DPP – 3 (Magnetic Field & Force)

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Q 1. A charged particle moving in a magnetic field experiences a resultant force
(a) In the direction of field
(b) In the direction opposite to that field
(c) In the direction perpendicular to both the field and its velocity
(d) None of the above

Q 2. Two particles X and Y having equal charges, after being accelerated through the same potential difference, enter a region of uniform magnetic field and describes circular path of radius R_1 and R_2 respectively. The ratio of mass of X to that of Y is:
(a) $\left(\frac{R_1}{R_2}\right)^{\frac{1}{2}}$ (b) $\frac{R_2}{R_1}$
(c) $\left(\frac{R_1}{R_2}\right)^{2}$ (d) $\frac{R_1}{R_2}$

Q 3. A doubly ionized He^{+2} atom travels at right angles to a magnetic field of induction 0.4T at a velocity of $10^5\ m/s$ describing a circle of radius r. A proton traveling with same speed in the same direction in the same field will describe a circle of radius:
(a) $0.25r$ (b) $0.5r$
(c) r (d) $2r$

Q 4. An electron enters a magnetic field of intensity $10^{-4}\ Wb/m^2$, with a velocity of 106 m/s and describes a circular path of radius 5.6cm. The value of $\frac{e}{m}$ of electron is:
(a) $1.79 \times 10^7\ C/kg$ (b) $1.89 \times 10^7\ C/kg$
(c) $1.69 \times 10^7\ C/kg$ (d) $1.99 \times 10^7\ C/kg$

Q 5. A proton of energy 2 MeV is moving perpendicular to a uniform magnetic field of 2.5 tesla. The force on the proton is:
(mass of proton = 1.6×10^{-27}Kg)
(a) $2.5 \times 10^{-10}\ N$ (b) $8 \times 10^{-11}\ N$
(c) $2.5 \times 10^{-11}\ N$ (d) $8 \times 10^{-12}\ N$

Q 6. A beam of protons with a velocity of $4 \times 10^5\ m/s$ enters a uniform magnetic field of 0.3 T. The velocity makes an angle of 60^0 with the magnetic field. Find the radius of the helical path taken by the proton beam and the pitch of the helix: (mass of proton = 1.6×10^{-27}Kg)
(a) $1.2\ cm,\ 4.2\ cm$ (b) $1.2\ cm,\ 2.4\ cm$

(c) $1.6\ cm,\ 4.8\ cm$ (d) $1.6\ cm,\ 8.4\ cm$

Q 7. A proton is moving along Z-axis in a magnetic field. The magnetic field is along X-axis. The proton will experience a force along:
(a) X-axis (b) Y-axis
(c) Z-axis (d) Negative Z-axis

Q 8. A particle having charge of 1C, mass 1kg and speed 1 m/s enters a uniform magnetic field having magnetic induction of 1T at an angle $\theta = 30^0$ between velocity vector and magnetic induction. The pitch of its helical path is (in meters)
(a) $\frac{\sqrt{3}\pi}{2}$ (b) $\sqrt{3}\pi$
(c) $\frac{\pi}{2}$ (d) π

Q 9. A charged particle enters a uniform magnetic field perpendicular to the direction of magnetic field. How will its kinetic energy and momentum change?
(a) Kinetic energy changes but the momentum is constant
(b) The momentum changes but the kinetic energy is constant
(c) Both momentum and kinetic energy of the particle are not constant
(d) Both momentum and kinetic energy of the particle are constant

Q 10. A charged particle enters a magnetic field at right angles to the field. The field exists for a length equal to 1.5 times the radius of circular path of particle. The particle will be deviated from its path by:
(a) 90^0 (b) $\sin^{-1}\left(\frac{2}{3}\right)$
(c) 30^0 (d) 180^0

Q 11. A proton of mass m and charge +e is moving in a circular orbit in a magnetic field with energy 1 MeV. What should be the energy of α-particle (mass = 4m and charge = + 2e), so that it can revolve in the path of same radius:
(a) 1 MeV (b) 4 MeV
(c) 2 MeV (d) 0.5 MeV

