سارونا

Principles of physics (10th eddition)

phy 132

CH28: Magnatic Fields

Problems: 4, 10, 18, 27, 47, 49, 54, 63

P4: An electron follows a helical path in a uniform magnatic field given by $\vec{B} = (20\hat{i} - 50\hat{j} - 30\hat{k})$ mT. At time $t=0$, the electron's Velocity is given by $\vec{v} = (40\hat{i} - 30\hat{j} + 50\hat{k})$ m/s. (a) what is the angle ϕ between $\vec{v}$ and $\vec{B}$? The electron's velocity changes with time. Do (b) its speed and (c) the angle ϕ change with time? (d) What is the radius of the helical path?

Sol: $\vec{v} = (40\hat{i} - 30\hat{j} + 50\hat{k})$ m/s

$\vec{B} = (20\hat{i} - 50\hat{j} - 30\hat{k}) \times 10^{-3}$

$\vec{B} = (0.020\hat{i} - 0.050\hat{j} - 0.030\hat{j})$ T

a) $\vec{v} \times \vec{B} = |\vec{v}||\vec{B}| \sin\phi$

$$\Rightarrow \vec{v}\times\vec{B} = \begin{vmatrix} \overset{+}{\hat{i}} & \overset{-}{\hat{j}} & \overset{+}{\hat{k}} \\ 40 & -30 & 50 \\ 0.020 & -0.050 & -0.030 \end{vmatrix}$$

$$= (-30 \times -0.030 - 50 \times -0.050)\hat{i} - (40 \times -0.030 - 50 \times 0.020)\hat{j} + (40 \times -0.050 - -30 \times 0.020)\hat{k}$$

$$= 3.4\hat{i} - (-2.2)\hat{j} + -1.4\hat{k}$$

$$= 3.4\hat{i} + 2.2\hat{j} - 1.4\hat{k}$$

$$|\vec{v}\times\vec{B}| = \sqrt{(3.4)^2 + (2.2)^2 + (-1.4)^2}$$

$$= \sqrt{18.36}$$

$$= 4.28 \text{ m.T/s}$$

$$|\vec{v}| = \sqrt{40^2 + (-30)^2 + (50)^2} = \sqrt{5000} = 70.71 \text{ m/s}$$

$$|\vec{B}| = \sqrt{(0.02)^2 + (-0.05)^2 + (0.03)^2} = \sqrt{3.8 \times 10^{-3}} = 61.6 \times 10^{-3} \text{ T}$$

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$\vec{V} \times \vec{B} = |V||B| \sin\phi$

$$\sin\phi = \frac{|\vec{V} \times \vec{B}|}{|\vec{U}||\vec{B}|} \Rightarrow \phi = \sin^{-1}\left(\frac{(\vec{U} \times \vec{B})}{|\vec{U}||\vec{B}|}\right)$$

$$\phi = \sin^{-1}\left(\frac{4.28}{70.71 \times 61.6 \times 10^{-3}}\right)$$

$$\phi = \sin^{-1}(0.98$$

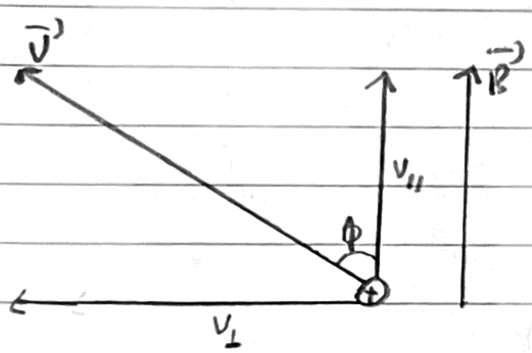
$$\phi = 79.08$$

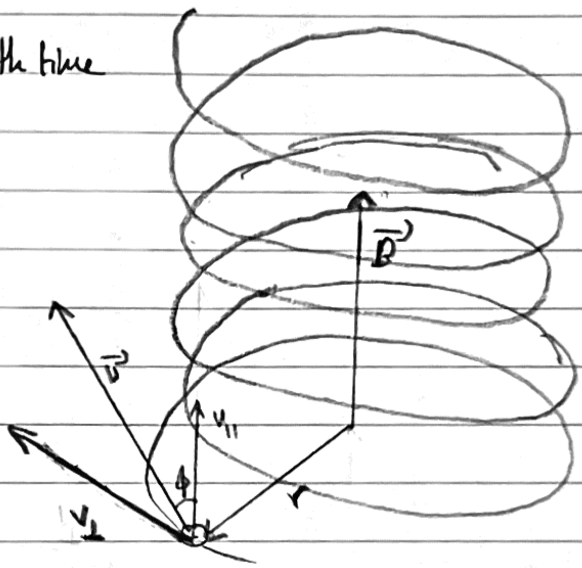
$$\phi \simeq 79.1^\circ$$

The angle between $\vec{U}$ and $\vec{B}$ is 79.1°

b) The magnetic field changes the direction of motion of the particle, but it can't change its speed
$\Rightarrow$ The speed doesn't change with time or the kinetic energy

