DPP – 2 (Magnetic Field & Force)

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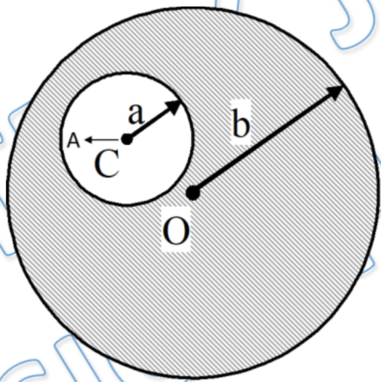
Q 1. The average radius of a toroid made out of a nonmagnetic material is 0.1m and it has 500 turns. If it carries 0.5 ampere current, then the intensity of magnetic field along its circular axis in Tesla will be

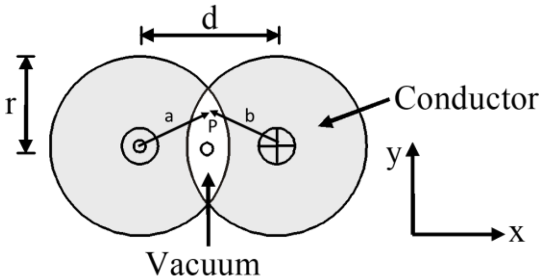
(a) 5×10^{-4} (b) 5×10^{-3}
(c) 5×10^{-2} (d) 2×10^{-3}

Q 2. A long straight metal rod has a very long hole of radius 'a' drilled parallel to the rod axis as shown in the figure. If the rod carries a current 'i' find the value of magnetic induction at point A ,which is at distance r from axis of hole, given OC = c



(a) $\frac{\mu_0 ir}{\pi(b^2-a^2)}$ (b) $\frac{\mu_0 ic}{2\pi(b^2-a^2)}$
(c) $\frac{\mu_0 i(b^2-a^2)}{2\pi c}$ (d) $\frac{\mu_0 ir}{2\pi a^2 b^2}$

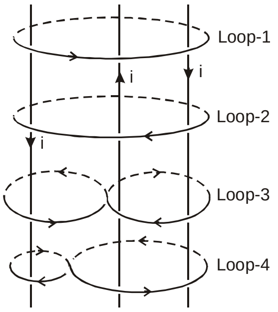
Q 3. Two long conductors are arranged as shown to form overlapping cylinders, each of radius r, whose centers separated by a distance d. Current of density J flows into the plane of the page along the shaded part of one conductor and an equal current flows out of the plane of the page along the shaded portion of the other, as shown. What are the magnitude and direction of the magnetic field at point P ?



(a) $(\mu_0/2\pi)\, \pi dJ$, in the +y-direction

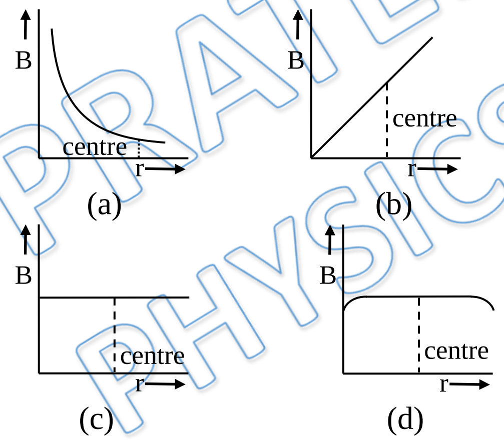
(b) $(\mu_0/2\pi)\, d^2/r$, in the +y-direction
(c) $(\mu_0/2\pi)\, 4d^2J/r$, in the –y-direction
(d) $(\mu_0/2\pi)\, Jr^2/d$, in the –y-direction

Q 4. Three wires are carrying same constant current i in different directions. Four loops enclosing the wires in different manners are shown. The direction of $d\vec{\ell}$ is shown in the figure :



Column I	**Column II**
(A) Along closed Loop-1	(p) $\oint \vec{B}.\vec{dl} = \mu_0$ i
(B) Along closed Loop-2	(q) $\oint \vec{B}.\vec{dl} = -\mu_0$ i
(C) Along closed Loop-3	(r) $\oint \vec{B}.\vec{dl} = 0$
(D) Along closed Loop-4	(s) $\oint \vec{B}.\vec{dl} = 2\mu_0$ i

Q 5. In a solenoid the magnetic induction produced due to current (B) is a function of distance r from one end –