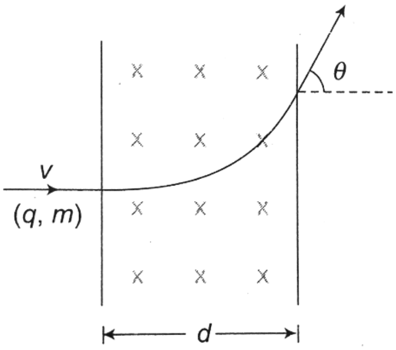
Q 12. A proton (mass = 1.67×10^{-27}kg and charge = 1.6×10^{-19}C) enters perpendicular to a magnetic field of intensity 2 weber/m^2 with a velocity 3.4×10^7m/s. The acceleration of the proton should be:
(a) $6.5 \times 10^{15}\ m/s^2$ (b) $6.5 \times 10^{13}\ m/s^2$
(c) $6.5 \times 10^{11}\ m/s^2$ (d) zero

Q 13. A strong magnetic field is applied on a stationary proton, then
(a) The proton moves in the direction of the field
(b) The proton moves in a circle
(c) The proton remains stationary
(d) The proton starts spinning

Q 14. A proton enters a magnetic field of flux density 2.5T with a speed of $1.5 \times 10^7\ m/s$ at an angle of 30^0 with the field, Find the force on the proton:
(a) 2.3×10^{-12}N (b) 4.2×10^{-11}N

(c) 7.1×10^{-11}N (d) 3×10^{-12}N

Q 15. A charged particle (q, m) enters perpendicular in a uniform magnetic field B and comes out of field as shown. The angle of deviation θ and time taken by particle to cross magnetic field will be:



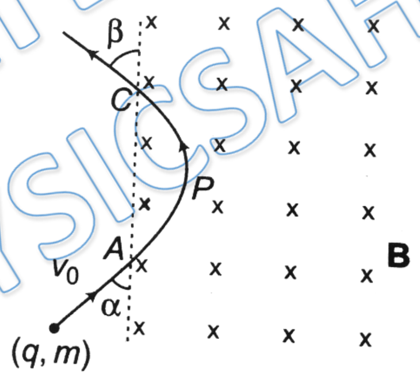
(a) $\sin^{-1}\left(\frac{Bqd}{mv}\right), \frac{m\theta}{Bq}$

(b) $\sin^{-1}\left(\frac{Bqv}{md}\right), \frac{m\theta}{Bq}$

(c) $\cos^{-1}\left(\frac{Bqd}{mv}\right), \frac{m\theta}{Bq}$

(d) $\cos^{-1}\left(\frac{Bqv}{md}\right), \frac{m\theta}{Bq}$

Q 16. A charged particle (q, m) enters uniform magnetic field B at angle α shown in figure with speed v_0. Find The angle β at which it leaves the magnetic field and the distance AC?



