DPP –3 (EMI)

Video Solution on Website :- https://physicsaholics.com/home/courseDetails/104

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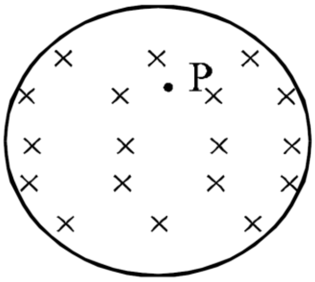
Q 1. Figure shows a uniform magnetic field B confined to a cylindrical volume and is increasing at a constant rate. The instantaneous acceleration experienced by an electron placed at P is



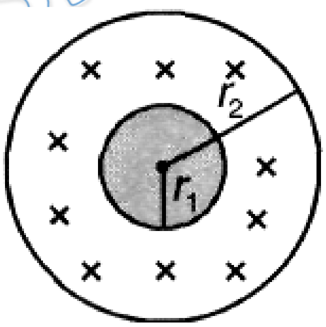
(a) zero
(b) towards right
(c) towards left
(d) upwards

Q 2. Consider cylindrical region of the magnetic field shown in the figure. Region I and II have fields directed perpendicularly outward and inward respectively. Fields are varying with time as

Region I : B = $3B_0$t

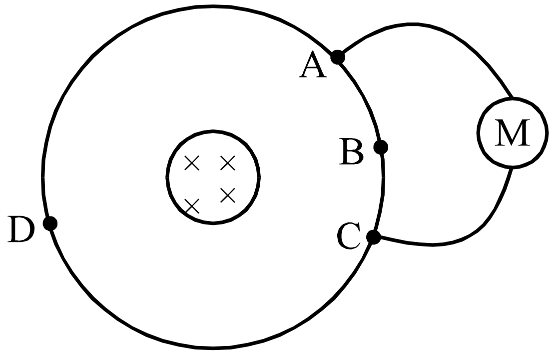
Region II : B = B_0 t

such that there is no net induced electric field in the region r > r_2 , find $\frac{r_1}{r_2}$?



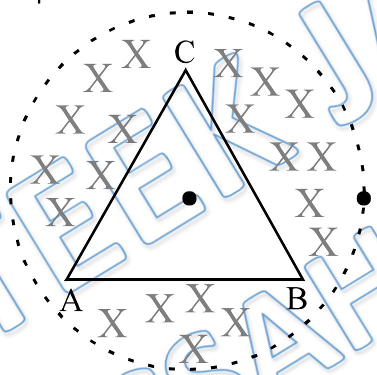
(a) 0.5 (b) 0.6 (c) 0.8 (d) 0.2

Q 3. A variable magnetic field creates a constant emf 11 V in a conductor ABCDA. The resistances of portion ABC, CDA and AMC are 1 ohm, 2 ohm and 3 ohm respectively. What current will be shown by meter M? The magnetic field is concentrated near the axis of the circular conductor.



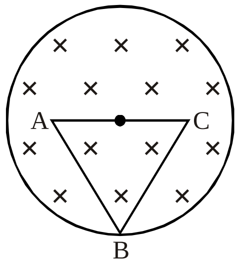
(a) 1 A (b) 2 A (c) 3 A (d) 4A

Q 4. A triangular wire frame (each side = 2m) is placed in a region of time variant magnetic field having dB/dt = $\sqrt{3}$T/s. The magnetic field is perpendicular to the plane of the triangle. The base of the triangle AB has a resistance 1 ohm while the other two sides have resistance 2 ohm each. The magnitude of potential difference between the points A and B will be



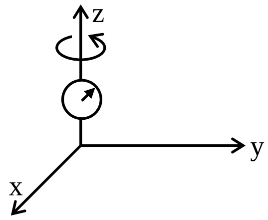
(a) Zero
(b) .2 V
(c) .4 V
(d) .6 V

Q 5. An equilateral triangle ABC of side a is placed in the magnetic field with side AC and its centre coinciding with the centre of the magnetic field. The magnetic field varies with time as B = kt. The emf induced across side AB is



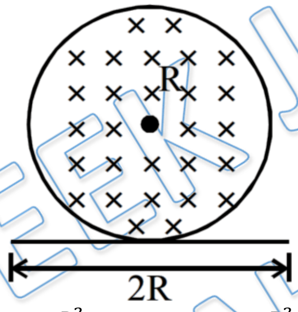
(a) $\frac{\sqrt{3}}{4}a^2k$ (b) Zero (c) $\frac{\sqrt{3}}{8}a^2k$ (d) $\frac{(\sqrt{2}-1)}{2}a^2k$

Q 6. A circular loop of wire of radius r rotates about z-axis with angular velocity w. The normal to the loop is always perpendicular to z axis. At t =0 , normal parallel to y axis. An external magnetic field$\vec{B}$= By$\hat{j}$ + Bz$\hat{k}$ is applied. The EMF induced in the loop at time 't' -



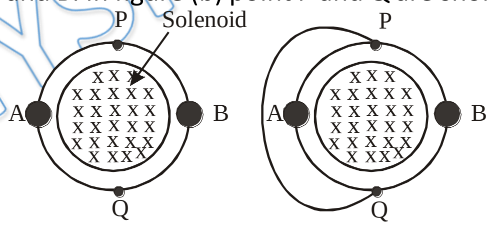
(a) πr_2 ω By sin ωt (b) πr_2 ω Bz cos ωt
(c) πr_2 ω Bz sin ωt (d) πr_2 ω By cos ωt

Q 7. A uniform but time varying magnetic field is present in a circular region of radius R. The magnetic field is perpendicular and into the plane of the loop and the magnitude of field is increasing at a constant rate α. There is a straight conducting rod of length 2R placed as shown in figure. The magnitude of induced emf across the rod is.