c) The angle doesn't change with time





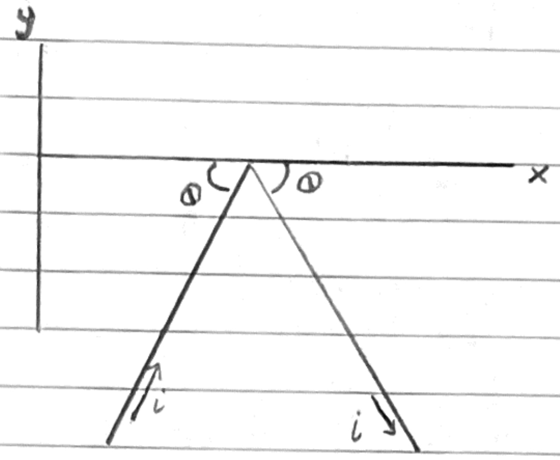
d) $F_B = F_c$, $V_{\perp} = U \sin\phi$

$$qV_{\perp}B = \frac{mV_{\perp}^2}{r} \Rightarrow r = \frac{mV}{qB} \sin\theta = \frac{9.11 \times 10^{-31} \times 70.71}{1.6 \times 10^{-19} \times 61.6 \times 10^{-3}} \sin 79.1$$

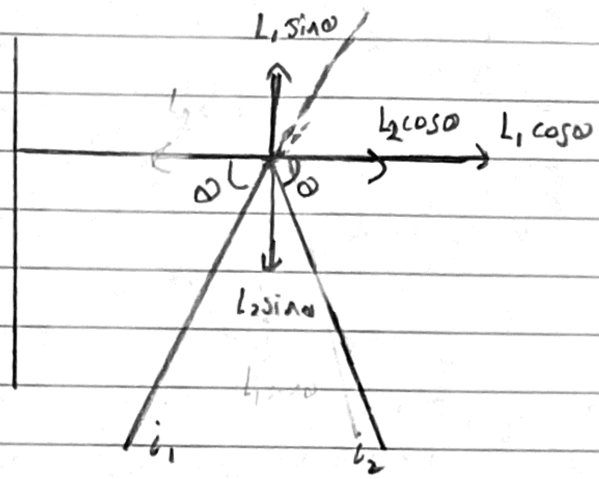
$$= 6.42 \times 10^{-9} \text{ m}$$

سارة

P10: The bent wire shown in Fig 28-25 lies in a uniform magnatic field. Each straight section is 2.0 m long and makes an angle of $\theta = 60°$ with the x-axis and the wire carries a current of 3.5 A. What is the net magnetic force on the wire in unit-vector notation if the magnatic field is given by (a) $4.0\hat{k}$ T and (b) $4.0\hat{i}$ T?



Sol:



$\vec{L}_1 = L_1 \cos\theta\,\hat{i} + L_1 \sin\theta\,\hat{j}$ $\qquad L_1 = L_2 = 2m \Rightarrow L$

$\vec{L}_1 = L \cos\theta\,\hat{i} + L \sin\theta\,\hat{j}$

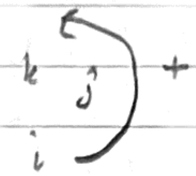
$\vec{L}_2 = L_2 \cos\theta\,\hat{i} - L_2 \sin\theta\,\hat{j}$

$\vec{L}_2 = L \cos\theta\,\hat{i} - L \sin\theta\,\hat{j}$

$\Rightarrow \quad \vec{L} = 2L \cos\theta\,\hat{i}$

سارة جبار

a) $B = 4\hat{k}\ T$



$$\vec{F}_B = iL \times B$$
$$= i(2L\cos\theta\,\hat{i}) \times 4\hat{k}$$
$$= 3.5 \times 2 \times 2 \times \cos 60\ (\hat{i} \times k)$$
$$= 7(-\hat{j})$$
$$F_B = -7\hat{j}\ N$$

b) $\vec{F}_B = iL \times B$
$$= i(2L\cos\theta\,\hat{i}) \times 4\hat{i}$$
$$= \text{zero}$$

