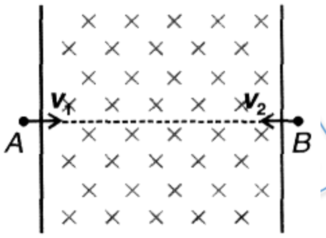
# DPP – 3 (Magnetic Field & Force)

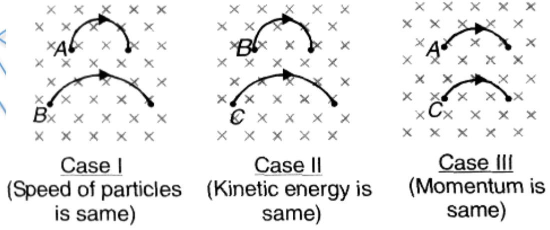
| | |
|---|---|
| Video Solution on Website:- | https://physicsaholics.com/home/courseDetails/97 |
| Video Solution on YouTube:- | https://youtu.be/AlqRysIjOXs |
| Written Solution on Website:- | https://physicsaholics.com/note/notesDetalis/51 |

Q 1. Two particles A and B of same mass and having charges of same magnitude but of opposite nature are thrown in a region of magnetic field (as shown) with speeds $v_1$ and $v_2$ ($v_1 > v_2$). At the time particle A escapes out of the magnetic field, angular momentum of particle B w.r.t. particle A is proportional to (Assume both the particles escape in the region from where they respectively entered the field)



(a) $v_1 + v_2$
(b) $v_1 - v_2$
(c) $v_1^2$ - $v_2^2$
(d) $v_1^2 + v_2^2$

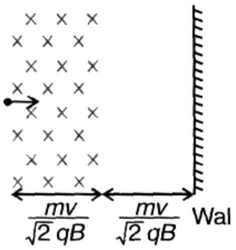
Q 2. Trajectories of three particles A , B and C projected perpendicular to a uniform transverse magnetic field in three different cases are shown in figure. A, B and C can be



Case I (Speed of particles is same)
Case II (Kinetic energy is same)
Case III (Momentum is same)

(a) ${}^1_1H, {}^4_2He, {}^2_1H$
(b) ${}^1_1H, {}^2_1H$ , ${}^4_2He$
(c) ${}^2_1H$ , ${}^4_2He, {}^1_1H$
(d) ${}^4_2He, {}^1_1H, {}^2_1H$

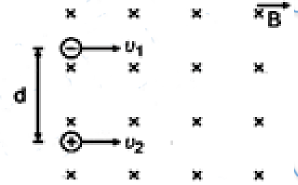
Q 3. A particle of mass m and charge q enters a region of magnetic field (as shown) with speed v. There is a region in which the magnetic field is absent, as shown. The particle after entering the region collides elastically with a rigid wall. Time after which the velocity of particle becomes antiparallel to its initial velocity is



(a) $\frac{m}{2qB}(\pi+4)$ (b) $\frac{m}{qB}(\pi+2)$
(c) $\frac{m}{4qB}(\pi+2)$ (d) $\frac{m}{4qB}(2\pi+3)$

Q 4. A uniform magnetic field $\vec{B} = B_0\hat{j}$ exists in space. A particle of mass m and charge q is projected towards negative x-axis with speed v from a point (d 0, 0). The maximum value of v for which the particle does not hit the y-z plane is:
(a) $\frac{2Bq}{dm}$ (b) $\frac{Bqd}{m}$ (c) $\frac{Bq}{2dm}$ (d) $\frac{Bqd}{2m}$

Q 5. Two identical particles having the same mass m and charges +q and -q separated by a distance d enter in uniform magnetic field B directed perpendicular to paper inwards with speeds $v_1$ and $v_2$ as shown in figure. The particles will not collide if: (Ignore electrostatic force)

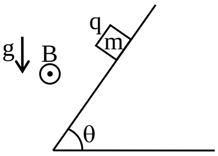


(a) $d > \frac{m}{Bq}(v_1+v_2)$ (b) $d < \frac{m}{Bq}(v_1+v_2)$
(c) $d < \frac{2m}{Bq}(v_1+v_2)$ (d) $v_1 = v_2$

Q 6. A charged particle having charge q experience a force $\vec{F}_1 = q(-\hat{j}+\hat{k})$ N in a magnetic field $\vec{B}$ when it has a velocity $\vec{v}_1 = 1\hat{\imath}$ m/s. The force becomes $\vec{F}_1 = q(\hat{\imath}-\hat{k})$ N when the velocity is changed to $\vec{v}_2 = 1\hat{\jmath}$ m/s. The magnetic induction vector at that point is :
(a) $(\hat{\imath}+\hat{\jmath}+\hat{k})T$ (b) $(\hat{\imath}-\hat{\jmath}-\hat{k})T$
(c) $(-\hat{\imath}-\hat{\jmath}+\hat{k})T$ (d) $(\hat{\imath}+\hat{\jmath}-\hat{k})T$

Q 7. A charged particle is projected with velocity $v_0$ along positive x-axis. The magnetic field B is directed along negative z-axis between x = 0 and x = L. The particle emerges out (at x = L) at an angle of 60° with the direction of projection. Find the velocity with which the same particle is projected (at x =0) along positive x-axis so that when it emerges out (at x = L), the angle made by it is 30° with the direction of projection:
(a) $2\,v_0$ (b) $v_0/2$ (c) $v_0/\sqrt{3}$ (d) $v_0\sqrt{3}$

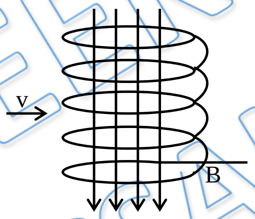
Q 8. A block of mass m & charge q is released on a long smooth inclined plane. Magnetic field B is constant, uniform, horizontal and parallel to surface as shown. Find the time from start when block loses contact with the surface –



(a) $\frac{m\cos\theta}{qB}$ (b) $\frac{m\,cos\,ec\theta}{qB}$
(c) $\frac{m\cot\theta}{qB}$ (d) none of these

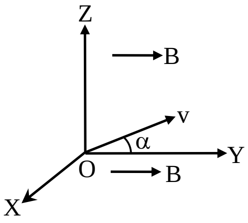
Q 9. Two particles of charges +Q and –Q are projected from the same point with a velocity v in a region of uniform magnetic field B such that the velocity vector makes an angle θ with the magnetic field. Their masses are M and 2M, respectively. Then, they will meet again for the first time at a point whose distance from the point of projection is-
(a) 2πMv cos θ/QB (b) 8 π Mv cos θ /QB
(c) π Mv cos θ /QB (d) 4 π Mv cos θ /QB

Q 10. A direct current flowing through the winding of a long cylindrical solenoid of radius R produces in it a uniform magnetic field of induction $\vec{B}$. An electron flies into the solenoid along the radius between its turns (at right angles to the solenoid axis) at a velocity $\vec{v}$ (Figure). After a certain time, the electron deflected by the magnetic field leaves the solenoid. Determine the time *t* during which the electron moves in the solenoid.



