Q1 F-112-19

A proton travels through both a uniform magnetic field $\vec{B}$ and a uniform electric field $\vec{E}$. The magnetic field is given by $\vec{B} = (2.5\ mT)\ \hat{\imath}$. At one instant, the velocity of the proton is $\vec{v} = (2.0 \times 10^3\ \ m/s)\ \hat{\jmath}$ and the net force acting on it is zero. Find the electric field $\vec{E}$ in units of V/m. Ignore the gravitational force on the proton.

A) $+5.0\ \hat{k}$
B) $-5.0\ \hat{k}$
C) $+5.0\ \hat{\jmath}$
D) $-5.0\ \hat{\jmath}$
E) $-5.0\ \hat{k}\ +5.0\ \hat{\jmath}$

$\vec{F}_B = |q|\ \vec{v} \times \vec{B} = e\, v\, \hat{\jmath} \times B\, \hat{\imath} = evB(-\hat{k})$

$\hat{\jmath} \times \hat{\imath} = -\hat{k}$

net Force $= 0 \Rightarrow \vec{F}_B + \vec{F}_E = 0$

$\Rightarrow \vec{F}_B = -\vec{F}_E$

$\vec{F}_E = q\vec{E} = e\vec{E}$

$\Rightarrow \cancel{e}vB(-\hat{k}) = -\cancel{e}\vec{E}$

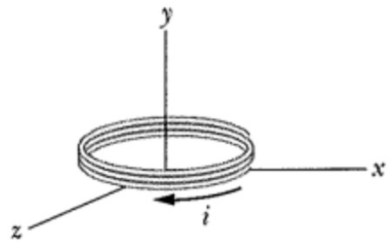
$\Rightarrow \vec{E} = vB\hat{k} = (2.5 \times 10^{-3})(2 \times 10^{3})\hat{k}$

$\vec{E} = 5\ \hat{k}$

Q2 F-112-22

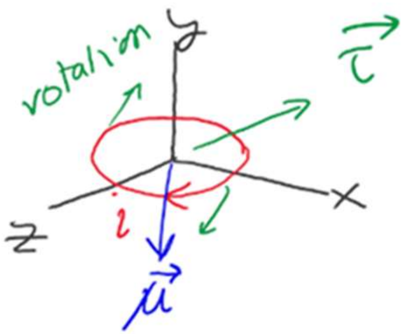
The coil in the figure has its plane parallel to the *xz* plane and carries current $i = 1.0\ A$ in the direction indicated. The coil has 8.0 turns and a cross sectional area of $4.0 \times 10^{-3}\ m^2$ and lies in an external uniform magnetic field that is given by $\vec{B} = (-2.0\ mT)\ \hat{\imath}$. Find the torque (in units of μN.m) on the coil due to the magnetic field .

A) $-64\ \hat{k}$
B) $+64\ \hat{k}$
C) $+12\ \hat{\imath}$
D) $-12\ \hat{\imath}$
E) $-64\ \hat{\jmath}$



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

$NAi(-\hat{j})$



$\vec{\tau} = NAi(-\hat{j}) \times B(-\hat{i})$

$\vec{\tau} = NAiB(-\hat{k})$ $\quad \hat{j} \times \hat{i} = -\hat{k}$

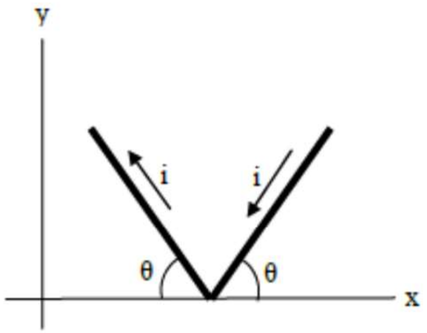
$\vec{\tau} = -8(4\times10^{-3})(1)(2\times10^{-3})\ \hat{k}$

$\vec{\tau} = (-64\ \mu Nm)\ \hat{k}$

Q3 F-122-22

A wire is bent as shown in the figure. It lies in a uniform magnetic field $\vec{B} = (4.0\,T)\,\hat{k}$. Each wire section is 2.0 m long and makes an angle of θ = 60° with the x-axis, and the wire carries a current of 2.0 A. What is the net magnetic force on the wire? (the positive z-axis is out of the page).