(a) β = α, AC = $\frac{2mv_o}{qB}$

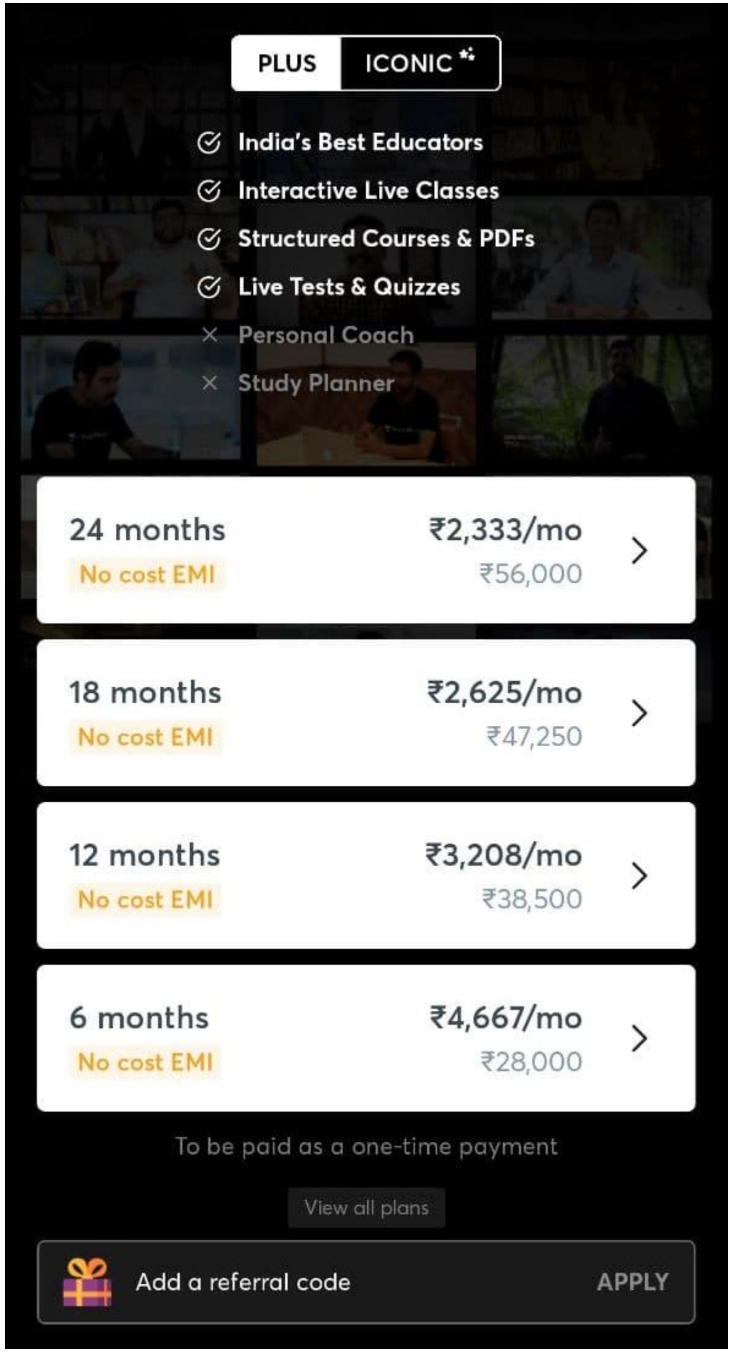
(b) β = α/2, AC = $\frac{2mv_o}{qB}\sin\alpha$

(c) β = 2α, AC = $\frac{mv_o}{qB}\sin\alpha$

(d) β = α, AC = $\frac{2mv_o}{qB}\sin\alpha$

Answer Key

Q.1 c	Q.2 c	Q.3 b	Q.4 b	Q.5 d
Q.6 a	Q.7 b	Q.8 b	Q.9 b	Q.10 d
Q.11 a	Q.12 a	Q.13 c	Q.14 d	Q.15 a
Q.16 d				