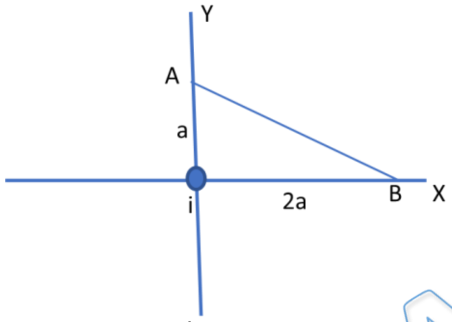
Q 6. A hollow tube of inner radius a and outer radius b is carrying an electric current along the length distributed uniformly over its cross section. The magnetic field from distance a to b from axis of tube –
(a) increases linearly
(b) increases nonlinearly
(c) decreases linearly
(d) decreases nonlinearly

Q 7. In a long solid cylindrical current carrying wire magnetic field at distance r from axis of wire is B = $B_0\, r^2$ and magnetic field lines are coaxial circles. Then current density at distance r from axis will be

(a) $\frac{\mu_0 B_0 r^4}{2}$ (b) $\frac{\mu_0 B_0 r^3}{8}$

(c) 3 B_0 r/ μ_0 (d) $\frac{\mu_0 B_0 r^4}{4}$

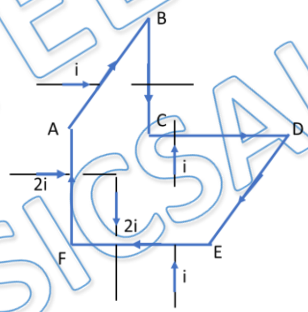
Q 8. An infinitely long current carrying thin wire is placed on z axis. Direction of current is along positive z axis. Line integration of magnetic field from A to B along given line is



(a) $\mu_0 i$ (b) $\frac{\mu_0 i}{2}$

(c) - $\frac{\mu_0 i}{4}$ (d) None of these

Q 9. There are three current carrying wires having currents i,i and 2i as shown in figure. $\oint \vec{B}.\vec{dl}$ along closed loop ABCDEFGA is μ_0 times (all wires are extended to infinity)