(a) $\pi R^2 a$ (b) $\frac{\pi R^2 \alpha}{2}$ (c) $\frac{R^2 \alpha}{\sqrt{2}}$ (d) $\frac{\pi R^2 \alpha}{4}$

Q 8. In figure (a) a solenoid produce a magnetic field whose strength increases into the plane of the page . An induced emf is established in a conduction loop surrounding the solenoid, and this emf lights bulbs A and B. In figure (b) point P and Q are shorted. After the short is inserted



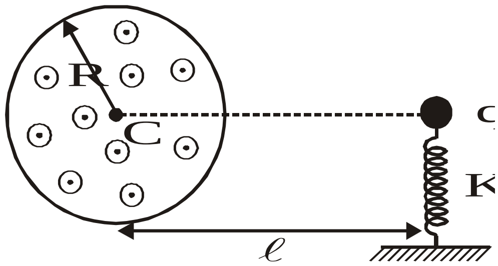
(a) Bulb A goes out bulb B gets brighter
(b) Bulb B goes out bulb A gets brighter
(c) Bulb A goes out bulb B gets dimmer
(d) Bulb B goes out bulb A gets dimmer

Q 9. A uniform circular ring of radius R, mass m has uniformly distributed charge q. The ring is free to rotate about its own axis (which is vertical) without friction. In the space, a uniform magnetic field B, directed vertically downwards, exists in a cylindrical region. Cylindrical region of magnetic field is coaxial with the ring and has radius 'r' greater than R. If magnetic field starts increasing at a constant rate α , angular acceleration of the ring will be

(a) $\frac{qR\alpha}{2mr}$ (b) $\frac{q\alpha}{2m}$

(c) $\frac{qR\alpha}{mr}$ (d) $\frac{qR\alpha}{m}$

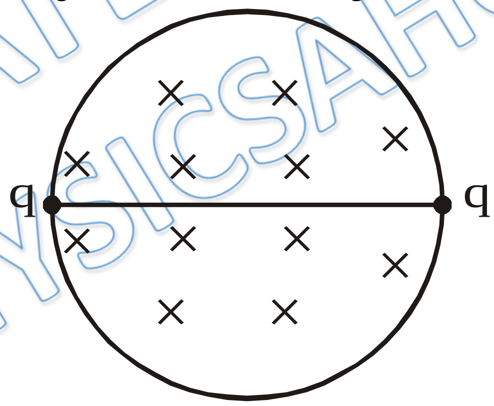
Q 10. There is a horizontal cylindrical uniform but time varying magnetic field increasing at a constant rate $\frac{dB}{dt}$ as shown. A charged particle having charge q and mass m is kept in equilibrium, at the top of a spring of spring constant K in such a way that it is on the horizontal line passing through the center of the magnetic field as shown in figure. The compression in the spring will be



(a) $\frac{1}{K}\left[mg - \frac{qR^2}{2\ell}\frac{dB}{dt}\right]$ (b) $\frac{1}{K}\left[mg + \frac{qR^2}{\ell}\frac{dB}{dt}\right]$

(c) $\frac{1}{K}\left[mg + \frac{2qR^2}{\ell}\frac{dB}{dt}\right]$ (d) $\frac{1}{K}\left[mg + \frac{qR^2}{2\ell}\frac{dB}{dt}\right]$.

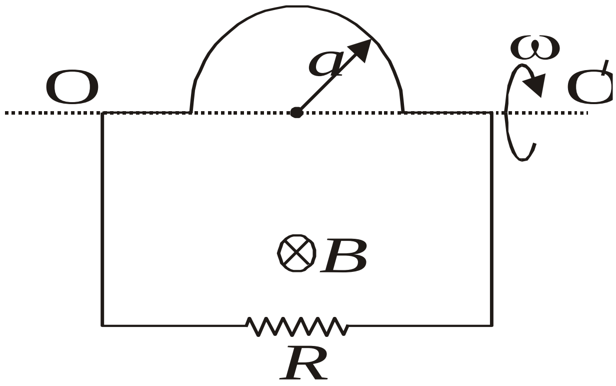
Q 11. A cylindrical region of uniform magnetic field exists perpendicular to plane of paper which is increasing at a constant rate $\frac{dB}{dt} = \alpha$. The diameter of cylindrical region is ℓ. A non–conducting rigid rod of length ℓ having two charged particles is kept fixed on the diameter of cylindrical region w.r.t. inertial frame. If two charged particles having charges q each is kept fixed at the ends of the non-conducting rod. The net electromagnetic force on system is



(a) $\frac{q\ell\alpha}{4}$ (b) $\frac{q\ell\alpha}{2}$

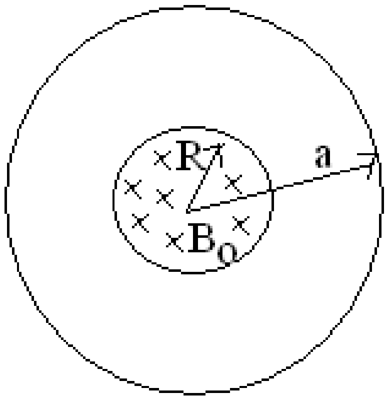
(c) Zero (d) $q\ell\alpha$.

