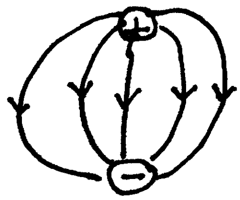
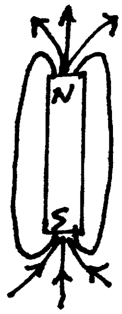
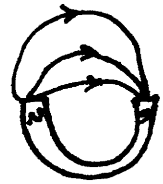
MAGNETIC FIELDS



$E = \frac{F}{q_0}$





MAGNETIC FIELDS OCCUR

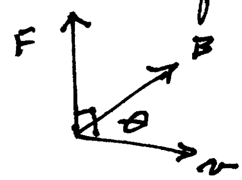
1. IN CERTAIN MATERIALS Ni, Co, Fe
2. WHEN AN ELECTRICAL CHARGE MOVES THROUGH SPACE

MAGNETIC FIELD IS DESIGNATED $\vec{B}$

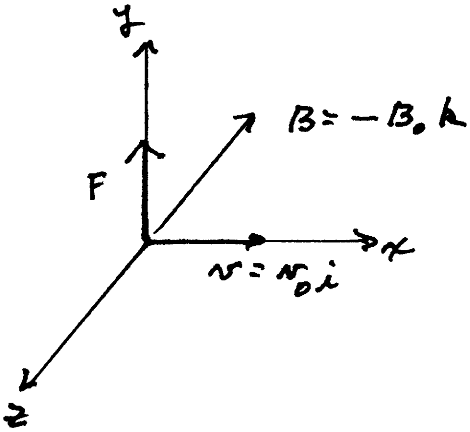
UNITS TESLA

	TESLA
EARTH	10^{-4}
BAR	10^{-2}
ELECTROMAGNET	10^{-1}

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



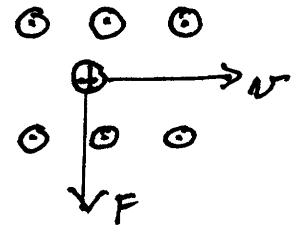
$$[1T] = \frac{[N]}{[C][m/s]}$$



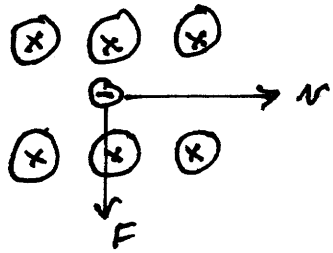
$$\vec{F} = q\,(v_0 i) \times (-B_0 k)$$

$$= -q v_0 B_0 \underbrace{i \times k}_{-j}$$

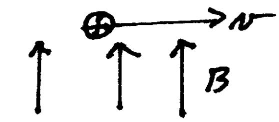
$$= q v_0 B_0 \vec{j}$$



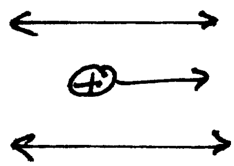
$F = q\,v \times B = q\,v\,B$



$F = q\,v\,B \downarrow$

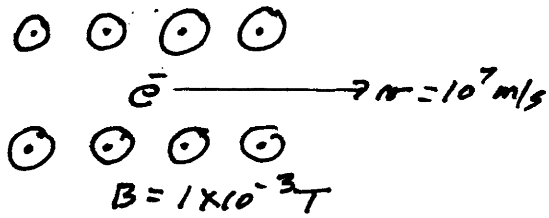


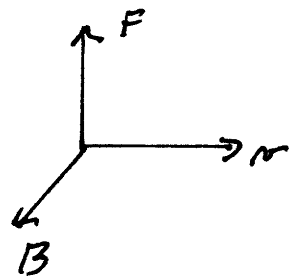
$F = q\,v\,B \odot$



$F = q\,v\,B \underbrace{\sin\theta}_{\theta = 0} = 0$

EXAMPLE I





a) FIND THE FORCE ON THE e^-

$F = q\,\vec{v} \times \vec{B} = (-1.6\times10^{-19})(1\times10^{7})(1\times10^{-3}) = -1.6\times10^{-15}\,N$