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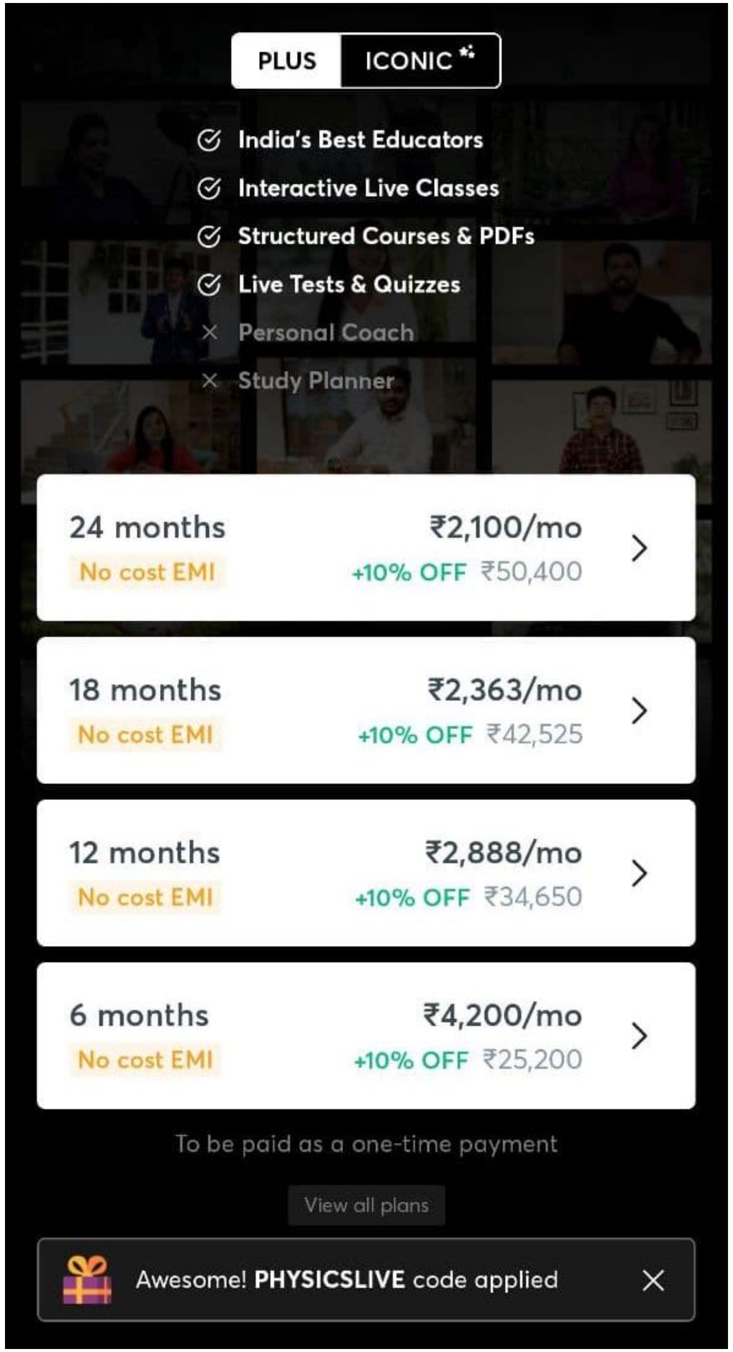

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Written Solution

DPP- 3 Moving charge in Magnetic field, Helical path

By Physicsaholics Team

Solution: 1

$$\vec{F} = q(\vec{v} \times \vec{B})$$

$\therefore \vec{F}$ is $\perp$ to $\vec{v}$ & $\vec{B}$ Both,

Ans. c

Solution: 2

$$r = \frac{mv}{qB} = \frac{\sqrt{2m(KE)}}{qB}$$

$$r = \frac{\sqrt{2mq(\Delta V)}}{qB}$$

$r \propto \sqrt{m}$ [as q & B & ΔV are same]

$$\therefore \frac{R_1}{R_2} = \sqrt{\frac{m_1}{m_2}}$$

$$\frac{R_1^2}{R_2^2} = \frac{m_1}{m_2}$$

$$\Rightarrow \frac{M_1}{M_2} = \frac{R_1^2}{R_2^2}$$

or

$$\boxed{\frac{M_1}{M_2} = \left(\frac{R_1}{R_2}\right)^2}$$

Ans. c

Solution: 3

He^{+2}

$q = 2e \quad m = 4m_p$

$B = 0.4\,T$

$$r = \frac{mv}{qB} = \frac{(4m_p)(10^5)}{(2e)(0.4)} \quad \text{--- (1)}$$

Now for proton

$q_p = e \; ; \; m = m_p$

$$\therefore r_p = \frac{m_p v_p}{q_p B} = \frac{(m_p)(10^5)}{(e)(0.4)} \quad \text{--- (2)}$$