(a) $\frac{m}{eB}\tan^{-1}\frac{eBR}{mv}$ (b) $\frac{2m}{eB}\tan^{-1}\frac{eBR}{mv}$
(c) $\frac{m}{eB}\tan^{-1}\frac{mv}{eBR}$ (d) $\frac{2m}{eB}\tan^{-1}\frac{mv}{eBR}$

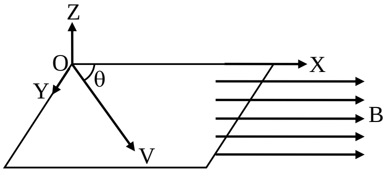
Q 11. In a region of space, a uniform magnetic field B exists in the y-direction. A proton is fired from the origin, with its initial velocity v making a small angle α with the y-direction in the y-z plane. In the subsequent motion of the proton –



(a) its x-coordinate can never be positive
(b) its x-and z-coordinates cannot both be zero at the same time
(c) its z-coordinate can never be negative
(d) its y-coordinate will be proportional to the square of its time of flight

Q 12. A charged particle is moving with constant speed in a horizontal x-y plane in a straight line as shown. Suddenly a uniform magnetic field is switched on parallel to

X-axis, when particle is at origin. What must be the value of θ so that particle passes through point P (L, 0, –H) in the minimum possible time ?



(a) θ = $\tan^{-1}\left(\frac{\pi H}{2L}\right)$
(b) θ = $\tan^{-1}\left(\frac{\pi H}{4L}\right)$
(c) θ = $\tan^{-1}\left(\frac{\pi H}{3L}\right)$
(d) θ = $\tan^{-1}\left(\frac{2\pi H}{3L}\right)$

Q 13. A charged particle of specific charge (charge/mass) α is released from origin at time t =0 with velocity $\vec{v} = v_0(\hat{\imath} + \hat{\jmath})$ in uniform magnetic field $\vec{B} = -B_0\hat{\imath}$. Co-ordinates of the particle at time t = $\frac{\pi}{B_0\alpha}$ are :

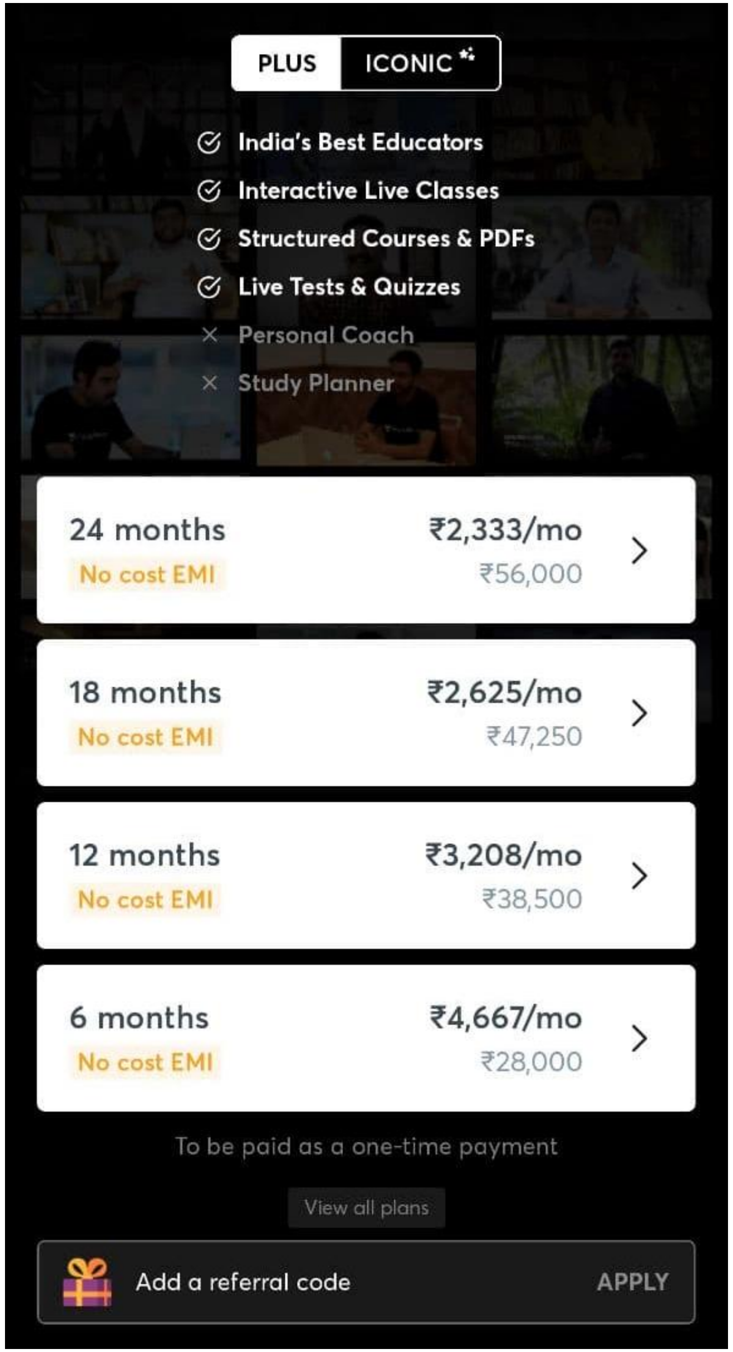
(a) $\left(\frac{v_0}{2B_0\alpha}, \frac{\sqrt{2}v_0}{\alpha B_0}, \frac{-v_0}{B_0\alpha}\right)$ (b) $\left(\frac{-v_0}{2B_a\alpha}, 0,0\right)$
(c) $\left(0, \frac{2v_0}{B_0\alpha}, \frac{v_0\pi}{2B_0\alpha}\right)$ (d) $\left(\frac{v_0\pi}{B_0\alpha}, 0, \frac{-2v_0}{B_0\alpha}\right)$

Q 14. Two very long straight parallel wires carry steady currents i and 2i in opposite directions. The distance between the wires is d. At a certain instant of time a point charge q is at a point equidistant from the two wires in the plane of the wires. Its instantaneous velocity $\vec{v}$ is perpendicular to this plane. The magnitude of the force due to the magnetic field acting on the charge at this instant is:

(a) $\frac{\mu_0 iqv}{2\pi d}$ (b) $\frac{\mu_0 iqv}{\pi d}$ (c) $\frac{3\mu_0 iqv}{2\pi d}$ (d) zero