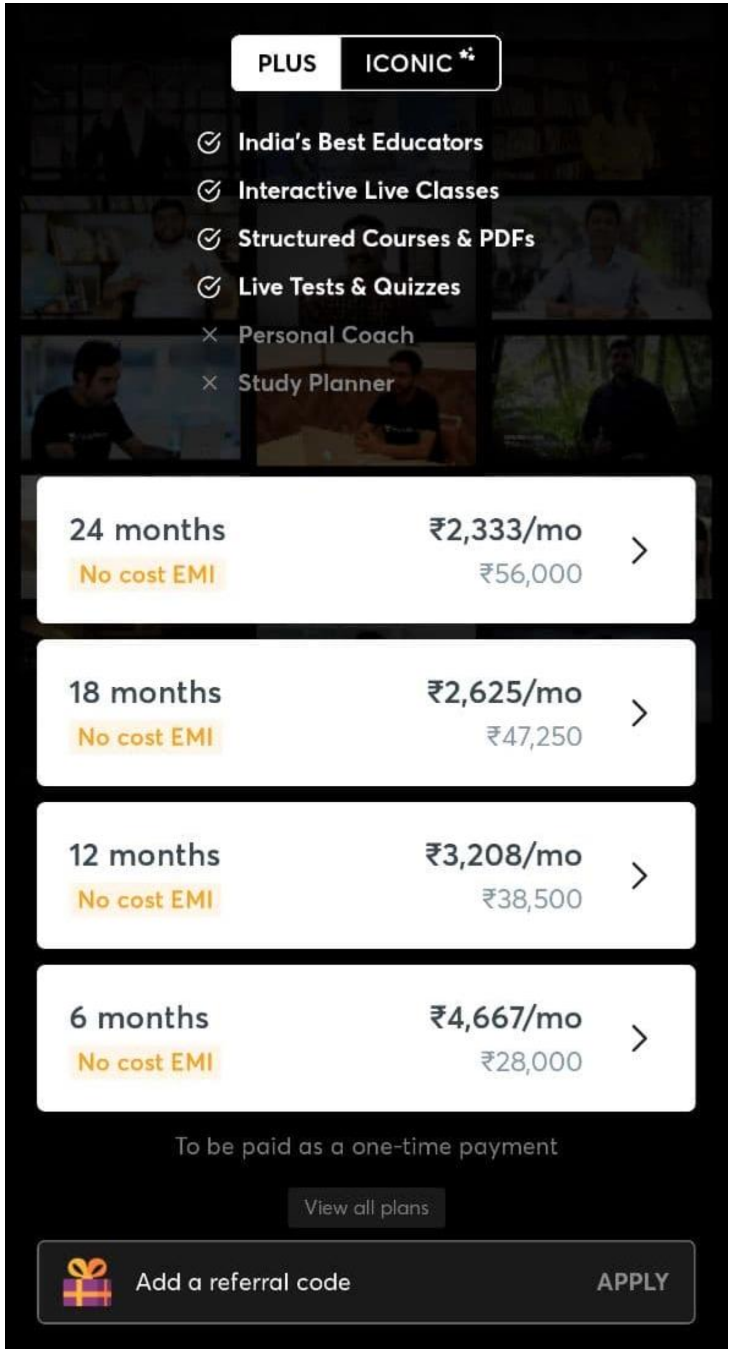
(a) i (b) -2i

(c) -3i (d) 4i

Answer Key

Q.1 a	**Q.2 b**	**Q.3 a**	**Q.5 d**
Q.6 b	**Q.7 c**	**Q.8 c**	**Q.9 b**

Q.4 (A) q (B) p (C) q (D) p



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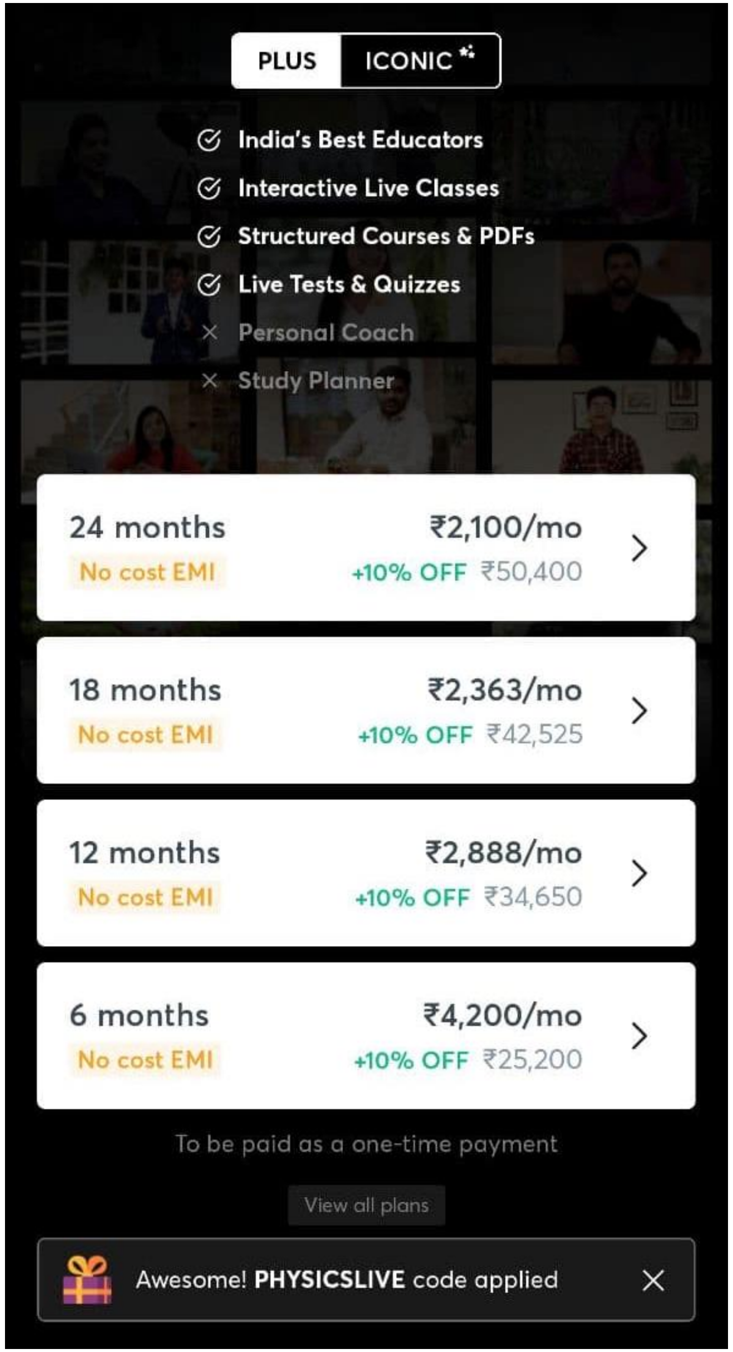