$\frac{(1)}{(2)}$

$$\frac{r}{r_p} = \frac{\frac{(4m_p)(10^5)}{(2e)(0.4)}}{\frac{(m_p)(10^5)}{(e)(0.4)}} = \frac{4}{2}$$

$$\frac{r}{r_p} = 2$$

$$\boxed{r_p = \frac{r}{2}}$$

Ans. b

Solution: 4

$$\because \quad r = \frac{mv}{qB}$$

$$5.6 \times 10^{-2} = \frac{m}{e} \times \frac{10^6}{10^4}$$

$$\frac{e}{m} = \frac{10^6}{5.6 \times 10^{-2} \times 10^4}$$

$$\frac{e}{m} = \frac{10^6 \times 10^{-6}}{5.6}$$

$$\frac{e}{m} = \frac{10.6}{5.6} \times 10^7$$

$$\boxed{\frac{e}{m} = 1.89 \times 10^7 \ c/kg}$$

Ans. b

Solution: 5

$E = 2\,MeV = 2\times10^{6}\times1.6\times10^{-19}$

$E = 3.2\times10^{-13}\,J.$

$\frac{1}{2}mv^2 = 3.2\times10^{-13}$

$\frac{1}{2}(1.6\times10^{-27})v^2 = 3.2\times10^{-13}$

$v = 2\times10^{7}$

$F = qvB\sin\theta = 1.6\times10^{-19}\times2\times10^{7}\times2.5\times\sin90^\circ$

$F = 3.2\times2.5\times10^{-12}$

$F = 8\times10^{-12}\,N$

Ans. d

Solution: 6

$V = 4\times10^5$ m/s & $\theta = 60^\circ$

$\therefore V_\perp = V\sin60^\circ = 4\times10^5\times\frac{\sqrt3}{2} = 2\sqrt3\times10^5$ m/s

$V_{\parallel} = V\cos60^\circ = 4\times10^5\times\frac{1}{2} = 2\times10^5$ m/s

$$r = \frac{mV_\perp}{qB} = \frac{1.6\times10^{-27}\times2\sqrt3\times10^5}{1.6\times10^{-19}\times0.3} = \frac{2\sqrt3}{0.3}\times10^{-3}$$

$$r = \frac{2\sqrt3}{3}\times10^{-2} = \frac{2\sqrt3}{3}\text{ cm}$$

$$\boxed{r = 1.15\text{ cm} \simeq 1.2\text{ cm}}$$

Time period of one complete revolution

$$T = \frac{2\pi m}{qB} = \frac{2\times3.14\times1.6\times10^{-27}}{1.6\times10^{-19}\times0.3}$$

$$T = 2.09\times10^{-7}\text{ sec}$$

Pitch $p = T\times V_{\parallel} = 2.09\times10^{-7}\times2\times10^5$

$$p = 4.18\times10^{-2}$$

$$\boxed{p \simeq 4.2\text{ cm}}$$

Ans. a

Solution: 7

$$\vec{F} = q(\vec{v} \times \vec{B})$$

$$\hat{F} = q(\hat{v} \times \hat{B})$$

$$\hat{v} = \hat{k}$$

$$\hat{B} = \hat{i}$$

$$\hat{F} = \hat{k} \times \hat{i}$$

$$\boxed{\hat{F} = \hat{j}}$$

The proton will experience a force along y-axis

Ans. b

Solution: 8

Pitch ⇒ P

$$P = T \times V_{\parallel}$$

$$P = \frac{2\pi m}{qB} \times V\cos\theta$$

$$P = \frac{2\pi \times 1}{1 \times 1} \times 1 \cos 30^\circ$$

$$P = 2\pi \times \frac{\sqrt{3}}{2}$$

$$\boxed{P = \sqrt{3}\pi \ m}$$

Ans. b

Solution: 9

when; charge enters in uniform magnetic field; force due to magnetic field acts perpendicular to the velocity, hence it ~~velocity~~ does not changes its magnitude but changes its direction

so; as magnitude of velocity is constant

⇒ kinetic energy is constant.