# Answer Key

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



PLUS ICONIC

- India's Best Educators
- Interactive Live Classes
- Structured Courses & PDFs
- Live Tests & Quizzes
- Personal Coach
- Study Planner

24 months ₹2,333/mo
No cost EMI ₹56,000

18 months ₹2,625/mo
No cost EMI ₹47,250

12 months ₹3,208/mo
No cost EMI ₹38,500

6 months ₹4,667/mo
No cost EMI ₹28,000

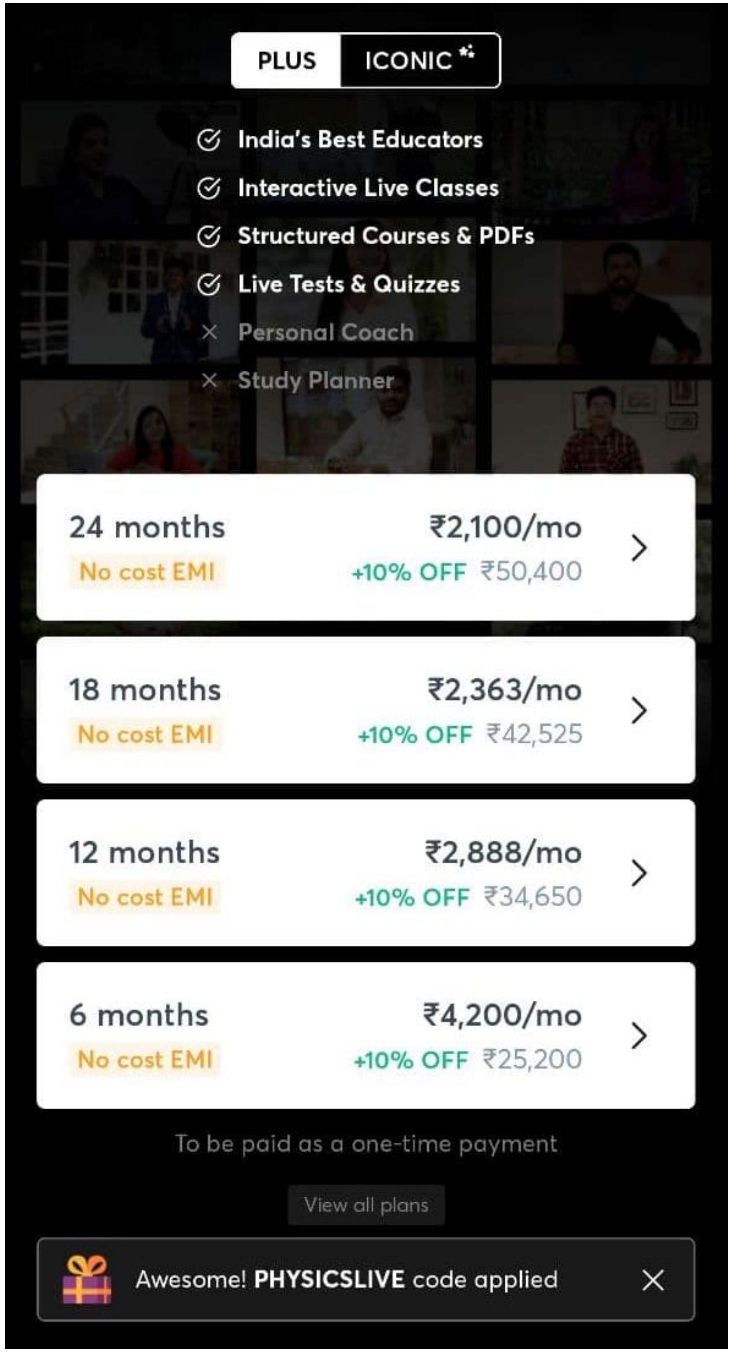
To be paid as a one-time payment

View all plans

Add a referral code APPLY

# PHYSICSLIVE

Use code PHYSICSLIVE to get 10% OFF on Unacademy PLUS.



PLUS ICONIC

- India's Best Educators
- Interactive Live Classes
- Structured Courses & PDFs
- Live Tests & Quizzes
- Personal Coach
- Study Planner

24 months ₹2,100/mo
No cost EMI +10% OFF ₹50,400

18 months ₹2,363/mo
No cost EMI +10% OFF ₹42,525

12 months ₹2,888/mo
No cost EMI +10% OFF ₹34,650

6 months ₹4,200/mo
No cost EMI +10% OFF ₹25,200

To be paid as a one-time payment

View all plans

Awesome! **PHYSICSLIVE** code applied

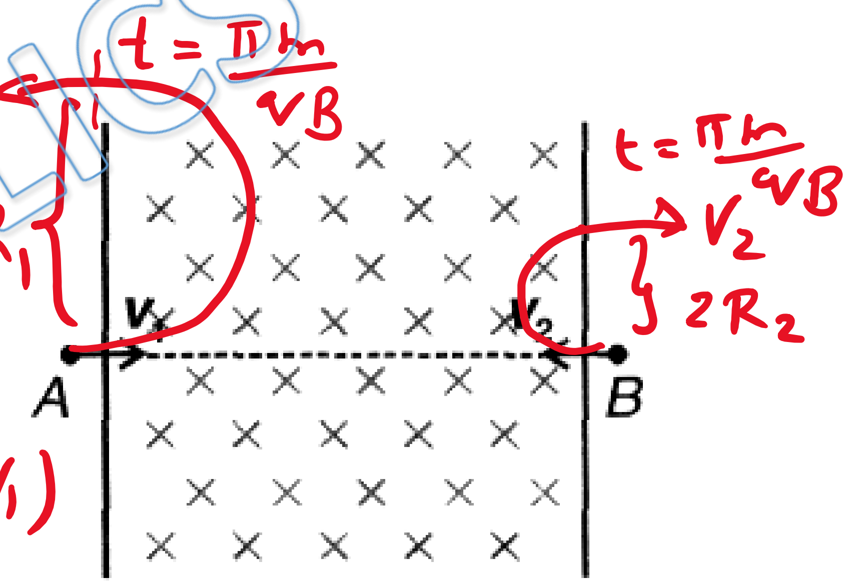
# Written Solution

## DPP- 3 Moving charge in Magnetic field, Helical path

## By Physicsaholics Team

Q.1) Two particles A and B of same mass and having charges of same magnitude but of opposite nature are thrown in a region of magnetic field (as shown) with speeds $v_1$ and $v_2$ ($v_1 > v_2$). At the time particle A escapes out of the magnetic field, angular momentum of particle B w.r.t. particle A is proportional to (Assume both the particles escape in the region from where they respectively entered the field)

w.r.t. A at $t = \frac{\pi m}{qB}$



(a) $v_1 + v_2$

(b) $v_1 - v_2$

[✓ (c) $v_1^2 - v_2^2$]

(d) $v_1^2 + v_2^2$

$$L_{B,A} = 2(R_1 - R_2)(V_2 + V_1)m$$

$$= 2m \frac{m}{qB}(V_1 - V_2)(V_1 + V_2)m$$

$$\propto V_1^2 - V_2^2$$

Q.2) Trajectories of three particles A , B and C projected perpendicular to a uniform transverse magnetic field in three different cases are shown in figure. A, B and C can be

from Case3 →

A & C have equal charge. means ${}_2He^4$ is B.