Written Solution

DPP-2 Magnetic Field & Force- Amperes Law, Solenoid and Toroid

By Physicsaholics Team

Q.1) The average radius of a toroid made out of a nonmagnetic material is 0.1m and it has 500 turns. If it carries 0.5 ampere current, then the intensity of magnetic field along its circular axis in Tesla will be

(a) 5×10^{-4} (b) 5×10^{-3}

(c) 5×10^{-2} (d) 2×10^{-3}

$$B = \frac{\mu_0 N i}{2\pi r}$$

$$= \frac{2 \times 10^{-7} \times 500 \times 0.5}{0.1}$$

$$= 5 \times 10^{-4}$$

$\vec{B}$ inside solid wire $= \frac{\mu_0}{2}(\vec{J} \times \vec{r})$

Q.2) A long straight metal rod has a very long hole of radius 'a' drilled parallel to the rod axis as shown in the figure. If the rod carries a current 'i' find the value of magnetic induction at point A ,which is at distance r from axis of hole, given OC = c

$J = \frac{i}{\pi(b^2 - a^2)}$

$\vec{B} = \vec{B}_{complete} - \vec{B}_{cavity}$

$= \frac{\mu_0}{2}(\vec{J} \times \vec{d}) - \frac{\mu_0}{2}(\vec{J} \times \vec{r})$

$= \frac{\mu_0}{2} \vec{J} \times (\vec{d} - \vec{r})$

$= \frac{\mu_0}{2}(\vec{J} \times \vec{c})$

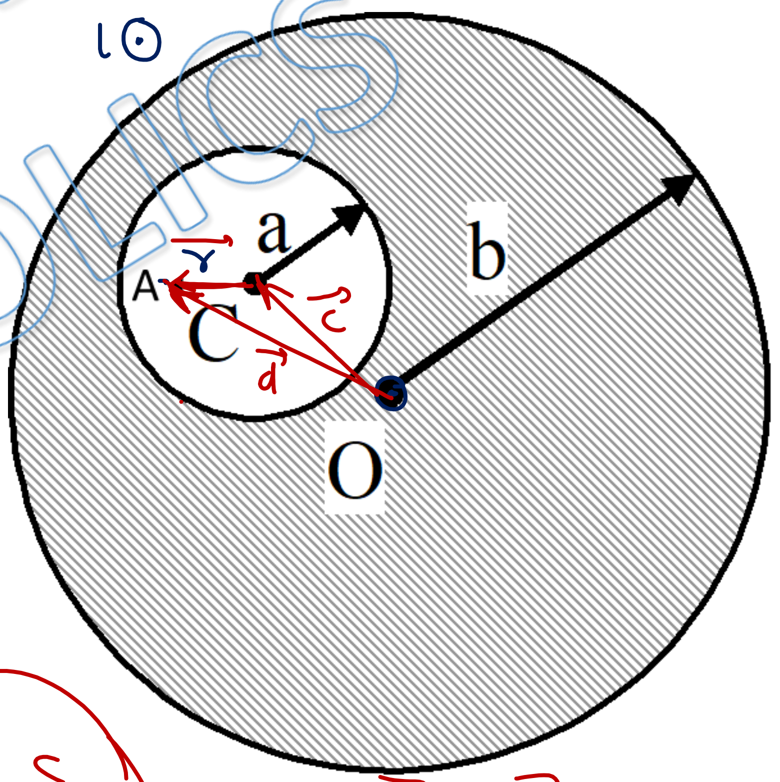
$B = \frac{\mu_0 J c}{2} = \frac{\mu_0 i c}{2\pi(b^2 - a^2)}$