توضيح

$$\vec{F}_{net} = \vec{F}_{B_1} + \vec{F}_{B_2}$$
$$= i_1 L_1 \times B + i_2 L_2 \times B$$
$$= i_1(L_1\cos\theta\,\hat{i} + L_1\sin\theta\,\hat{j}) \times B + i_2(L_2\cos\theta\,\hat{i} - L_2\sin\theta\,\hat{j}) \times B$$

but $i_1 = i_2 = i = 3.5\,A$

$L_1 = L_2 = L = 2\,m$

$$F_{net} = i(L\cos\theta\,\hat{i} + L\sin\theta\,\hat{j}) \times B + i(L\cos\theta\,\hat{i} - L\sin\theta\,\hat{j}) \times B$$
$$= i\left[L\cos\theta\,\hat{i} + \cancel{L\sin\theta\,\hat{j}} + L\cos\theta\,\hat{i} - \cancel{L\sin\theta\,\hat{j}}\right] \times B$$
$$= i(2L\cos\theta\,\hat{i}) \times B$$

سارة بنا

P18: An electron is accelerated from rest by a potential difference of 380 V. It then enters a uniform magnetic field of magnitude 200 mT with its velocity perpendicular to the field. calculate (a) the speed of the electron and (b) the radius of its path in the magnetic field.

Sol: $V = 380$ Volt , $B = 200\ mT = 200 \times 10^{-3}\ T$

a) we use the conservation of energy

$$PE = KE$$

$$qV = \frac{1}{2} m v^2$$

$$v^2 = \frac{2qV}{m}$$

$$v = \sqrt{\frac{2qV}{m}}$$

$$v = \sqrt{\frac{2 \times 1.6 \times 10^{-19} \times 380}{9.11 \times 10^{-31}}}$$

$$v = 1.155 \times 10^{7}\ m/s$$

b) The electron moves in a circular path in a magnetic field because the magnetic force is balanced by centripetal force

$$qvB = \frac{mv^2}{r} \Rightarrow r = \frac{mv}{qB} = \frac{9.11 \times 10^{-31} \times 1.155 \times 10^{7}}{1.6 \times 10^{-19} \times 200 \times 10^{-3}}$$

$$r = 3.288 \times 10^{-4}\ m$$

سارة بكار

P27: A positron with kinetic energy 950 eV is projected into a uniform magnatic field $\vec{B}$ of magnitude 0.732 T, with its velocity vector making an angle of 89.0° with $\vec{B}$. Find (a) the period (b) the pitch p and (c) the radius r of its helical path.

sol: $T = \frac{2\pi r}{V}$

$K = 950\ eV = 950 \times 1.6 \times 10^{-19} = 1.52 \times 10^{-16}\ J$

$B = 0.732\ T$

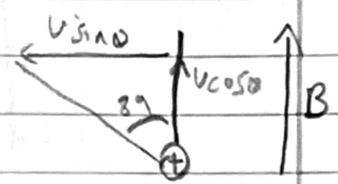
dor $p = V\cos\phi \times T$

$\phi = 89$

$r = \frac{m_e v \sin\phi}{eB}$ helical path

$K = \frac{1}{2} m_e V^2$

a) $T = \frac{2\pi r}{V} = \frac{2\pi r}{V\sin\phi}$



but $r = \frac{m_e v \sin\phi}{eB}$ (helical path)

$T = \frac{2\pi}{\cancel{V\sin\phi}} \frac{m_e \cancel{v\sin\phi}}{eB}$

$= \frac{2\pi m_e}{eB}$

$= \frac{2(3.14)(9.11 \times 10^{-31})}{(1.6 \times 10^{-19})(0.732)}$

$= 4.88 \times 10^{-11}$

$= 48.8 \times 10^{-12}\ s$

$= 48.8\ ps$

سارة نجار

b) $k = \frac{1}{2} m v^2 \Rightarrow v = \sqrt{\frac{2k}{m}}$

$$= \sqrt{\frac{2 \times 1.52 \times 10^{-16}}{9.11 \times 10^{-31}}}$$

$$= \sqrt{1.668 \times 10^{14}}$$

$$v = 1.83 \times 10^{7} \ m/s$$

$$d = v \cos\theta \, t$$
$$d = 1.83 \times 10^{7} \cos 89 \times 48.8 \times 10^{-12}$$
$$d = 1.558 \times 10^{-5}$$
$$d \simeq 15.6 \ \mu m$$

c) $r = \frac{m v \sin\theta}{qB}$

$$r = \frac{9.11 \times 10^{-31} \times 1.83 \times 10^{7} \sin 89}{1.6 \times 10^{-19} \times 0.732}$$

$$r = 1.42 \times 10^{-4} \ m$$
$$r = 0.142 \times 10^{-3} \ m$$
$$r = 0.142 \ mm$$