But as the direction of velocity changing means velocity vector is changing

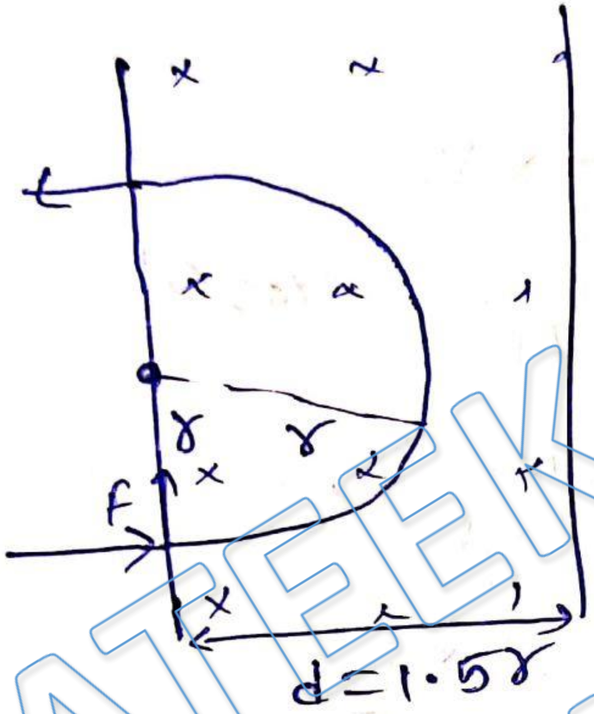
⇒ ~~so~~ momentum will change.

∴ K.E is constant

But Momentum changes.

Ans. b

Solution: 10



∴ Particle will complete half ~~circle~~ circle in the magnetic field & return back

∴ deviation = 180°

Ans. d

Solution: 11

$$r = \frac{mv}{qB} = \frac{\sqrt{2mE}}{qB}$$

for α - Particle,

$$r_\alpha = \frac{\sqrt{2(4m)E_\alpha}}{(2e)\ B} \quad \text{--- (1)}$$

for Proton.

$$r_p = \frac{\sqrt{2(m)E_p}}{(e)\ B} \quad \text{--- (2)}$$

$$\frac{(1)}{(2)} \quad \frac{r_\alpha}{r_p} = 1 = \frac{\frac{\sqrt{2(4m)E_\alpha}}{2eB}}{\frac{\sqrt{2mE_p}}{eB}} = \frac{\frac{\sqrt{4E_\alpha}}{2}}{\sqrt{E_p}}$$

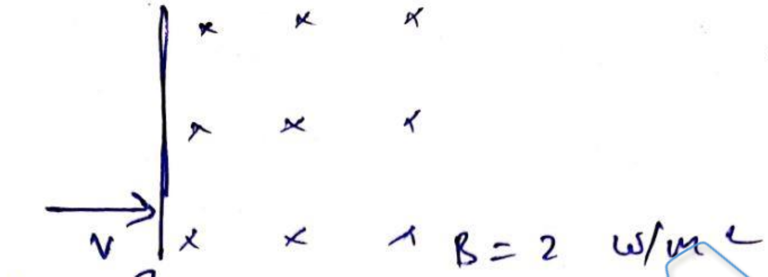
$$\sqrt{E_p} = \frac{\sqrt{4E_\alpha}}{2} \Rightarrow E_p = \frac{4E_\alpha}{4}$$

$$\boxed{E_p = E_\alpha}$$

$$\therefore \boxed{E_p = E_\alpha = 1\ \text{MeV}}$$

Ans. a

Solution: 12



~~$V = 10^7$~~

$V = 3.4 \times 10^7\ m/s$

Path will be circular

$\therefore$ acceleration $a = \dfrac{V^2}{r}$

$$r = \frac{mV}{qB}$$

$$\therefore a = \frac{V^2}{mV} \times qB = \frac{qVB}{m}$$

$$a = \frac{1.6 \times 10^{-19} \times 3.04 \times 10^7 \times 2}{1.67 \times 10^{-27}}$$

$$a = \frac{1.6 \times 3.04 \times 2}{1.67} \times 10^{-19} \times 10^{34}$$

$$\boxed{a = 6.5 \times 10^{15}\ m/s^2}$$

Ans. a

Solution: 13

$F = qVB\sin\theta$

as $V = 0$

$\therefore \boxed{F = 0}$

force due to magnetic field on stationary proton is zero. So proton will remain stationary.