(a) $\frac{\mu_0 i r}{\pi(b^2 - a^2)}$

(b) $\frac{\mu_0 i c}{2\pi(b^2 - a^2)}$

(c) $\frac{\mu_0 i (b^2 - a^2)}{2\pi c}$

(d) $\frac{\mu_0 i r}{2\pi a^2 b^2}$



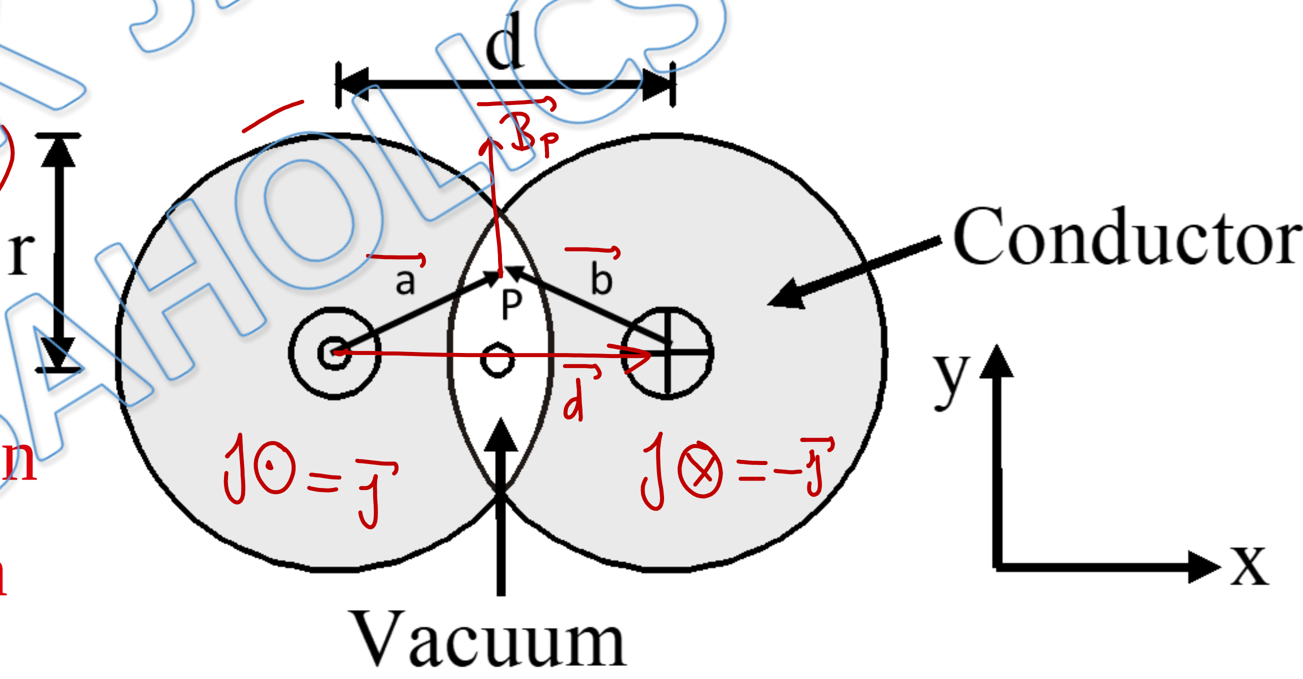
$\vec{c} + \vec{r} = \vec{d}$

$\vec{B} = \frac{\mu_0}{2}(\vec{J} \times \vec{r})$

Q.3) Two long conductors are arranged as shown to form overlapping cylinders, each of radius r, whose centers separated by a distance d. Current of density J flows into the plane of the page along the shaded part of one conductor and an equal current flows out of the plane of the page along the shaded portion of the other, as shown. What are the magnitude and direction of the magnetic field at point P ?

$\vec{B}_P = \vec{B}_{left} + \vec{B}_{right}$

$= \frac{\mu_0}{2}(\vec{J} \times \vec{a}) + \frac{\mu_0}{2}(-\vec{J} \times \vec{b})$



(a) $(\mu_0/2\pi)\ \pi dJ$, in the +y-direction ✓

(b) $(\mu_0/2\pi)\ d^2/r$, in the +y-direction

(c) $(\mu_0/2\pi)\ 4d^2J/r$, in the –y-direction

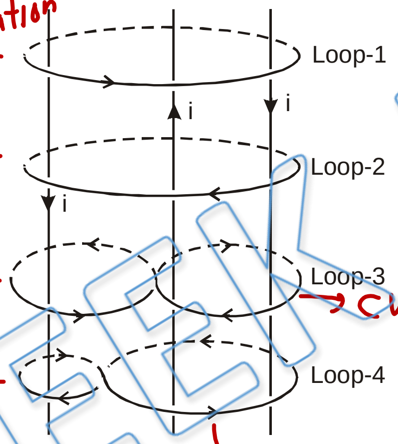
(d) $(\mu_0/2\pi)\ Jr^2/d$, in the –y-direction

$\vec{d} + \vec{b} = \vec{a}$

$\vec{B}_P = \frac{\mu_0}{2}\vec{J} \times (\vec{a} - \vec{b})$

$= \frac{\mu_0}{2}\vec{J} \times \vec{d} \Rightarrow B_P = \frac{\mu_0 J d}{2}$

Q.4) Three wires are carrying same constant current i in different directions. Four loops enclosing the wires in different manners are shown. The direction of $d\vec{\ell}$ is shown in the figure :



