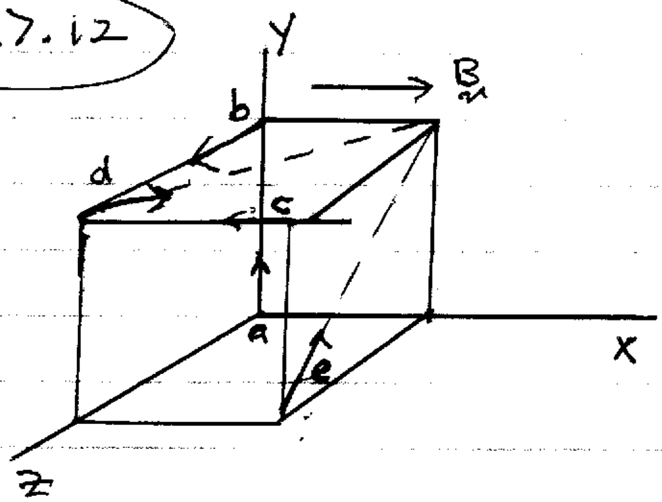
Hwk 6 Solutions

Q 27.12



$$\mathbf{F} = q\,\mathbf{v} \times \mathbf{B}$$

$$\mathbf{B} = B\,\hat{\imath}$$

$$\mathbf{v}_a = v\,\hat{\jmath}$$

$$\mathbf{v}_b = v\,\hat{k}$$

$$\mathbf{v}_c = -v\,\hat{\imath}$$

$$\mathbf{v}_d = \frac{v}{\sqrt{2}}(\hat{\imath} - \hat{k})$$

$$\mathbf{v}_e = \frac{v}{\sqrt{2}}(\hat{\jmath} - \hat{k})$$

a) All but c experience a force since their velocities have components $\perp$ to $\mathbf{B}$

Direction of force?

$$\mathbf{F}_a = vBq(\hat{\jmath} \times \hat{\imath}) = -vBq\,\hat{k}$$

$$\mathbf{F}_b = vBq(\hat{k} \times \hat{\imath}) = vBq\,\hat{\jmath}$$

$$\mathbf{F}_c = 0$$

$$\mathbf{F}_d = \frac{vBq}{\sqrt{2}}(\hat{\imath} - \hat{k}) \times \hat{\imath} = -\frac{vBq}{\sqrt{2}}\,\hat{\jmath}$$

$$\mathbf{F}_e = \frac{vBq}{\sqrt{2}}(\hat{\jmath} - \hat{k}) \times \hat{\imath} = \frac{vBq}{\sqrt{2}}(-\hat{k} - \hat{\jmath})$$

27.4

Particle mass:

$m = 1.81 \times 10^{-3}\,\text{kg}$,

charge: $q = 1.22 \times 10^{-8}\,\text{C}$

velocity: $\mathbf{v} = 3 \times 10^{4}\,\frac{\text{m}}{\text{s}}\,\hat{\jmath}$

$\mathbf{B} = 1.63\,\text{T}\,\hat{\imath} + .98\,\text{T}\,\hat{\jmath}$

Force:

$\mathbf{F} = q\,\mathbf{v} \times \mathbf{B}$

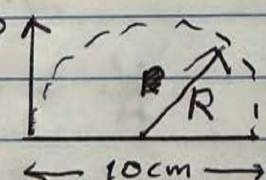
note: y component of $\mathbf{B}$ does not contribute since is $\parallel$ to $\mathbf{v}$