$R = \frac{P}{qB} \Rightarrow$ same R same P

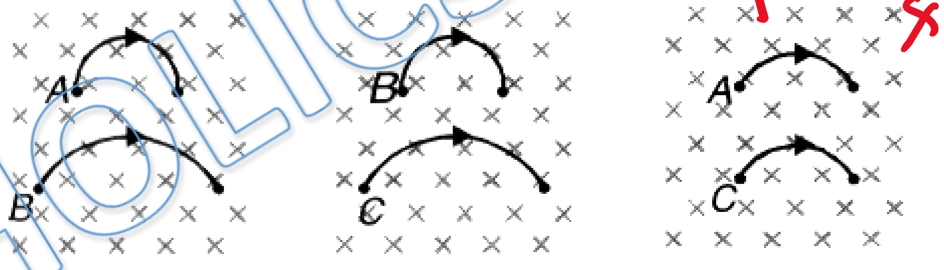
↑ means same q

✓ (a) ${}_1^1H$, ${}_2^4He$, ${}_1^2H$

(b) ${}_1^1H$, ${}_1^2H$ , ${}_2^4He$

(c) ${}_1^2H$ , ${}_2^4He$, ${}_1^1H$

(d) ${}_2^4He$, ${}_1^1H$, ${}_1^2H$



Case I (Speed of particles is same)

Case II (Kinetic energy is same)

Case III (Momentum is same)

↓

$$R = \frac{mv}{qB} = \left(\frac{m}{q}\right)\frac{v}{B}$$

$$R_A < R_B$$

$$\Rightarrow \left(\frac{m}{q}\right)_A < \left(\frac{m}{q}\right)_B$$

form Case 1

$$\left(\frac{m}{q}\right)_A < \left(\frac{m}{q}\right)_B$$

Sim $\frac{m}{q}$ is same for ${}_1H^2$ & ${}_2He^4$,

A is ${}_1H^1$

Q.3) A particle of mass m and charge q enters a region of magnetic field (as shown) with speed v. There is a region in which the magnetic field is absent, as shown. The particle after entering the region collides elastically with a rigid wall. Time after which the velocity of particle becomes antiparallel to its initial velocity is

ABC & CDE are symmetric.

Angle of deflection $\theta = \sin^{-1}\left(\frac{d}{R}\right)$

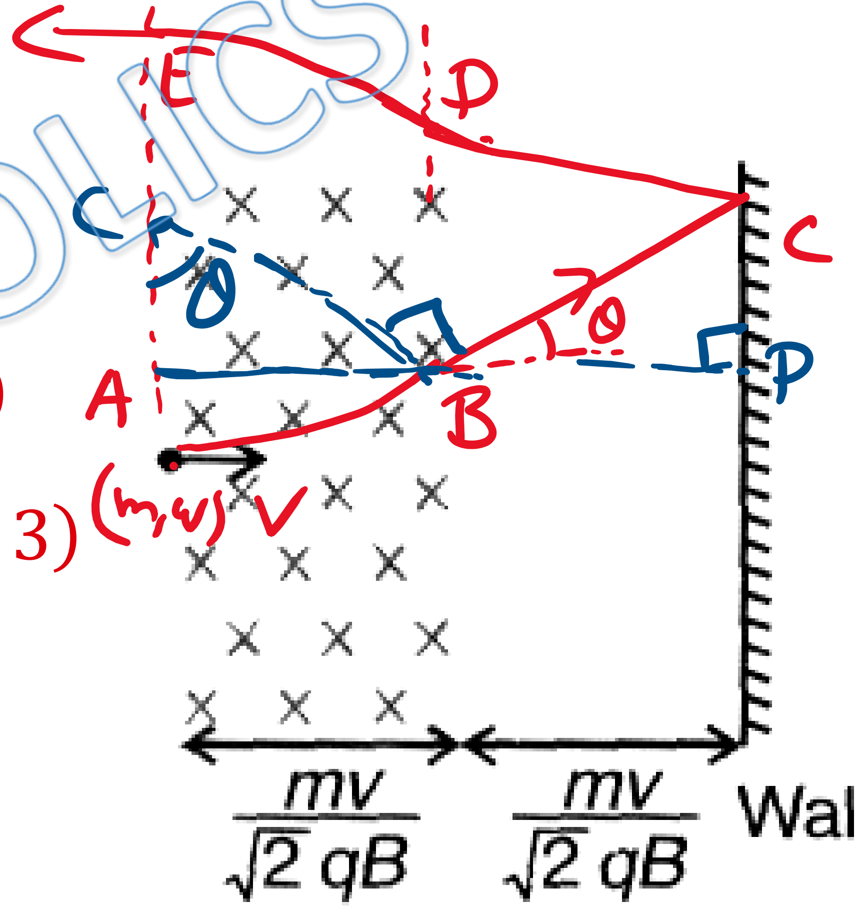
$\theta = \sin^{-1}\left(\frac{1}{\sqrt{2}}\right) = \pi/4$