Column I	Column II
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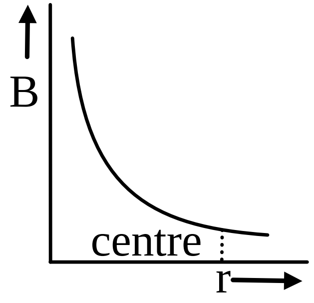
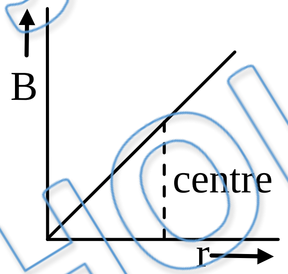
(B) Along closed Loop-2	(q) $\oint \vec{B}.\vec{dl} = -\mu_0$ i
(C) Along closed Loop-3	(r) $\oint \vec{B}.\vec{dl} = 0$
(D) Along closed Loop-4	(s) $\oint \vec{B}.\vec{dl} = 2\mu_0$ i

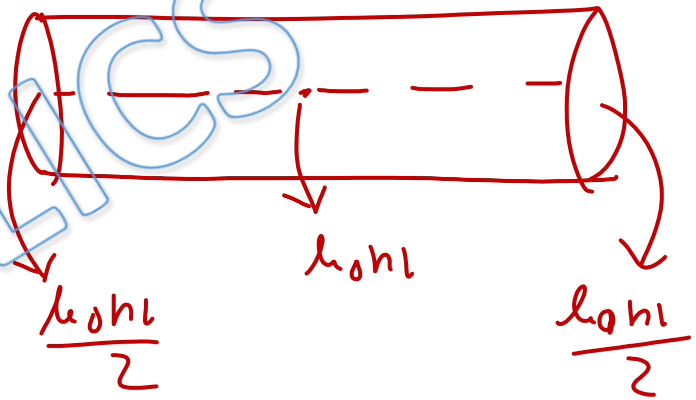
Q.5) In a solenoid the magnetic induction produced due to current (B) is a function of distance r from one end -

(a)

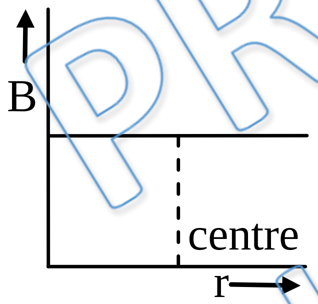


(b)

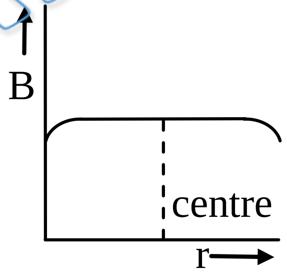




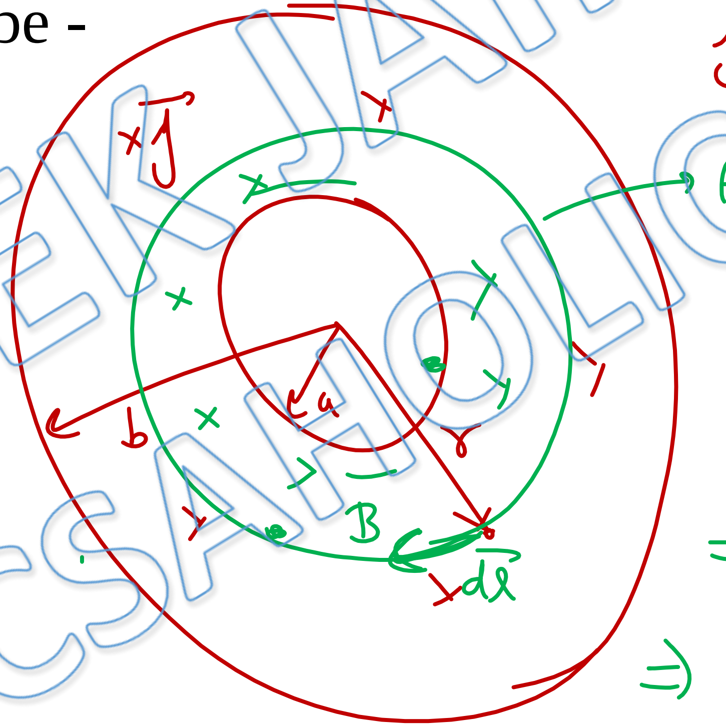
(c)



(d)



Q.6) A hollow tube of inner radius a and outer radius b is carrying an electric current along the length distributed uniformly over its cross section. The magnetic field from distance a to b from axis of tube -



