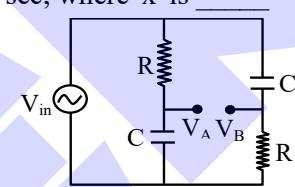
$$I_{PQ} = \frac{MR^2}{4} + \left( \frac{2}{5}MR^2 + MR^2 \right) + \left( \frac{2}{3}MR^2 + MR^2 \right)$$

$$I_{PQ} = \frac{15MR^2 + 24MR^2 + 60MR^2 + 40MR^2 + 60MR^2}{60}$$

$$I_{PQ} = \frac{199}{60}MR^2 = \frac{199}{15}\left(\frac{MR^2}{4}\right)$$

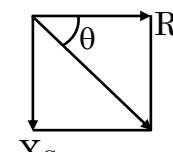
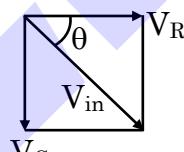
$$= \frac{199}{15}I$$

47. For ac circuit shown in figure, R = 100 kΩ and C = 100 pF and the phase difference between  $V_{in}$  and  $(V_B - V_A)$  is  $90^\circ$ . The input signal frequency is  $10^x$  rad/sec, where 'x' is \_\_\_\_\_

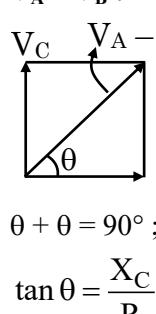


**Ans. (5)**

**Sol.** Input voltage



$V_A - V_B$  :



$$X_C = R \Rightarrow \frac{1}{W_C} = R$$

$$W = \frac{1}{R_C} = \frac{1}{100 \times 10^3 \times 100 \times 10^{-12}} \\ = \frac{10^{12}}{10^7} = 10^5$$



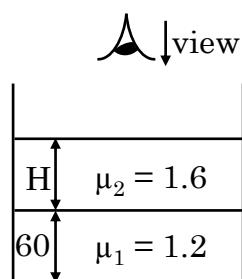
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48. A container contains a liquid with refractive index of 1.2 up to a height of 60 cm and another liquid having refractive index 1.6 is added to height H above first liquid. If viewed from above, the apparent shift in the position of bottom of container is 40 cm. The value of H is \_\_\_\_ cm.  
(Consider liquids are immisible)

**Ans. (80)**

**Sol.**



y = apparent depth of bottom

$$\frac{y}{1} = \frac{H}{1.6} + \frac{60}{1.2}$$

Shift = 40

$$H + 60 - y = 40$$

$$H + 60 - \frac{H}{1.6} - \frac{60}{1.2} = 40$$

$$\frac{6}{16}H = 30$$

$$H = 80 \text{ cm}$$

49. A wire of length 10 cm and diameter 0.5 mm is used in a bulb. The temperature of the wire is  $1727^{\circ}\text{C}$  and power radiated by the wire is 94.2 W.

Its emissivity is  $\frac{x}{8}$  where  $x = \underline{\hspace{2cm}}$

(Given  $\sigma = 6.0 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$ ,  $\pi = 3.14$  and assume that the emissivity of wire material is same at all wavelength.)

**Ans. (5)**

**Sol.**  $L = 10 \text{ cm}$ ,  $d = 0.5 \text{ mm}$ ,  $T = 1727^{\circ}\text{C} = 2000 \text{ K}$

Power,  $P = 94.2 \text{ W}$

$$P = \epsilon \sigma A T^4$$

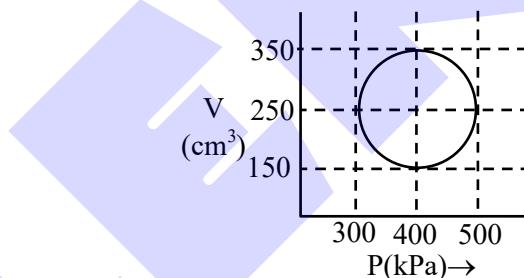
$$94.2 = \epsilon \times (6 \times 10^{-8})(\pi d L)(2000)^4$$

$$94.2 = \epsilon \times (6 \times 10^{-8}) (3.14) (0.5) (10^{-3}) (10 \times 10^{-2}) (2000)^4$$

$$\epsilon = \frac{94.2}{(94.2)(16)} = \frac{5}{8}$$

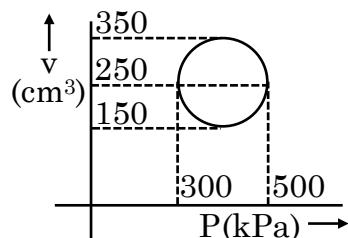
50. An ideal gas has undergone through the cyclic process as shown in the figure. Work done by the gas in the entire cycle is \_\_\_\_  $\times 10^{-1} \text{ J}$ .

(Take  $\pi = 3.14$ )



**Ans. (314)**

**Sol.**



$$\text{Area of circle, } W = \frac{\pi}{4} d_1 d_2$$

$$W = \frac{\pi}{4} (500 - 300) \times 10^3 (350 - 150) \times 10^{-6}$$

$$W = 31.4 \text{ Joule}$$

$$W = 314 \times 10^{-1} \text{ Joule}$$



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