Q 12. A wire shaped as a semi – circle of radius a rotates about an axis OO' with an angular velocity ω in a uniform magnetic field of induction B (shown in figure). The rotation axis is perpendicular to the field direction. The total resistance of the circuit is equal to R. Neglecting the magnetic field of induced current, calculate the mean amount of thermal power being generated in the loop during one rotation period and express it in the form : $P_{mean} = B^m a^n \omega^p \times$ constant. Find the value of p.



(a) 1 (b) 2 (c) 4 (d) 0

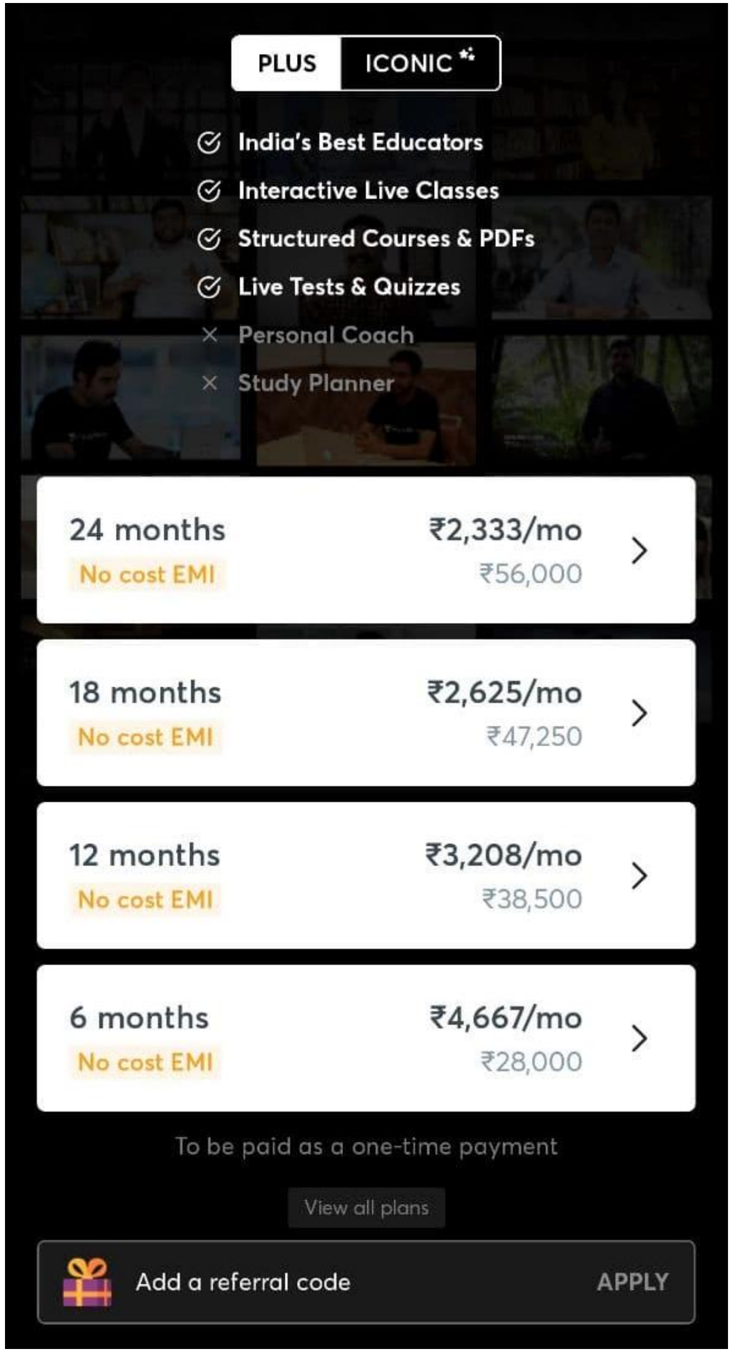
Q 13. A uniform magnetic induction field B_o exists in a cylindrical region of radius R . A nonconducting ring of radius a (>R) is placed co-axially with the field region. The ring has mass 'm' and linear charge density λ. The angular velocity gained by the ring if the field is switched off is



(a) $\frac{\lambda\pi B_o a^2}{mR}$ (b) $\frac{\lambda\pi B_o a^2}{2mR}$ (c) $\frac{\lambda\pi B_o R^2}{ma}$ (d) $\frac{\lambda\pi B_o R^2}{2ma}$

Answer Key

Q.1 b	Q.2 a	Q.3 a	Q.4 c	Q.5 c
Q.6 a	Q.7 d	Q.8 a	Q.9 b	Q.10 d
Q.11 c	Q.12 b	Q.13 c		