(a) increases linearly

(b) increases nonlinearly ✓

(c) decreases linearly

(d) decreases nonlinearly

$\oint \vec{B}\cdot\vec{dl} = \mu_0 I_{in}$

$\Rightarrow \oint B\,dl = \mu_0 J\pi(r^2 - a^2)$

$\Rightarrow B\oint dl = 2\pi\mu_0 J(r^2 - a^2)$

$\Rightarrow B = \frac{2\pi\mu_0 J(r^2 - a^2)}{2\pi r}$

$B = \mu_0 J\left(r - \frac{a^2}{r}\right)$

$\frac{dB}{dr} = \mu_0 J\left(1 - a^2(-1)r^{-2}\right) = \mu_0 J\left(1 + \frac{a^2}{r^2}\right)$

always +ve

Q.7) In a long solid cylindrical current carrying wire magnetic field at distance r from axis of wire is B = $B_0\, r^2$ and magnetic field lines are coaxial circles. Then current density at distance r from axis will be

$$I = \frac{B_0\, 2\pi r^3}{\mu_0}$$

(a) $\frac{\mu_0 B_0 r^4}{2}$

$$dI = \frac{B_0\, 2\pi \times 3r^2\, dr}{\mu_0}$$

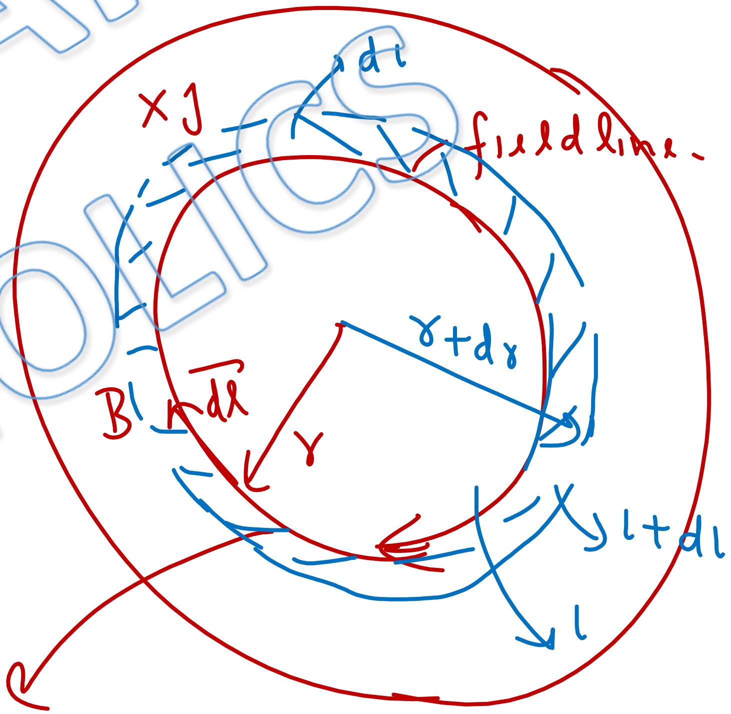
(b) $\frac{\mu_0 B_0 r^3}{8}$

$$J\, 2\pi r\, dr = \frac{B_0\, 2\pi \times 3r^2\, dr}{\mu_0}$$

(c) $3\, B_0\, r/\, \mu_0$ ✓

(d) $\frac{\mu_0 B_0 r^4}{4}$

$$J = \frac{3B_0 r}{\mu_0}$$



$$\oint \vec{B} \cdot \vec{dl} = \mu_0 I_{in}$$

$$\Rightarrow B\, 2\pi r = \mu_0 I$$ → Current within radius r

Q.8) An infinitely long current carrying thin wire is placed on z axis. Direction of current is along positive z axis. Line integration of magnetic field from A to B along given line is