Ans. c

Solution: 14

$$F = qVB \sin\theta$$

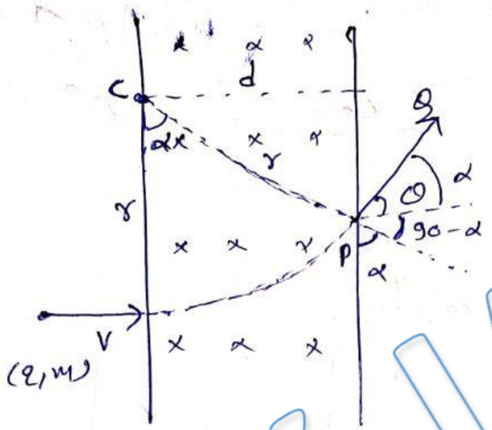
$$F = 1.6 \times 10^{-19} \times 1.5 \times 10^{7} \times 2.5 \times \sin 30^\circ$$

$$F = 1.6 \times 1.5 \times 2.5 \times 10^{-12} \times \frac{1}{2}$$

$$F = 3 \times 10^{-12}\, N$$

Ans. d

Solution: 15



let; charge covers angle (α) in magnetic field.

CP = radius

∴ CP will be ⊥ to PQ

(∵ P is tangent at P on circular path)

∴ $\boxed{\alpha = \theta}$

& from diagram.

$r \sin\alpha = d$

& $r = \frac{mv}{qB} \Rightarrow \frac{mv}{qB}\sin\alpha = d$

$\sin\alpha = \frac{qBd}{mv} \Rightarrow \boxed{\alpha = \sin^{-1}\left(\frac{qBd}{mv}\right)}$

& Time in magnetic field will be

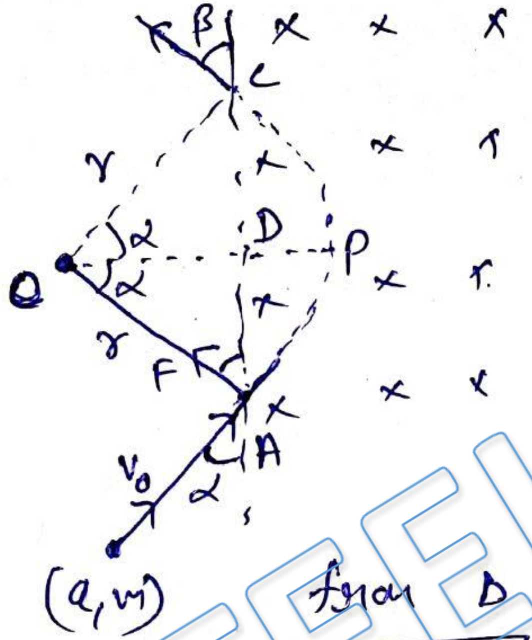
$t = \frac{T}{2\pi}\times\alpha = \frac{2\pi m}{qB}\times\frac{1}{2\pi}(\alpha)$

$t = \frac{m\alpha}{qB} = \frac{m\theta}{qB} \quad \because \alpha = \theta$

∴ $\boxed{t = \frac{m\theta}{qB}}$

Ans. a

Solution: 16



$r = \frac{m V_\perp}{qB}$

as V_0 is $\perp$ to $\vec{B}$

$\therefore \boxed{r = \frac{m V_0}{qB}}$

from Δ AOD & COD

$\boxed{\alpha = \beta}$

Now AC = ?

AC = 2 AD

& AD = r sin α [from Δ AOD]

$\therefore$ AC = 2r sin α

$\boxed{AC = \frac{2 m V_0}{qB} \sin\alpha}$

Ans. d

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