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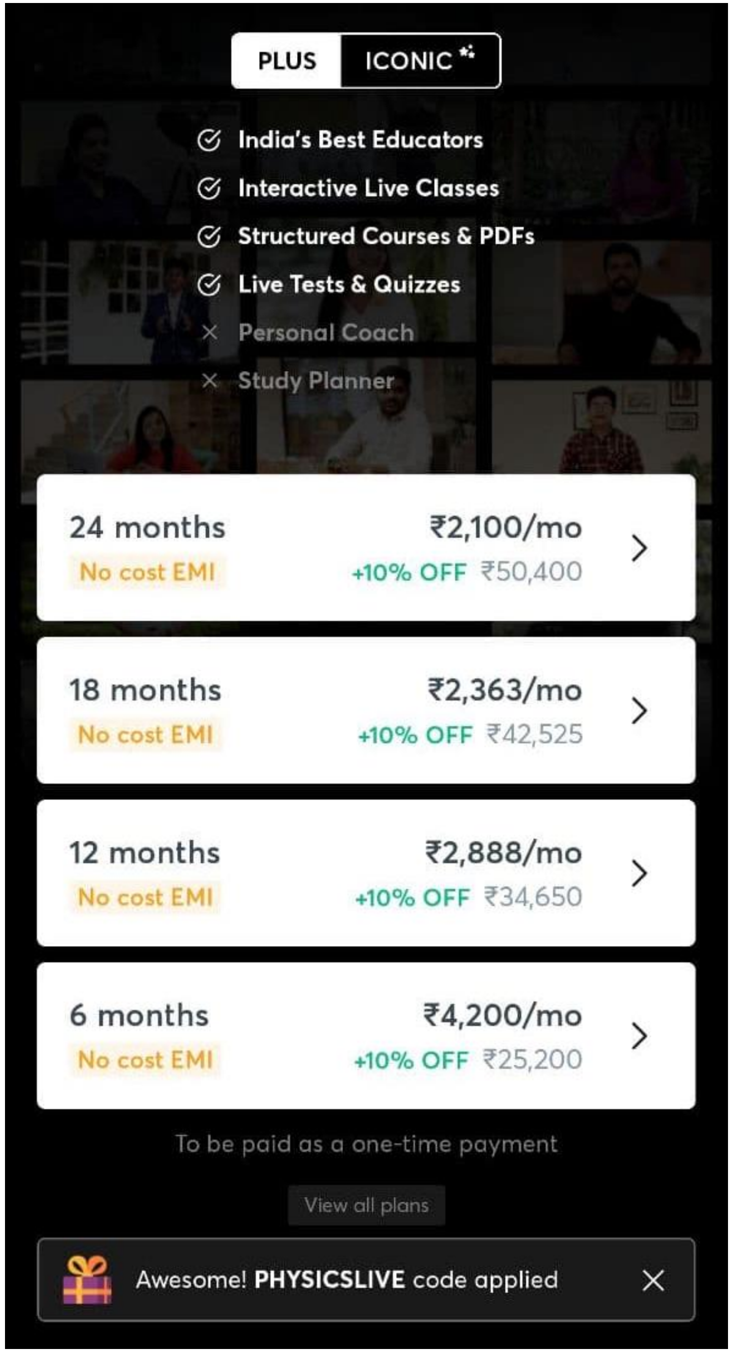

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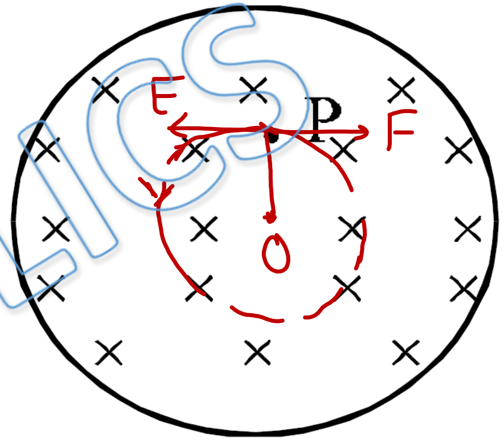
Written Solution

DPP- 3 EMI- Principle of AC Generator, induced electric field due to varying magnetic field and induced current in loop

By Physicsaholics Team

Q.1) Figure shows a uniform magnetic field B confined to a cylindrical volume and is increasing at a constant rate. The instantaneous acceleration experienced by an electron placed at P is



(a) zero

(b) towards right

(c) towards left

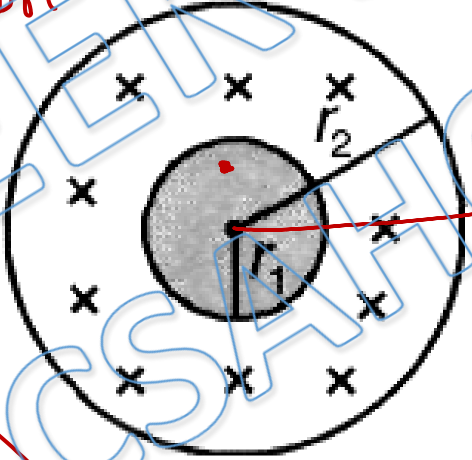
(d) upwards

Q.2) Consider cylindrical region of the magnetic field shown in the figure. Region I and II have fields directed perpendicularly outward and inward respectively. Fields are varying with time as

Region I : B = $3B_0$t

Region II : B = B_0 t

such that there is no net induced electric field in the region r > r_2 , find $\frac{r_1}{r_2}$?



(a) 0.5 (b) 0.6 (c) 0.8 (d) 0.2

$\phi = 3B_0 t \pi r_1^2 - \pi(r_2^2 - r_1^2)B_0 t$

$\phi = (3B_0\pi r_1^2 - B_0\pi(r_2^2 - r_1^2))t$

Since ϕ = Constant.