$\int_B^C \vec{B}\,\vec{dl} = 0$

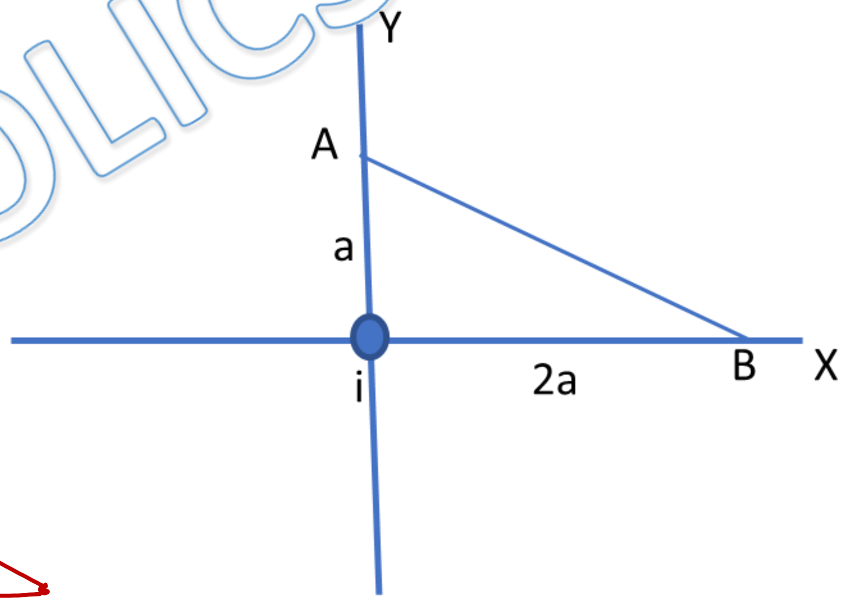
$\int_C^A \vec{B}\,\vec{dl} = 0$

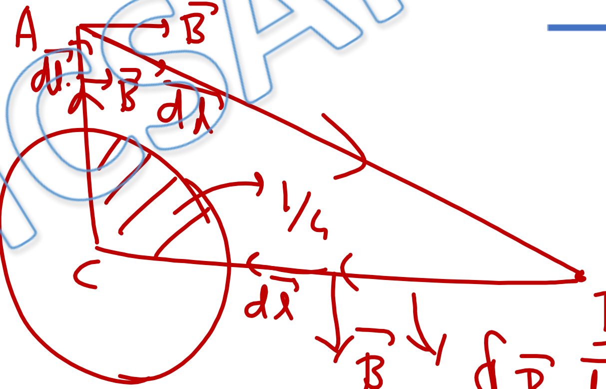
(a) $\mu_0 i$

(b) $\frac{\mu_0 i}{2}$

(c) $-\frac{\mu_0 i}{4}$ ✓

(d) None of these





$\int_A^B \vec{B}\,\vec{dl} = -\frac{\mu_0 i}{4}$

$\oint \vec{B}\cdot\vec{dl} = \mu_0 i_{in}$

$\Rightarrow \int_A^B \vec{B}\,\vec{dl} + \int_B^C \vec{B}\,\vec{dl} + \int_C^A \vec{B}\,\vec{dl} = \mu_0\left(-i/4\right)$

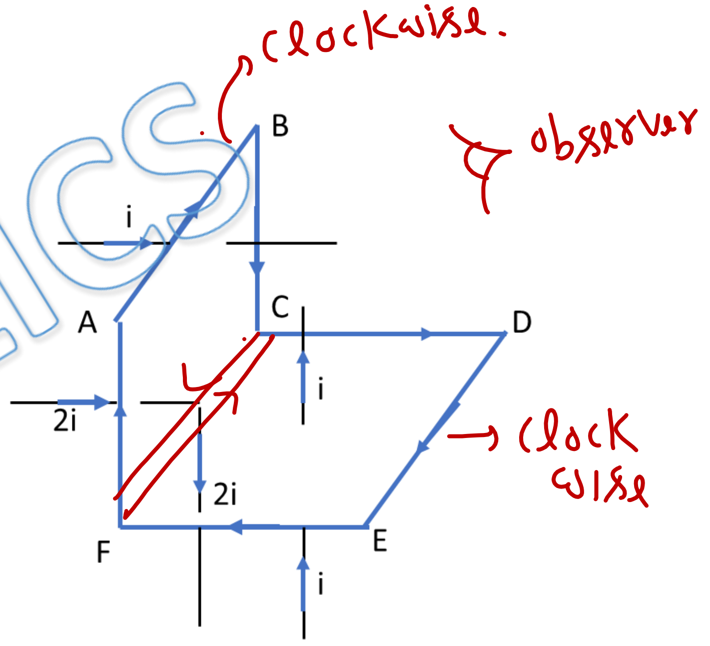
Q.9) There are three current carrying wires having currents i,i and 2i as shown in figure. $\oint \vec{B}.\vec{dl}$ along closed loop ABCDEFGA is μ_0 times (all wires are extended to infinity)

for ABCFA → $I_{in} = -3i$

for CDEFC → $I_{in} = 2i - i$

$= i$

for ABCDEFA → $I_{in} = -2i$



(a) i

(b) -2i

(b) -3i

(d) 4i

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