(a) $\frac{m}{2qB}(\pi + 4)$

(b) $\frac{m}{qB}(\pi + 2)$

(c) $\frac{m}{4qB}(\pi + 2)$

(d) $\frac{m}{4qB}(2\pi + 3)$



$t_{AB} = \theta/\omega$

$= \frac{\pi m}{4qB}$

$\cos 45^\circ = \frac{BP}{BC} \Rightarrow BC = mv/qB$

$t_{BC} = \frac{BC}{v} = \frac{m}{qB}$

$$\text{total time} = 2\left(t_{AB} + t_{BC}\right)$$

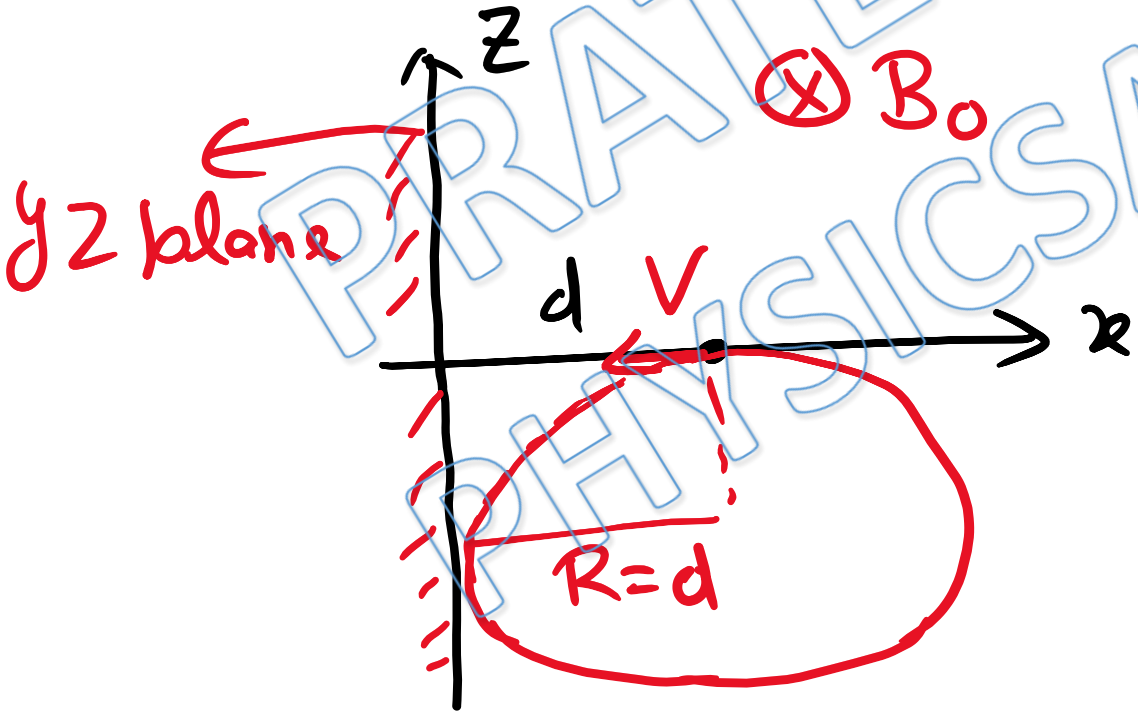
$$= 2\left(\frac{\pi m}{4qB} + \frac{m}{qB}\right)$$

$$= \frac{m}{2qB}\left(\pi + 4\right)$$

Ans. a

Q.4) A uniform magnetic field $\vec{B} = B_0\hat{j}$ exists in space. A particle of mass m and charge q is projected towards negative x-axis with speed v from a point (d 0, 0). The maximum value of v for which the particle does not hit the y-z plane is:

(a) $\frac{2Bq}{dm}$ [✓ (b) $\frac{Bqd}{m}$] (c) $\frac{Bq}{2dm}$ (d) $\frac{Bqd}{2m}$

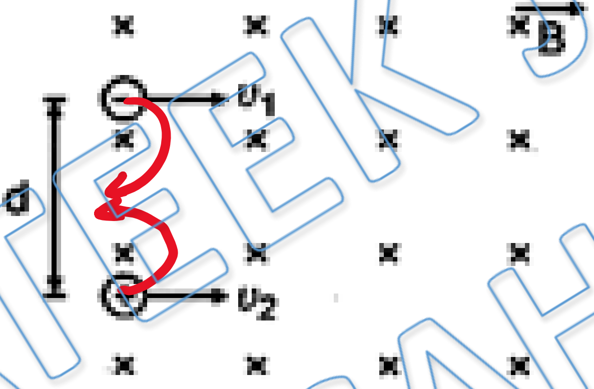


At max value of V particle with just touch yz plane.

$$R = d = \frac{mV}{qB}$$

$$V = qBd/m$$

Q.5) Two identical particles having the same mass m and charges +q and -q separated by a distance d enter in uniform magnetic field B directed perpendicular to paper inwards with speeds $v_1$ and $v_2$ as shown in figure. The particles will not collide if: (Ignore electrostatic force)



$d = 2R_1 + 2R_2$ for just collision.

$d > 2R_1 + 2R_2 \rightarrow$ no collision

(a) $d > \frac{m}{Bq}(v_1 + v_2)$

(b) $d < \frac{m}{Bq}(v_1 + v_2)$

✓ (c) $d > \frac{2m}{Bq}(v_1 + v_2)$

(d) $v_1 = v_2$

$$d > \frac{2m}{qB}(v_1 + v_2)$$

Q.6) A charged particle having charge q experience a force $\vec{F}_1 = q(-\hat{j} + \hat{k})$ N in a magnetic field $\vec{B}$ when it has a velocity $\vec{v}_1 = 1\hat{i}$ m/s. The force becomes $\vec{F}_1 = q(\hat{i} - \hat{k})$ N when the velocity is changed to $\vec{v}_2 = 1\hat{j}$ m/s. The magnetic induction vector at that point is :

$$\vec{F_1} = q(\vec{V_1} \times \vec{B}) \Rightarrow q(-\hat{j} + \hat{k}) = q\,\hat{i} \times (B_x\hat{i} + B_y\hat{j} + B_z\hat{k})$$

$$\Rightarrow -\hat{j} + \hat{k} = B_y\hat{j} - B_z\hat{j}$$

$$\Rightarrow B_z = 1 \quad , B_y = 1$$

✓ (a) $(\hat{i} + \hat{j} + \hat{k})T$

(b) $(\hat{i} - \hat{j} - \hat{k})T$

(c) $(-\hat{i} - \hat{j} + \hat{k})T$

(d) $(\hat{i} + \hat{j} - \hat{k})T$

$$\vec{F_2} = q(\vec{V} \times \vec{B}) \Rightarrow q(\hat{i} - \hat{k}) = q\,\hat{j} \times (B_x\hat{i} + B_y\hat{j} + B_z\hat{k})$$

$$\Rightarrow \hat{i} - \hat{k} = -B_x\hat{k} + B_z\hat{i}$$

$$B_x = 1$$

Q.7) A charged particle is projected with velocity $v_0$ along positive x-axis. The magnetic field B is directed along negative z-axis between x = 0 and x = L. The particle emerges out (at x = L) at an angle of 60° with the direction of projection. Find the velocity with which the same particle is projected (at x =0) along positive x-axis so that when it emerges out (at x = L), the angle made by it is 30° with the direction of projection:

$$\sin\theta = \frac{d}{R} = \frac{d\,qB}{mv}$$

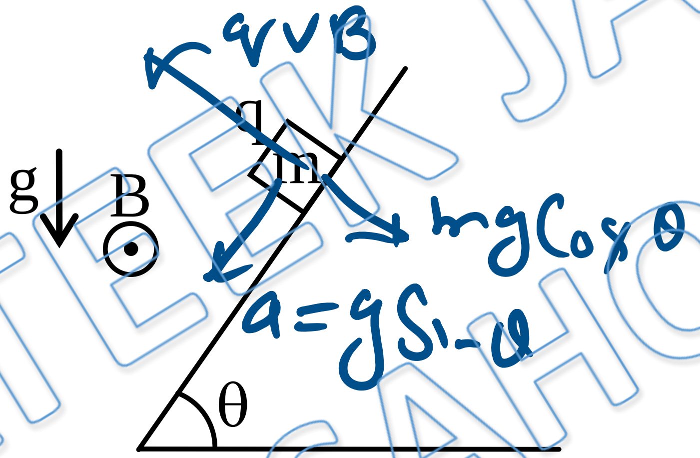
(a) $2\,v_0$
(b) $v_0/2$
(c) $v_0/\sqrt{3}$
[✓ (d) $v_0\sqrt{3}$]

$$V = \frac{qBd}{m\sin\theta.}$$

$$V_0 = \frac{qBd}{m\sin 60^\circ}$$

$$V = \frac{qBd}{m\sin 30} = \frac{V_0 \sin 60}{\sin 30} = V_0\sqrt{3}$$

Q.8) A block of mass m & charge q is released on a long smooth inclined plane. Magnetic field B is constant, uniform, horizontal and parallel to surface as shown. Find the time from start when block loses contact with the surface –



To loose Contact

$$qvB = mg\cos\theta$$

$$v = \frac{mg\cos\theta}{qB}$$

$$v = u + at$$

$$\frac{mg\cos\theta}{qB} = g\sin\theta \cdot t$$

$$t = \frac{m\cot\theta}{qB}$$

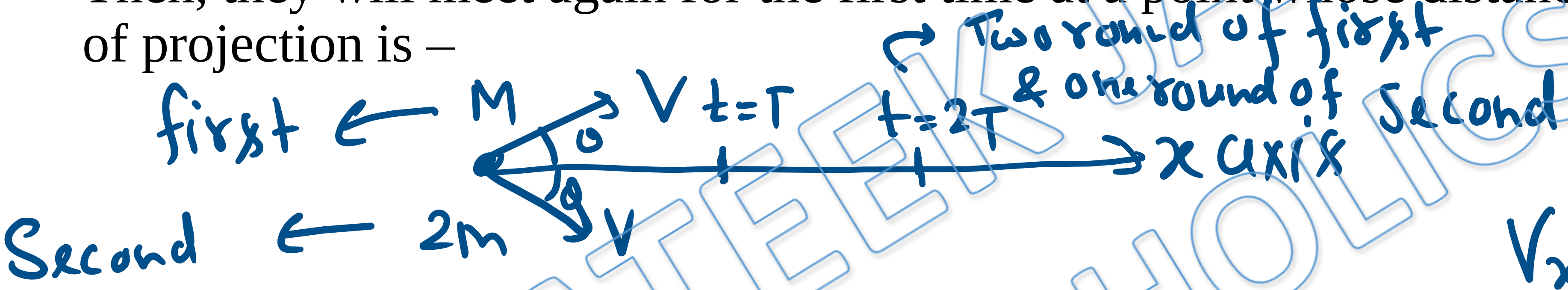
[✓ (a) $\frac{m\cos\theta}{qB}$]

(b) $\frac{m\,\mathrm{cosec}\,\theta}{qB}$

(c) $\frac{m\cot\theta}{qB}$

(d) none of these

Q.9) Two particles of charges +Q and –Q are projected from the same point with a velocity v in a region of uniform magnetic field B such that the velocity vector makes an angle θ with the magnetic field. Their masses are M and 2M, respectively. Then, they will meet again for the first time at a point whose distance from the point of projection is –



(a) 2πMv cos θ/QB

(b) 8 π Mv cos θ /QB

(c) π Mv cos θ /QB

(d) 4 π Mv cos θ /QB

$V_x$ is equal & Constant for both.

Timeperiod of first $T = \frac{2\pi m}{QB}$

Timeperiod of Second

$$T' = \frac{4\pi M}{QB} = 2T$$

particles will return to x axis after Completing integeral no of rounds.

at $t = T' = 2T$

both will be on $x$ axis at bosition

$$x = V\cos\theta \cdot T'$$

$$= \frac{4\pi M V\cos\theta}{QB}$$

Ans. d

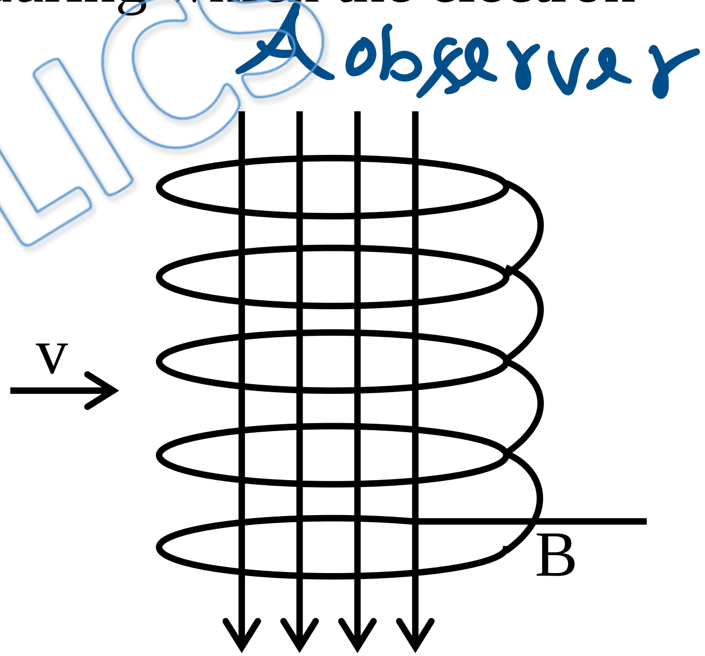
Q.10) A direct current flowing through the winding of a long cylindrical solenoid of radius R produces in it a uniform magnetic field of induction $\vec{B}$. An electron flies into the solenoid along the radius between its turns (at right angles to the solenoid axis) at a velocity $\vec{v}$ (Figure). After a certain time, the electron deflected by the magnetic field leaves the solenoid. Determine the time *t* during which the electron moves in the solenoid.