$3B_0\pi r_1^2 = B_0\pi(r_2^2 - r_1^2)$

$4r_1^2 = r_2^2$

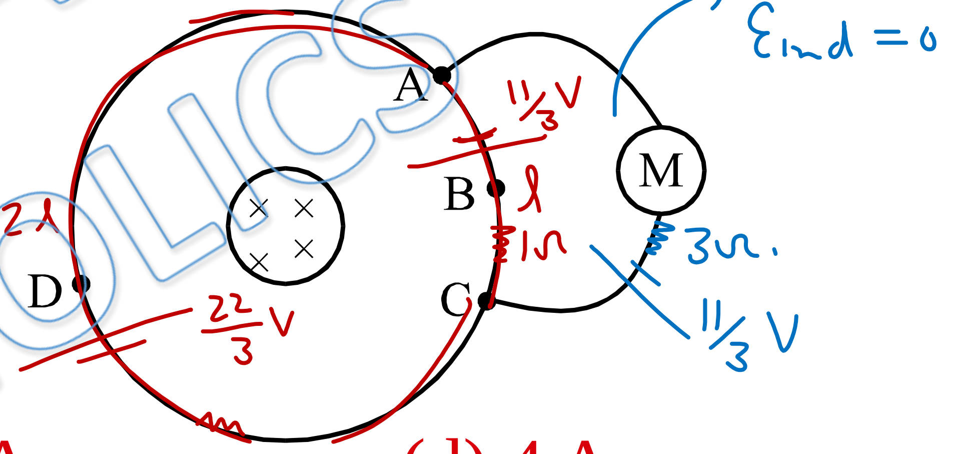
$\frac{r_1}{r_2} = \frac{1}{2}$

→ Conductor loop

$\mathcal{E}_{ind} = 0 \Rightarrow \phi$ = Constant

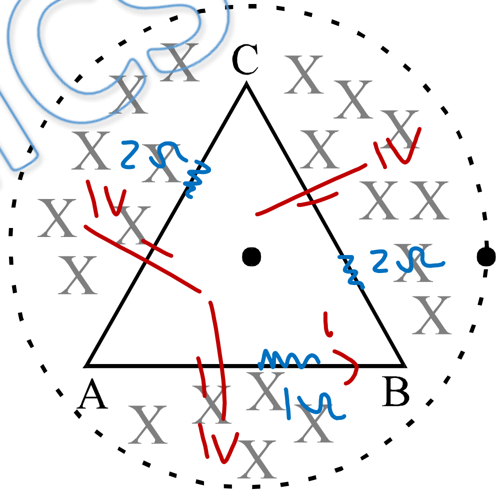
E = 0

Q.3) A variable magnetic field creates a constant emf 11 V in a conductor ABCDA. The resistances of portion ABC, CDA and AMC are 1 ohm, 2 ohm and 3 ohm respectively. What current will be shown by meter M? The magnetic field is concentrated near the axis of the circular conductor.



(a) 1 A (b) 2 A (c) 3 A (d) 4 A

Q.4) A triangular wire frame (each side = 2m) is placed in a region of time variant magnetic field having dB/dt = $\sqrt{3}$T/s. The magnetic field is perpendicular to the plane of the triangle. The base of the triangle AB has a resistance 1 ohm while the other two sides have resistance 2 ohm each. The magnitude of potential difference between the points A and B will be



$\Delta = \frac{\sqrt{3}}{4} \times 4 = \sqrt{3}\ m^2 \otimes$

$\phi = \sqrt{3}\ B \Rightarrow \frac{d\phi}{dt} = \sqrt{3}\sqrt{3}$

$\mathcal{E}_{ind} = -\frac{d\phi}{dt} = -3V$

$I = \frac{3}{5} A$

$V_B - V_A = +1 - \frac{3}{5} \times 1 = \frac{2}{5} V$

$= .4V$

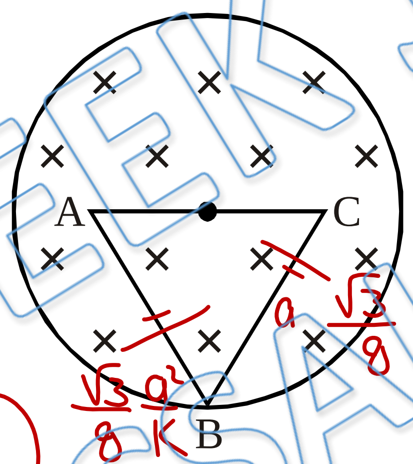
(a) Zero

(b) .2 V

(c) .4 V ✓

(d) .6 V

Q.5) An equilateral triangle ABC of side a is placed in the magnetic field with side AC and its centre coinciding with the centre of the magnetic field. The magnetic field varies with time as B = kt. The emf induced across side AB is



(a) $\frac{\sqrt{3}}{4}a^2k$ (b) Zero (c) $\frac{\sqrt{3}}{8}a^2k$ (d) $\frac{(\sqrt{2}-1)}{2}a^2k$

Q.6) A circular loop of wire of radius r rotates about z-axis with angular velocity w. The normal to the loop is always perpendicular to z axis. At t =0 , normal parallel to y axis. An external magnetic field $\vec{B} = B_y\hat{j} + B_z\hat{k}$ is applied. The EMF induced in the loop at time 't' -