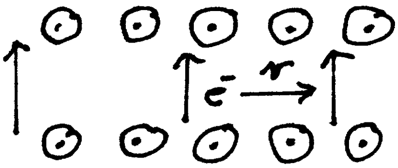
– SIGN GIVES A DIRECTION OPPOSITE TO THE RHR

b) WHAT IS THE ACCELERATION OF THE e^-

$a = \dfrac{F}{m} = \dfrac{1.6\times10^{-15}}{9.11\times10^{-31}} = 1.76\times10^{15}\,m/s^2$

IN THE DIRECTION OF THE FORCE

NOW WE WILL COMBINE $\vec{E}$ & $\vec{B}$ FIELDS



$F_E = -qE \downarrow$

$F_B = -q\,v \times B \uparrow$

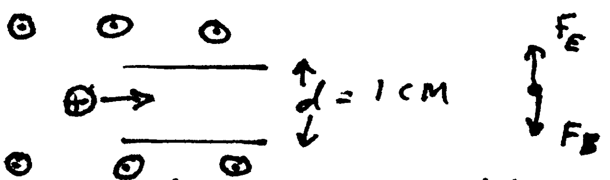
$= -q\,vB\sin\theta = -qvB \uparrow$ ($\theta = 90$)

FOR EQUILB. $F_B = F_E$

$-qvB = -qE$

$\vec{v} = \frac{|E|}{|B|}$

EXAMPLE II FIND THE VOLTAGE BETWEEN ∥ PLATES SUCH THAT WHEN THE CHARGE MOVES BETWEEN THE PLATES (1 CM APART) THE CHARGE WILL NOT BE DEFLECTED



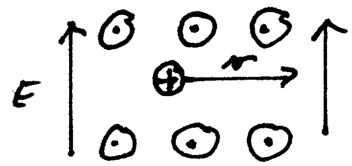
ASSUME $\vec{B} = 10^{-3}\,T$ $\vec{v} = 1\times10^{7}$ m/s

$E = vB = (1\times10^{-3})(1\times10^{7}) = 1\times10^{4}$ N/C

$V = |E|d = 1\times10^{4}(.01)$

$= 100$ VOLTS

IF THE MOVING Chg IS ⊕

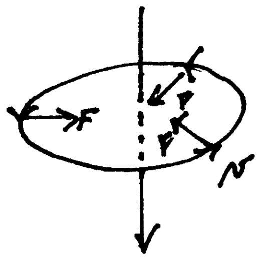


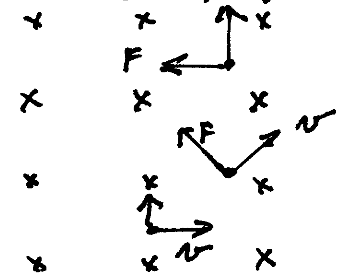
$F_e = Eq \uparrow$

$F_B = q\,v\times B = qvB\sin\theta = qvB \downarrow$ ($\theta = 90°$)