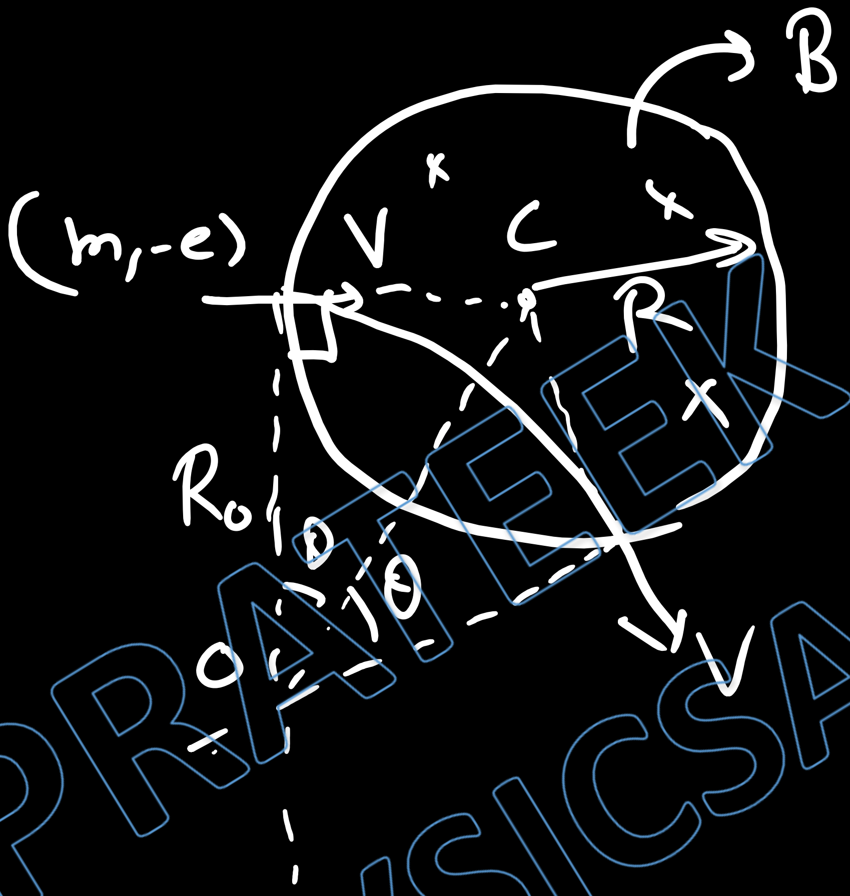
(a) $\frac{m}{eB}\tan^{-1}\frac{eBR}{mv}$

[✓ (b) $\frac{2m}{eB}\tan^{-1}\frac{eBR}{mv}$]

(c) $\frac{m}{eB}\tan^{-1}\frac{mv}{eBR}$

(d) $\frac{2m}{eB}\tan^{-1}\frac{mv}{eBR}$





Radius of circular path $R_0 = \frac{mV}{eB}$

$$\tan\theta = \frac{R}{R_0} = \frac{eBR}{mV}$$

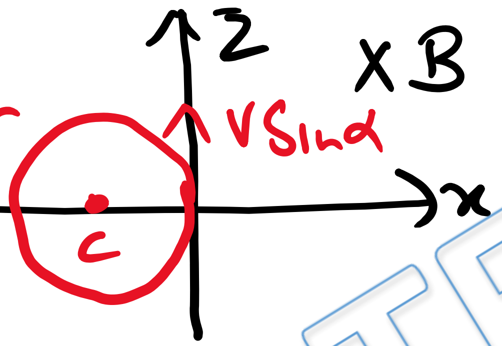
$$t = \frac{2\theta}{\omega}$$

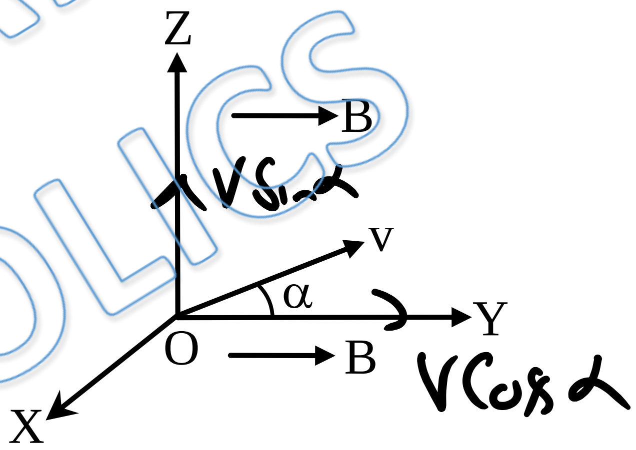
$$= \frac{2m}{qB}\tan^{-1}\left(\frac{eBR}{mV}\right)$$

Ans. b

Q.11) In a region of space, a uniform magnetic field B exists in the y-direction. A proton is fired from the origin, with its initial velocity v making a small angle α with the y-direction in the y-z plane. In the subsequent motion of the proton –

Circular projection of hellical path.





(a) its x-coordinate can never be positive

(b) its x-and z-coordinates cannot both be zero at the same time

(c) its z-coordinate can never be negative

(d) its y-coordinate will be proportional to the square of its time of flight

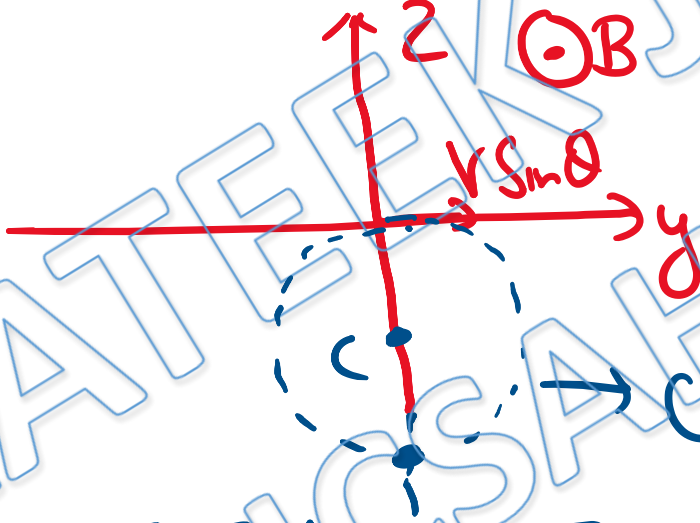
Q.12) A charged particle is moving with constant speed in a horizontal x-y plane in a straight line as shown. Suddenly a uniform magnetic field is switched on parallel to X-axis, when particle is at origin. What must be the value of θ so that particle passes through point P (L, 0, –H) in the minimum possible time ?