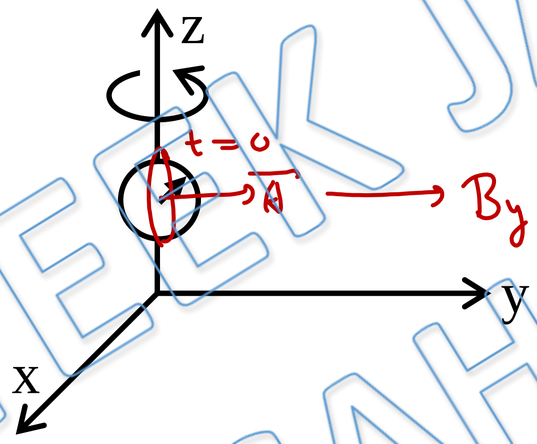
angle b/w $\vec{B}$ & $\vec{A}$

at t=0 , θ = 0

at t=t , θ = ωt

$\phi = B_y \pi r^2 \cos\omega t$

$\frac{d\phi}{dt} = -B_y \pi r^2 \omega \sin\omega t$



(a) πr_2 ω B_y sin ωt

(b) π r_2 ω B_z cosωt

(c) π r_2 ω B_z sinωt

(d) π r_2 ω B_y cosωt

$\mathcal{E} = B_y \pi r^2 \omega \sin\omega t$

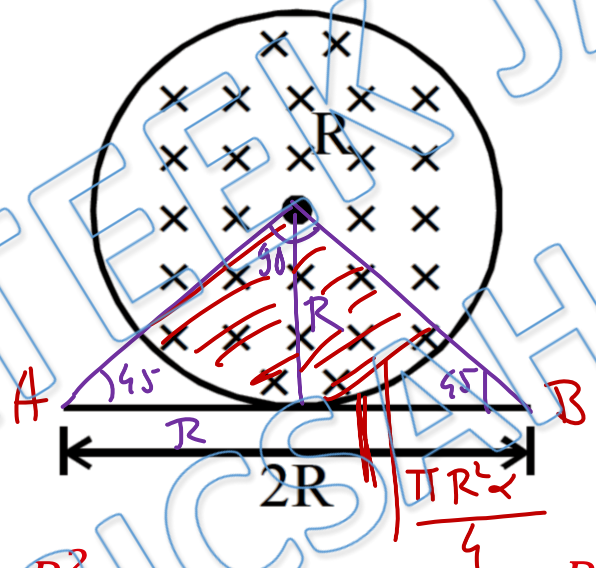
Q.7) A uniform but time varying magnetic field is present in a circular region of radius R. The magnetic field is perpendicular and into the plane of the loop and the magnitude of field is increasing at a constant rate α. There is a straight conducting rod of length 2R placed as shown in figure. The magnitude of induced emf across the rod is

Area of shaded region

$= \frac{\pi R^2}{4}$ ⊗

flux through triangle

$\phi = \frac{B\pi R^2}{4}$



(a) $\pi R^2\alpha$ (b) $\frac{\pi R^2\alpha}{2}$ (c) $\frac{R^2\alpha}{\sqrt{2}}$ (d) $\frac{\pi R^2\alpha}{4}$ ✓

$\mathcal{E}_{ind} = -\frac{\pi R^2}{4}\frac{dB}{dt} = -\frac{\pi R^2}{4}\alpha$

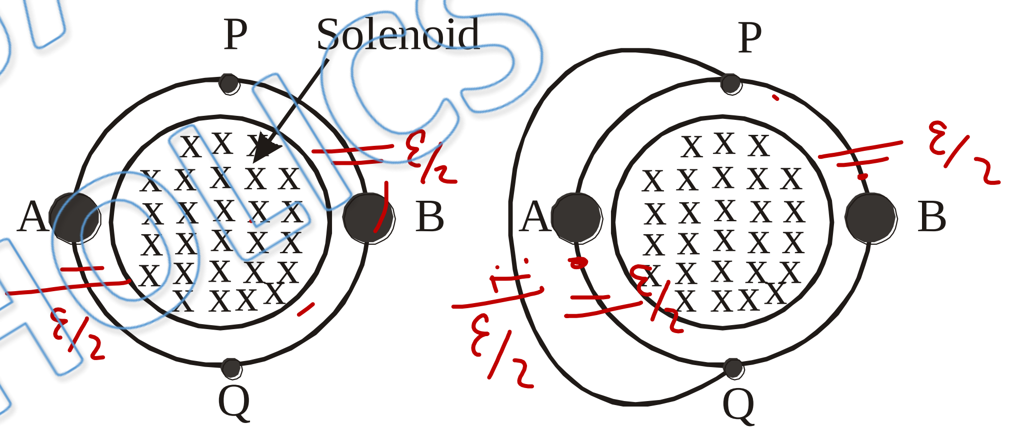
Q.8) In figure (a) a solenoid produce a magnetic field whose strength increases into the plane of the page . An induced emf is established in a conduction loop surrounding the solenoid, and this emf lights bulbs A and B. In figure (b) point P and Q are shorted. After the short is inserted