A) $(+\,16N)\,\hat{j}$
B) $(+\,28N)\,\hat{j}$
C) $(-\,28N)\,\hat{i}$
D) $(-\,16N)\,\hat{j}$
E) Zero



$\vec{F}_B = i\vec{L}\times\vec{B}$

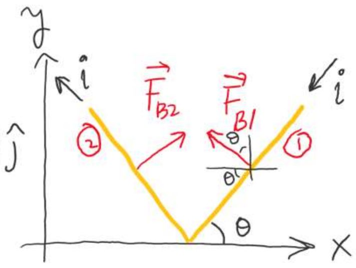
$\vec{F}_B = \vec{F}_{B1}+\vec{F}_{B2} = (F_{B1y}+F_{B2y})\,\hat{j}$

$F_{B1y} = F_{B2y} = F_{B1}\cos\theta$

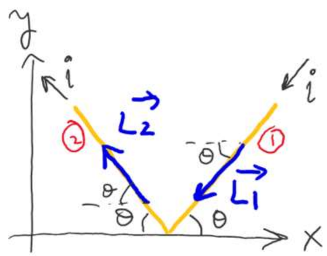
$= iL_1B\cos\theta$

$\vec{F}_B = 2iL_1B\cos\theta\,\hat{j}$

$= 2(2)(2)(4)\cos 60^\circ\,N\hat{j} = 16\,N\hat{j}$



Another way



$\vec{L}_1 = -L_1\cos\theta\,\hat{i} - L_1\sin\theta\,\hat{j}$

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

$L_1 = L_2 \equiv L$

$\vec{F}_B = \vec{F}_{B1}+\vec{F}_{B2} = i\vec{L}_1\times\vec{B} + i\vec{L}_2\times\vec{B}$

$= iLB[(-\cos\theta\,\hat{i}-\sin\theta\,\hat{j})\times\hat{k} + (-\cos\theta\,\hat{i}+\sin\theta\,\hat{j})\times\hat{k}]$

$= iLB[-2\cos\theta\,\underbrace{(\hat{i}\times\hat{k})}_{=-\hat{j}}] = 2iLB\cos\theta\,\hat{j}$

$= 2(2)(2)(4)\cos 60^\circ\,N\hat{j} = 16\,N\hat{j}$

Q4 F2-122-16

Two electrons 1 and 2 are trapped in a uniform magnetic field $\vec{B}$ and they move in a plane perpendicular to the magnetic field in circular paths of radii R_1 and R_2, respectively. Electron 1 has kinetic energy K_1= 500 eV and electron 2 has kinetic energy K_2= 300 eV. What is the value of R_1/R_2?

A) 1.3
B) 2.8
C) 1.7
D) 4.0
E) 1.0

$$r = \frac{mv}{|q|B}$$

$$K = \frac{1}{2}mv^2 \Rightarrow v = \sqrt{\frac{2K}{m}}$$

$$r = \frac{m\sqrt{\frac{2K}{m}}}{|q|B} = \frac{\sqrt{2Km}}{|q|B}$$

$$\frac{R_1}{R_2} = \frac{\frac{\sqrt{2K_1 m}}{|q|B}}{\frac{\sqrt{2K_2 m}}{|q|B}} = \sqrt{\frac{K_1}{K_2}} = \sqrt{\frac{5}{3}} = 1.3$$