$v = \frac{E}{B}$

CHARGED PARTICLES IN CIRCULAR MOTION





CHARGED PARTICLES MOVING IN A PLANE ⊥ TO A MAGNETIC FIELD MOVE IN CIRCLES IN THE PLANE

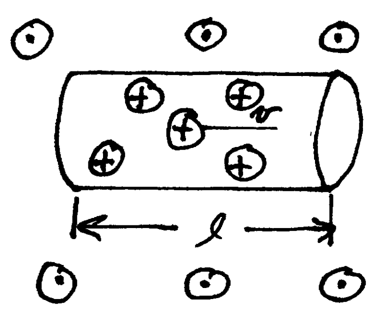
$$\frac{mv^2}{R} = F_B = qvB$$

$$R_{circle} = \frac{mv}{qB}$$

PERIOD OF THE PARTICLE } $T = \frac{2\pi R}{v}$ BUT $\frac{R}{v} = \frac{m}{qB}$

$$T = \frac{2\pi m}{qB}$$

MAGNETIC FORCE ON A WIRE CARRYING CURRENT

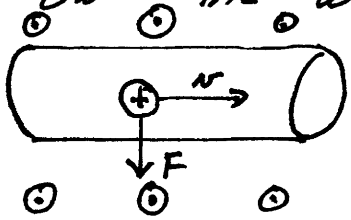


$$i = \frac{dq}{dt} \approx \frac{q}{t}$$

TIME FOR A CHG TO MOVE A DISTANCE l $\quad t = \frac{l}{v_d}$

$$q = it = \frac{il}{v_d}$$

NOW ESTABLISH THE DIRECTION OF THE FORCE ON THE WIRE



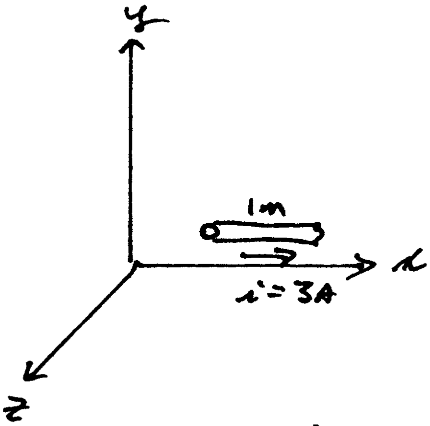
$$F = q\,\vec{v} \times \vec{B} = q v_d B$$

$$= \frac{i}{v_d} v_d B = i B$$

$\vec{L} = \ell \vec{\ell}$ — $\vec{\ell}$ is a unit vector in the current direction

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

EXAMPLE III A CURRENT OF 3A IS TRAVELING IN A CONDUCTOR 1 m long in the +x direction. THE $\vec{B} = 3i + 5j + 4k$ & YOU ARE TO DETERMINE THE FORCE F