(a) Bulb A goes out bulb B gets brighter

(b) Bulb B goes out bulb A gets brighter

(c) Bulb A goes out bulb B gets dimmer

(d) Bulb B goes out bulb A gets dimmer

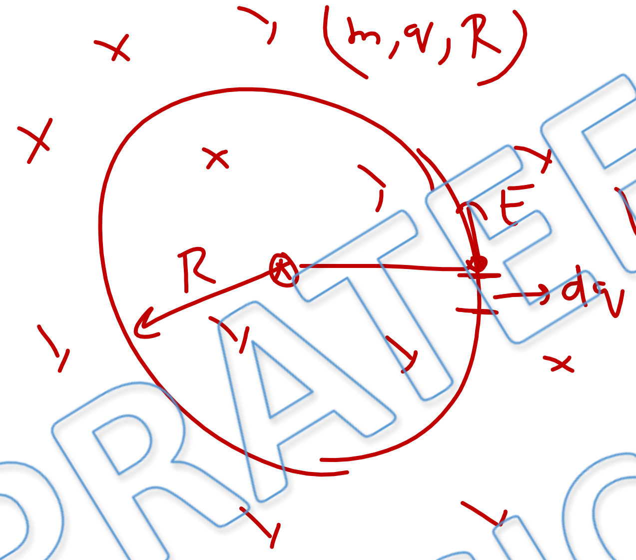


final voltage across A = 0

" " " $B = \varepsilon/2 + \varepsilon/2$

$= \varepsilon$

Q.9) A uniform circular ring of radius R, mass m has uniformly distributed charge q. The ring is free to rotate about its own axis (which is vertical) without friction. In the space, a uniform magnetic field B, directed vertically downwards, exists in a cylindrical region. Cylindrical region of magnetic field is coaxial with the ring and has radius ‘r’ greater than R. If magnetic field starts increasing at a constant rate α , angular acceleration of the ring will be



(a) $\frac{qR\alpha}{2mr}$ (b) $\frac{q\alpha}{2m}$

(c) $\frac{qR\alpha}{mr}$ (d) $\frac{qR\alpha}{m}$

$$E = \frac{R}{2}\frac{dB}{dt} = \frac{R\alpha}{2}$$

$$dF = dq\,\frac{R\alpha}{2}$$

$$d\tau = \frac{dq\,R^2\alpha}{2}$$

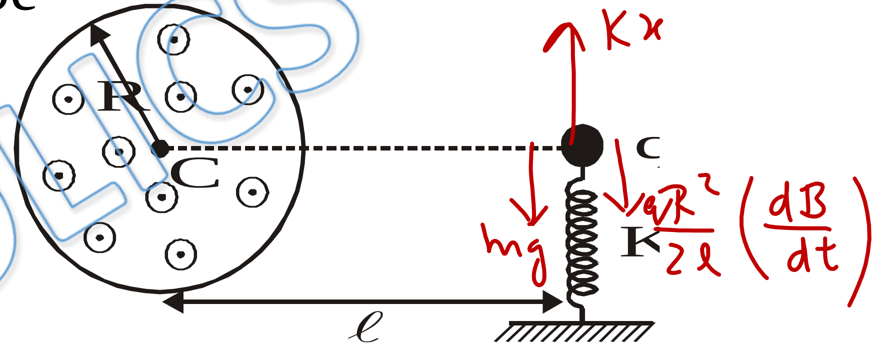
$$\tau = \frac{qR^2\alpha}{2} = I\alpha' \quad \text{(angular acc)}$$

$$\tau = \frac{qR^2\alpha}{2} = mR^2\alpha'$$

$$\alpha' = \frac{q\alpha}{2m}$$

Q.10) There is a horizontal cylindrical uniform but time varying magnetic field increasing at a constant rate $\frac{dB}{dt}$ as shown. A charged particle having charge q and mass m is kept in equilibrium, at the top of a spring of spring constant K in such a way that it is on the horizontal line passing through the center of the magnetic field as shown in figure. The compression in the spring will be

$x = \frac{1}{K}\left[mg + \frac{R^2 q}{2\ell}\left(\frac{dB}{dt}\right)\right]$



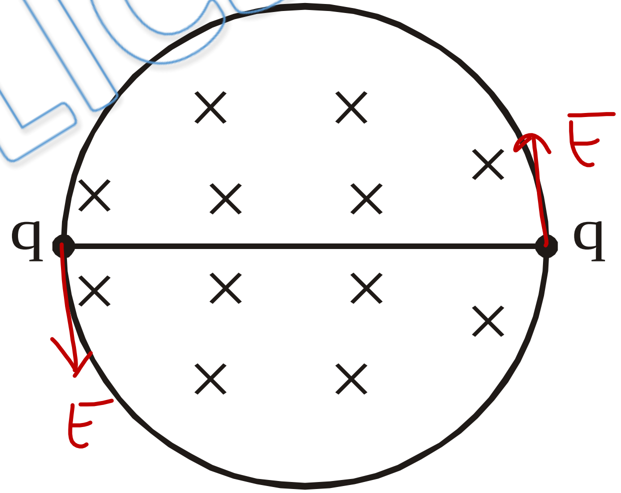
(a) $\frac{1}{K}\left[mg - \frac{qR^2}{2\ell}\frac{dB}{dt}\right]$

(b) $\frac{1}{K}\left[mg + \frac{qR^2}{\ell}\frac{dB}{dt}\right]$

(c) $\frac{1}{K}\left[mg + \frac{2qR^2}{\ell}\frac{dB}{dt}\right]$

(d) $\frac{1}{K}\left[mg + \frac{qR^2}{2\ell}\frac{dB}{dt}\right]$.