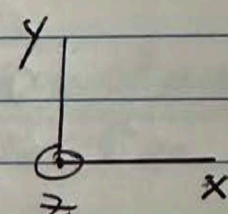
$$\underset{\sim}{a} = \frac{1}{m}\underset{\sim}{F}$$

$$a = \frac{1.22\times10^{-8}\,C}{1.81\times10^{-3}\,kg}\; 3\times10^{4}\frac{m}{s}\; 1.63\,T\,(\hat{j}\times\hat{i})$$

$$= -\frac{1.22(3)1.63}{1.81}\times10^{-1}\,\hat{k}\left(\frac{m}{s^2}\right)$$

$$= -0.33\,\hat{k}\,\frac{m}{s^2}$$





27.14 electron

$V_0 = 1.41\times10^{6}\,m/s$

$R =$ orbit radius $= 5\,cm$

$q = -1.6\times10^{-19}\,C$

$\omega = \frac{|q|B}{m}$

Circular motion: $V_0 = \omega R$

$$\Rightarrow \omega = \frac{1.41\times10^{6}\,m/s}{0.05\,m} = \frac{2.82\times10^{7}}{s}$$

a) $$B = \frac{m\omega}{q} = \frac{9.1\times10^{-31}\,kg}{1.6\times10^{-19}\,C}\;\frac{2.82\times10^{7}}{s}$$

$$= \frac{.91(2.82)}{1.6}\times10^{-4}\,T$$

$$= 1.6\times10^{-4}\,T$$

Force must initially point to the right

$\underset{\sim}{B}$ in the $-z$ direction: into the page

b) Time required $\Rightarrow \frac{1}{2}\tau$ with $\tau = \frac{2\pi}{\omega}$

$$\frac{1}{2}\tau = \frac{\pi}{\omega} = \frac{3.14}{2.82}\times10^{-7}\,s = 1.11\times10^{-7}\,s$$

27.22 Charge $q = 1.6 \times 10^{-19}$ C
velocity selector: $E = 155\ V/m$
$B = 0.0315\ T$

a) From velocity selector

$$V = \frac{E}{B} = \frac{155\ V/m}{0.0315 T} = 4.92 \times 10^{3} \frac{m}{s}$$

~~The following magnetic field does no change the velocity~~

b) Radius $R = 17.5$ cm

$$V = \omega R \Rightarrow \omega = \frac{V}{R} = \frac{4.92 \times 10^{3} m/s}{0.175 m}$$

$$= 2.81 \times 10^{4} / s$$

$$\omega = \frac{qB}{m} \Rightarrow m = \frac{qB}{\omega}$$

$$m = \frac{1.6 \times 10^{-19} C\ (0.0175) T}{2.81 \times 10^{4} / s}$$

$$= \frac{1.6 (1.75)}{2.81} \times 10^{-25} kg = 1.0 \times 10^{-25} kg$$

27.56 First calculate the current in the bar. $\Rightarrow R_{bar} = 10.0\ \Omega$

$\Rightarrow$ two resistors in parallel

$$\frac{1}{R} = \frac{1}{10\Omega} + \frac{1}{10\Omega} = \frac{1}{5\Omega} \Rightarrow R = 5\Omega$$

$$I_{total} = \frac{120 V}{(25+5)\Omega} = 4.0 A$$

$\Rightarrow$ I_{total} split equally between the bar and the 10Ω resistor since have the same resistance

$I_{bar} = 20A$, $F_{bar} = ILB \Rightarrow$ points to the right

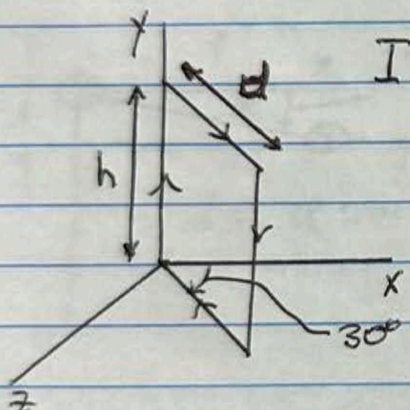
$F_{bar} = 20A \; 0.85m \; 1.6T = 2.72 N$

~~$\Rightarrow 27.2 N$~~

$$a_{bar} = \frac{F_{bar}}{m} = \frac{F_{bar}}{mg} g = \frac{27.2 N}{2.6 N} 9.8 \frac{m}{s^2}$$

$$= 10.3 \frac{m}{s^2}$$

27.64 The loop rotates



$I = 15A$, $h = 8cm$

$d = 6cm$

a) $\underset{\sim}{B} = 0.48T \hat{i}$

The forces on the top and bottom legs of the loop are along y so no torque for rotation around the y axis.