Q5 F-182-18

A particle with 2.58 $\times 10^{-15}$ kg mass and a negative charge is traveling through a region containing a uniform magnetic field $\vec{B} = -(0.120\,T)\,\hat{k}$. At a particular instant, the velocity of the particle is $\vec{v} = (1.05 \times 10^{6})[(-3.00\,m/s)\,\hat{\imath} + (4.00\,m/s)\,\hat{\jmath} + (12.0\,m/s)\,\hat{k}]$ and the force $\vec{F}$ on the particle has a magnitude of 2.45 N. Determine the magnitude of the charge of the particle

A) 3.89×10^{-6} C
B) 1.11×10^{-6} C
C) 2.33×10^{-6} C
D) 3.05×10^{-6} C
E) 4.88×10^{-6} C

$\hat{\imath} \times \hat{k} = -\hat{\jmath}$

$\hat{\jmath} \times \hat{k} = \hat{\imath}$

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

$$\vec{F}_B = q\,(v_x\hat{\imath} + v_y\hat{\jmath} + v_z\hat{k}) \times B(-\hat{k})$$

$$\vec{F}_B = qB(v_x\hat{\jmath} - v_y\hat{\imath})$$

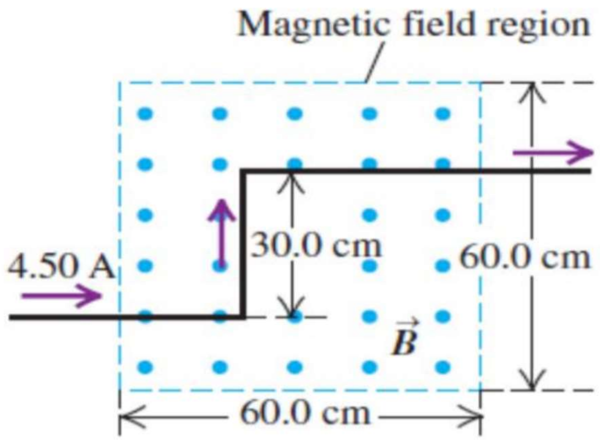
$$F_B = |q|B\sqrt{v_x^2 + v_y^2} \Rightarrow |q| = \frac{F_B}{B\sqrt{v_x^2 + v_y^2}}$$

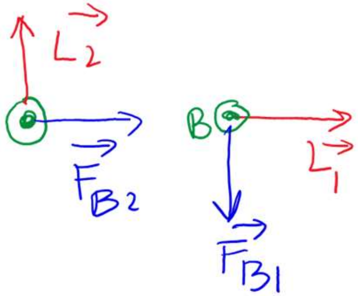
$$\Rightarrow q = \frac{2.45}{(0.12)(1.05\times10^{6})\sqrt{3^2+4^2}} = 3.89\times10^{-6}\ C$$

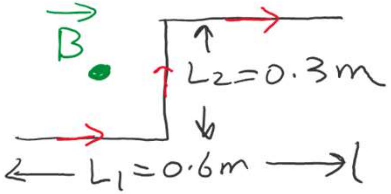
Q6 F-182-20

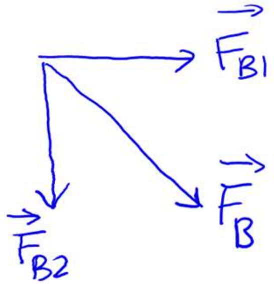
A long wire carrying 4.50 A of current makes two 90.0^0 bends, as shown in the Figure. The bent part of the wire passes through a uniform 0.240 T magnetic field, which is confined to a limited space region, as shown in the figure. Find the magnitude of the net force that the magnetic field exerts on the wire.

A) 0.724 N
B) 0.224 N
C) 0.323 N
D) 0.444 N
E) 0.175 N









$$\vec{F}_{1B} = iL_1 B \sin 90^\circ = iL_1 B$$

$$\vec{F}_{2B} = iL_2 B \sin 90^\circ = iL_2 B$$

$$F_B = \sqrt{F_{B1}^2 + F_{B2}^2} = iB\sqrt{L_1^2 + L_2^2}$$

$$F_B = (4.5)(0.24)\sqrt{0.3^2 + 0.6^2} = 0.724\ N$$