Q.11) A cylindrical region of uniform magnetic field exists perpendicular to plane of paper which is increasing at a constant rate $\frac{dB}{dt} = \alpha$. The diameter of cylindrical region is ℓ. A non–conducting rigid rod of length ℓ having two charged particles is kept fixed on the diameter of cylindrical region w.r.t. inertial frame. If two charged particles having charges q each is kept fixed at the ends of the non-conducting rod. The net electromagnetic force on system is



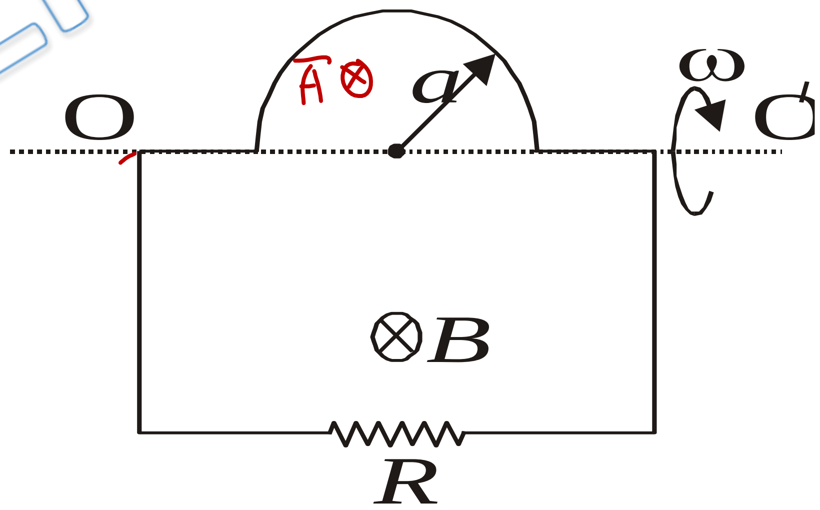
(a) $\frac{q\ell\alpha}{4}$

(b) $\frac{q\ell\alpha}{2}$

(c) Zero

(d) $q\ell\alpha$.

Q.12) A wire shaped as a semi – circle of radius a rotates about an axis OO’ with an angular velocity ωin a uniform magnetic field of induction B (shown in figure). The rotation axis is perpendicular to the field direction. The total resistance of the circuit is equal to R. Neglecting the magnetic field of induced current, calculate the mean amount of thermal power being generated in the loop during one rotation period and express it in the form : $P_{mean} = B^m a^n \omega^p \times$ constant. Find the value of p.



$A = \pi a^2/2$ at $t=0$, $\theta = 0$

at $t=t$, $\theta = \omega t$

$\phi_{semicircle} = \frac{\pi a^2}{2} B \cos\omega t$

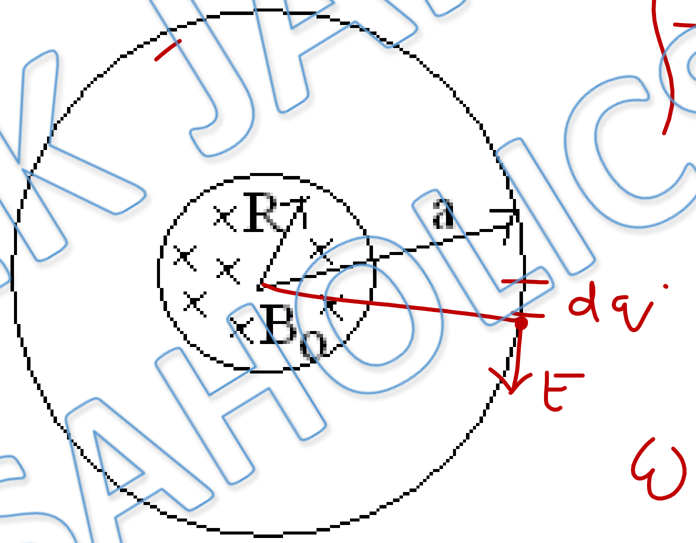
$\varepsilon_{ind} = -\frac{d\phi}{dt} = \frac{B\pi a^2 \omega}{2} \sin\omega t$

(a) 1 (b) 2 (c) 4 (d) 0

$P = \frac{\varepsilon_{ind}^2}{R} \propto \omega^2 \sin^2\omega t$

$P_{mean} \propto \omega^2$

Q.13) A uniform magnetic induction field B_o exists in a cylindrical region of radius R . A nonconducting ring of radius a (>R) is placed co-axially with the field region. The ring has mass 'm' and linear charge density λ. The angular velocity gained by the ring if the field is switched off is



$E = \frac{R^2}{2a}\frac{dB}{dt}$

$d\tau = dq\,E\,a$

$d\tau = dq\left(\frac{R^2}{2}\frac{dB}{dt}\right)$

$\tau = \frac{qR^2}{2}\frac{dB}{dt}$

$\tau = \frac{\lambda 2\pi a R^2}{2}\frac{dB}{dt}$

$\int \tau\, dt = \lambda\pi a R^2 \int dB$

$\tau \Delta t = \lambda\pi a R^2 \Delta B$

$I\omega = \lambda\pi a R^2 B_o$

$\omega = \frac{\lambda\pi a R^2 B_o}{m a^2}$

(a) $\frac{\lambda\pi B_o a^2}{mR}$ (b) $\frac{\lambda\pi B_o a^2}{2mR}$ (c) ✓ $\frac{\lambda\pi B_o R^2}{ma}$ (d) $\frac{\lambda\pi B_o R^2}{2ma}$

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