The force on the vertical leg intersection the origin does not produce a torque since the moment arm is zero

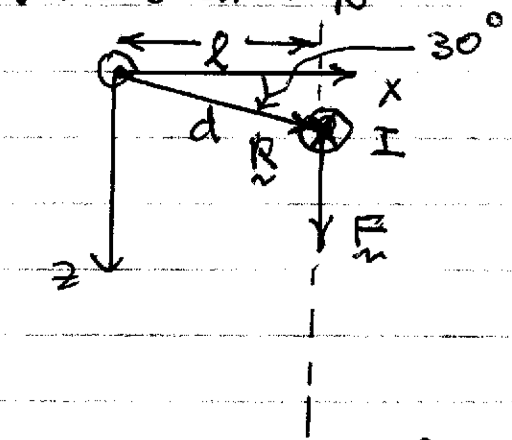
$\Rightarrow$ only the vertical segment with the downward current contributes.

$$\underset{\sim}{F} = I \underset{\sim}{L} \times \underset{\sim}{B} = IBh(-\hat{j} \times \hat{i}) = IBh \hat{k}$$

$$= 15A \; 0.48T (0.08) m$$

$$= 5.76 \times 10^{-1} N$$

view from top



$\underset{\sim}{\tau} = \underset{\sim}{R} \times \underset{\sim}{F} \Rightarrow$ in $-y$ direction

$\tau = F\ell \Rightarrow \ell = d\cos 30°$

$=$ moment arm

$\tau = 0.576\ N\ 0.06\ m\ 0.87$

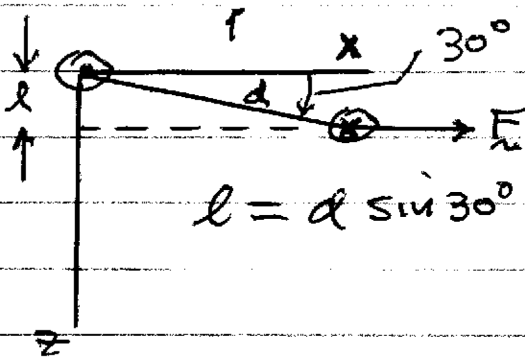
$= 3.0 \times 10^{-2}\ Nm$

$\Rightarrow$ applied torque in $+y$ direction

b) $\underset{\sim}{B} = -0.48\,\hat{k}$, $\underset{\sim}{F} = IBh(-\hat{j} \times (-\hat{k}))$

$= IBh\,\hat{\imath}$

$= 0.576\ N\ \hat{\imath}$



$\ell = d\sin 30°$

$\underset{\sim}{\tau} = \underset{\sim}{R} \times \underset{\sim}{F} \Rightarrow$ in y direction

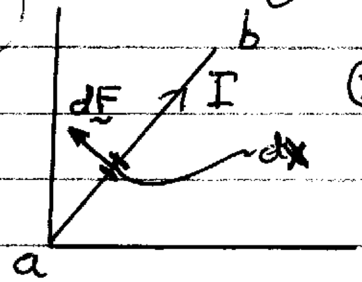
$\tau = 0.576\ N\ 0.06\ m\ 0.5$

$= 0.017\ Nm$

$\Rightarrow$ applied torque in $-y$ direction

c) No change from previous answers
$\Rightarrow$ moment arm reduced by a factor of two but both vertical legs contribute equally $\Rightarrow$ same answer

27.66



$\otimes\ \underset{\sim}{B}$

$d\underset{\sim}{F} = I\,d\underset{\sim}{x} \times \underset{\sim}{B}$

$d\underset{\sim}{\tau} = \underset{\sim}{R} \times d\underset{\sim}{F}$

$\Rightarrow$ out of page

$d\tau = I\,dx\,B\,x$

$\tau = \int d\tau = IBL^2/2 = (BIL)\frac{L}{2}$