سلاس/ مجلار

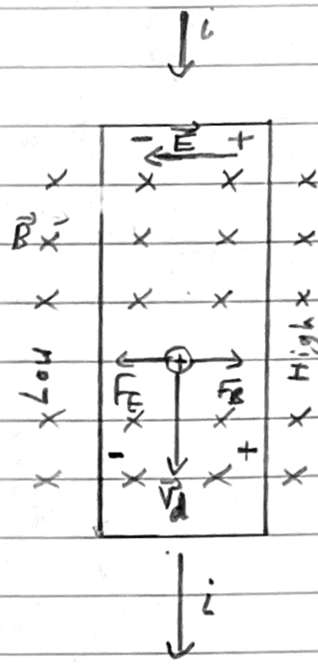
P47: A strip of copper 75.0 μm thick and 4.5 mm wide is placed in a uniform magnetic field $\vec{B}$ of magnitude 0.65T, with $\vec{B}$ perpendicular to the strip. A current $i = 57\,A$ is then sent through the strip such that a Hall potential difference V appears across the width of the strip. calculate V. (The number of charge carriers per unit volume for copper is 8.47×10^{28} electrons/m^3)

Sol: $L = 75.0\,\mu m$

$B = 0.65\,T$

$i = 57\,A$

$n = 8.47 \times 10^{28}$ electron/m^3



$$n = \frac{Bi}{VLe}$$

$$V = \frac{Bi}{nLe}$$

$$V = \frac{0.65 \times 57}{8.47 \times 10^{28} \times 75 \times 10^{-6} \times 1.6 \times 10^{-19}}$$

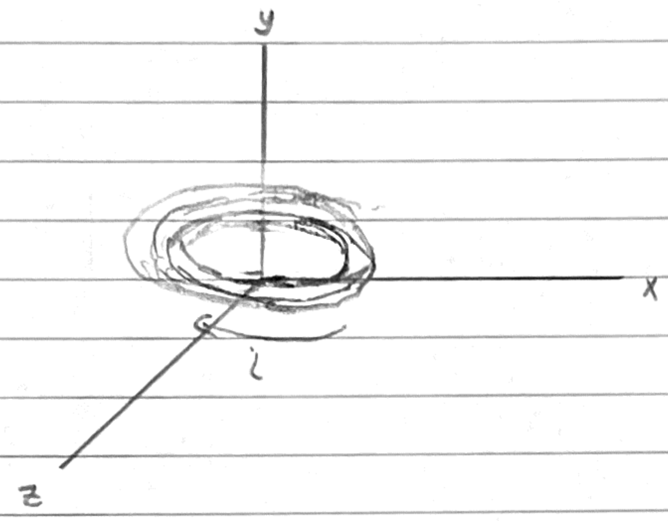
$V = 3.645 \times 10^{-5}$ volt

$V = 36 \times 10^{-6}\,V$

$V = 36\,\mu V$

مسار مجال

P49: The coil in Fig 28-39 carries current $i = 4.60\,A$ in the direction indicated, is parallel to an xz plane, has 3.00 turns and an area of $4.00 \times 10^{-3}\,m^2$, and lies in a uniform magnetic field $\vec{B} = (3.00\hat{i} - 3.00\hat{j} - 4.00\hat{k})\,mT$. What are (a) the orientation energy of the coil in the magnetic field and (b) the torque (in unit-vector notation) on the coil due to the magnetic field?



Sol: $U = -\vec{\mu} \cdot \vec{B}$

$N = 3$ turns, $i = 4.6\,A$, $A = 4 \times 10^{-3}\,m^2$, $B = (3\hat{i} - 3\hat{j} - 4\hat{k})\,mT$

$\vec{\mu} = NiA\,(-\hat{j})$ باستخدام قاعدة اليد اليمنى

$\vec{\mu} = (3)(4.6)(4 \times 10^{-3})(-\hat{j})$

$\vec{\mu} = -0.0552\,(\hat{j})\ A.m^2$

$U = -(-0.0552)\,\hat{j} \cdot [(3\hat{i} - 3\hat{j} - 4\hat{k}) \times 10^{-3}]$