$B = 3i + 5j + 4k$

$L = 1i \quad i = 3A$

$$F = i\, L \times B = 3 L \times B$$

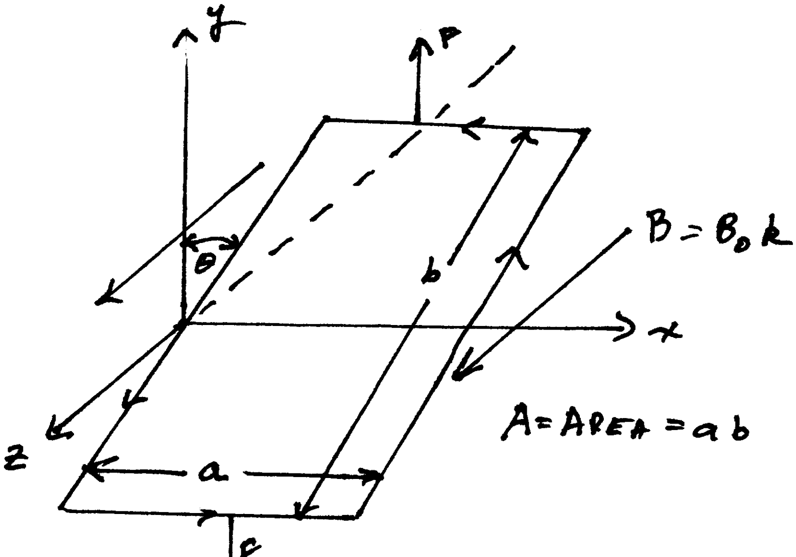
the CURRENT is IN the x direction so

$$F_x = 3 L_x \times B_x = 3(1i \times (3i)) = 3^2\, i \times i = 0$$

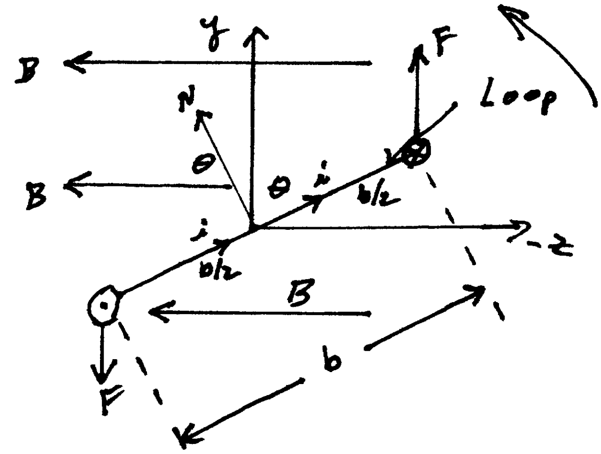
$$F_y = 3(1i) \times 5j = 15\, i \times j = 15k$$

$$F_z = 3(1i) \times 4k = 12 \underbrace{i \times k}_{-j} = -12j$$

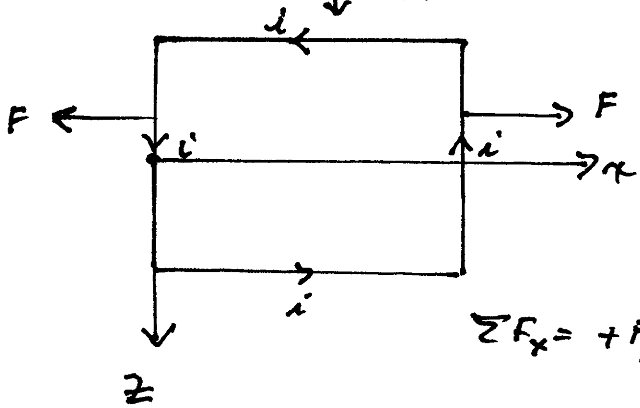
$$F = -12j + 15k$$



SIDE VIEW



TOP VIEW



$$\Sigma F_x = +F_b - F_b = 0$$

$$F_{NET} = i\,\vec{L} \times B = i\,a\,B \underbrace{\sin\theta'}_{\theta' = 90} = i\,a\,B$$

TORQUE ON THE LOOP }

$$\tau = F_{ENDS}\,(\perp \text{ DISTANCE})$$

$$= F\left(2\,\frac{b}{2}\sin\theta\right) = F\,b\,\sin\theta$$

FOR 1 TURN OF WIRE

$$\tau = \underbrace{i\,a\,B}_{F_{NET}}\; b\sin\theta = i\,A\,B\sin\theta$$

FOR MANY TURNS

$$\tau = i\,n\,A\,B\sin\theta = i\,n\,\vec{A} \times B$$

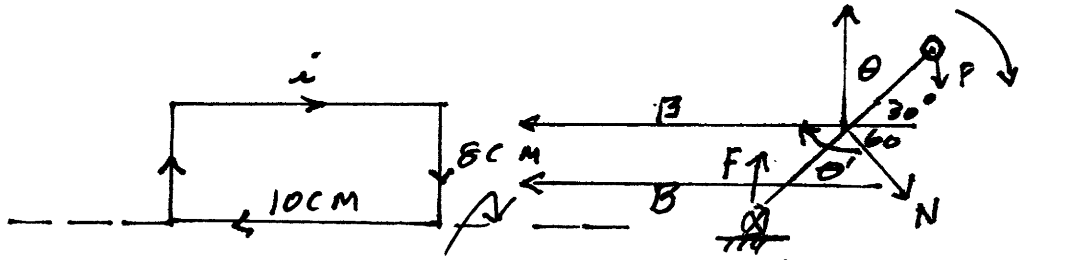
EXAMPLE IV

A CURRENT LOOP ROTATES ABOUT ITS LONG AXIS

$n = 1$ TURN

$i = 3A$

$B = 1\ T$



$\theta' = 180 - 60 = 120°$

DETERMINE THE TORQUE ON THE LOOP

$$\tau = i n A \times B = i n A |B| \sin \theta'$$

$$= 3(1)(0.10 \times 0.08)(1) \underbrace{\sin 120°}_{.866}$$

$$= 0.0208\ N\text{-}m$$