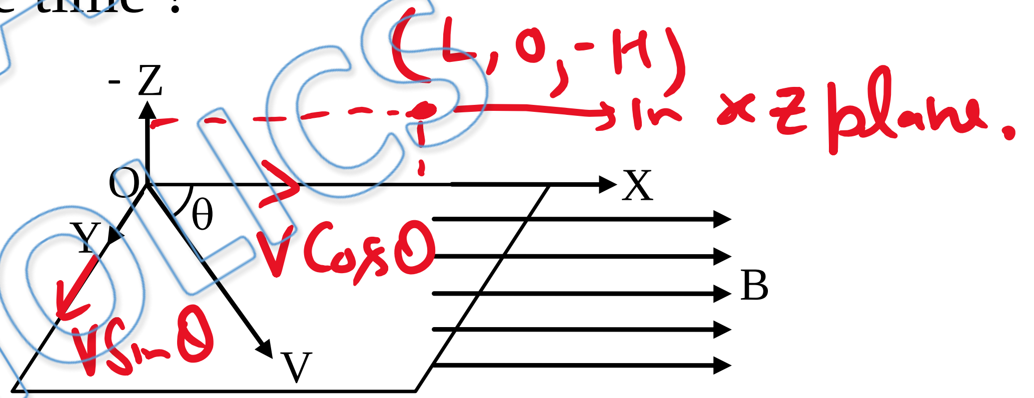
(a) $\theta = \tan^{-1}\left(\frac{\pi H}{2L}\right)$ ✓

(b) $\theta = \tan^{-1}\left(\frac{\pi H}{4L}\right)$

(c) $\theta = \tan^{-1}\left(\frac{\pi H}{3L}\right)$

(d) $\theta = \tan^{-1}\left(\frac{2\pi H}{3L}\right)$





→ Circular projection of hellical path.

In x-z plane Z co-ordinate of particle will be either 0 or -2R.

So $H = 2R = \frac{2mv}{qB}\sin\theta$

$$H = \frac{mv}{qB}\sin\theta$$

$$\Rightarrow \sin\theta = \frac{qBH}{mv} \text{ --- } (1)$$

Since $v_x = v\cos\theta = \text{Constant}$ $\quad L = v\cos\theta . t$

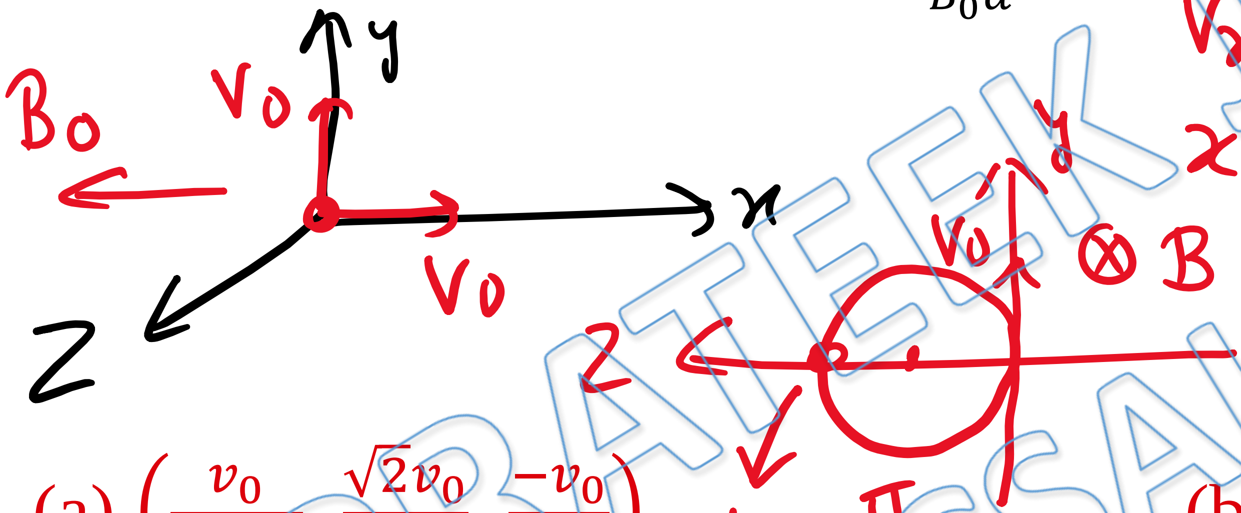
Let particle reaches to given position at

$t = \underset{\downarrow \text{ odd number}}{n}$ (half time period) $= n\pi m/qB$ Ans. a

$$L = v\cos\theta . \frac{n\pi m}{qB} \Rightarrow \cos\theta = \frac{qBL}{n\pi mL} \text{ --- } (1)$$

$\tan\theta = \frac{n\pi H}{2L}$ for min $\theta$, $n=1 \Rightarrow \theta = \tan^{-1}\left(\frac{\pi H}{2L}\right)$

Q.13) A charged particle of specific charge (charge/mass) α is released from origin at time t =0 with velocity $\vec{v} = v_0(\hat{\imath} + \hat{\jmath})$ in uniform magnetic field $\vec{B} = -B_0\hat{\imath}$. Co-ordinates of the particle at time t = $\frac{\pi}{B_0\alpha}$ are :



$V_x = V_0$ = Constant.

$x = V_x . t = \frac{V_0 \pi}{B_0 \alpha}$

$t = \frac{\pi}{B_0 \alpha}$ = Half time period.

(a) $\left(\frac{v_0}{2B_0\alpha}, \frac{\sqrt{2}v_0}{\alpha B_0}, \frac{-v_0}{B_0\alpha}\right)$

(b) $\left(\frac{-v_0}{2B_a\alpha}, 0, 0\right)$

(c) $\left(0, \frac{2v_0}{B_0\alpha}, \frac{v_0\pi}{2B_0\alpha}\right)$

✓(d) $\left(\frac{v_0\pi}{B_0\alpha}, 0, \frac{2v_0}{B_0\alpha}\right)$

$t = \frac{\pi}{B_0 \alpha}$

$z = 2R = \frac{2mV_0}{qB_0} = \frac{2V_0}{B_0\alpha}$

Q.14) Two very long straight parallel wires carry steady currents i and 2i in opposite directions. The distance between the wires is d. At a certain instant of time a point charge q is at a point equidistant from the two wires in the plane of the wires. Its instantaneous velocity $\vec{v}$ is perpendicular to this plane. The magnitude of the force due to the magnetic field acting on the charge at this instant is:

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

$= 0$

Since $\vec{V}$ is anti parallel to $\vec{B}$.

(a) $\frac{\mu_0 iqv}{2\pi d}$ (b) $\frac{\mu_0 iqv}{\pi d}$ (c) $\frac{3\mu_0 iqv}{2\pi d}$ [✓ (d) zero]

## For Video Solution of this DPP, Click on below link

| | |
|---|---|
| Video Solution on Website:- | https://physicsaholics.com/home/courseDetails/97 |
| Video Solution on YouTube:- | https://youtu.be/AIqRysIjOXs |
| Written Solution on Website:- | https://physicsaholics.com/note/notesDetalis/51 |

SUBSCRIBE

@Physicsaholics

@Physicsaholics_prateek

@NEET_Physics
@IITJEE_Physics

physicsaholics.com

Unacademy

CLICK

# Chalo Niklo