$= 0.0552\,\hat{j} \cdot -3 \times 10^{-3}\,\hat{j}$

$= -0.1656 \times 10^{-3}(\hat{j} \cdot \hat{j})$

$= -0.1656\,(1) \times 10^{-3}\ J$

$= -0.1656\ mJ$

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سادة جا

b) $\vec{\tau} = \vec{\mu} \times \vec{B}$

$\mu = (0\hat{i} + \mu_y\hat{j} + 0\hat{j})$

$(3\hat{i} - 3\hat{j} - 4\hat{k})\, mT$

$B = (B_x\hat{i} + B_y\hat{j} + B_z\hat{k})$

$$\vec{\mu} \times \vec{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 0 & \mu_y & 0 \\ B_x & B_y & B_z \end{vmatrix}$$

$= (\mu_y B_z - 0 \times B_y)\hat{i} - (0 \times B_z - 0 \times B_z)\hat{j} + (0 \times B_y - \mu_y B_x)\hat{k}$

$= \mu_y B_z \hat{i} - \mu_y B_x \hat{k}$

$= (-0.0552)(-4 \times 10^{-3})\hat{i} - (-0.0552)(3 \times 10^{-3})\hat{k}$

$\tau = (2.208 \times 10^{-4}\hat{i} + 1.656 \times 10^{-4}\hat{k})\, N.m$

$= (0.2208 \times 10^{-3}\hat{i} + 0.1656 \times 10^{-3}\hat{k})\, mN.m$

$\approx (0.221\hat{i} + 0.166\hat{k})\, mN.m$

(19)

ساراوكا

P54: In a certain cyclotron a proton moves in a circle of radius 0.500 m. The magnitude of the magnetic field is 1.00T. (a) What is the oscillator frequency? (b) What is the kinetic energy of the proton in electron-volts

Sol: $r = 0.5\,m$, $B = 1\,T$, $q_p = 1.6\times10^{-19}\,C$, $m_p = 1.67\times10^{-27}\,kg$

a) $f = \frac{1}{T} = \frac{\omega}{2\pi} = \frac{|q|B}{2\pi m_p}$ $\quad f = f_{osc}$

$= \frac{qB}{2\pi m_p}$

$= \frac{1.6\times10^{-19}\times 1}{2\times3.14\times1.67\times10^{-27}}$

$= 1.525\times10^{7}\,Hz$

b) $r = \frac{m_p v}{qB} = \frac{\sqrt{2m_p k}}{qB}$, k: kinetic energy

$r^2 = \frac{2m_p k}{q^2B^2}$

$k = \frac{r^2 q^2 B^2}{2m_p}$

$k = \frac{(rqB)^2}{2m_p} = \frac{(0.5\times1.6\times10^{-19}\times1)^2}{2(1.67\times10^{-27})}$

$k = 1.916\times10^{-12}\,J$

$k = \frac{1.916\times10^{-12}}{1.6\times10^{-19}}$

$k = 1.1976\times10^{7}\,eV$

سارة دكار

P63: An electron that has instantaneous velocity of

$$\vec{v} = (-5.0\times10^{6}\,m/s)\hat{i} + (3.0\times10^{6}\,m/s)\hat{j}$$

is moving through the uniform magnetic field

$$\vec{B} = (0.030T)\hat{i} - (0.15T)\hat{j}$$

a) Find the force on the electron due to the magnetic field

b) Repeat your calcultion for a proton having the same velocity.

Sol: $\vec{F}_B = q\,\vec{v}\times\vec{B}$

a) For electron $q = -e = -1.6\times10^{-19}$

$$\vec{v}\times\vec{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ -5\times10^{6} & 3\times10^{6} & 0 \\ 0.03 & -0.15 & 0 \end{vmatrix}$$

$$= \hat{i}(0-0)\hat{i} + \hat{j}(0-0)\hat{j} + \hat{k}\,(-5\times10^{6}\times -0.15 - 3\times10^{6}\times 0.03)\hat{k}$$

$$\vec{v}\times\vec{B} = 660000\,\hat{k}$$

$$\Rightarrow \vec{F}_B = -e\,\vec{v}\times\vec{B}$$

$$= -(1.6\times10^{-19})(660000)\,\hat{k}$$

$$= -1.056\times10^{-13}\,N\,\hat{k}$$

$$= 1.056\times10^{-13}\,N\,(-\hat{k})$$

$$\simeq 1.1\times10^{-13}\,N\,(-\hat{k})$$

سارة نجار

b) for proton $P = +e = +1.6 \times 10^{-19}$ C

$\vec{F}_B = e\, \vec{V} \times \vec{B}$

$= (1.6 \times 10^{-19})\ (660000)$

$\vec{F}_B = 1.056 \times 10^{-13}\ N(+\hat{k})$

$\simeq 1.1 \times 10^{-13}\ N\ \hat{k}$

