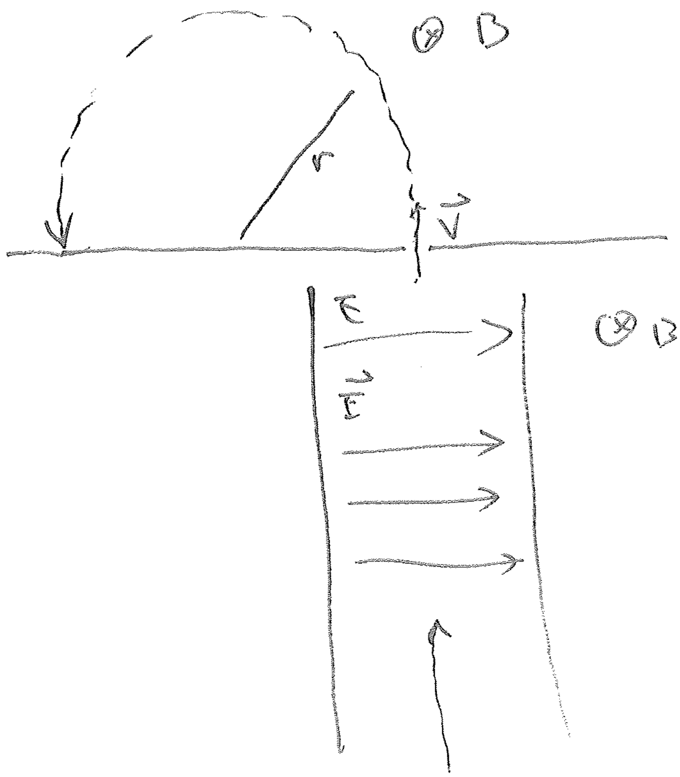
CALUTRON MASS SPECTROMETER

MAGNETIC FIELD
POINTS INTO THE SHEET



KNOWN : $|\vec{B}|, |\vec{E}|$

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

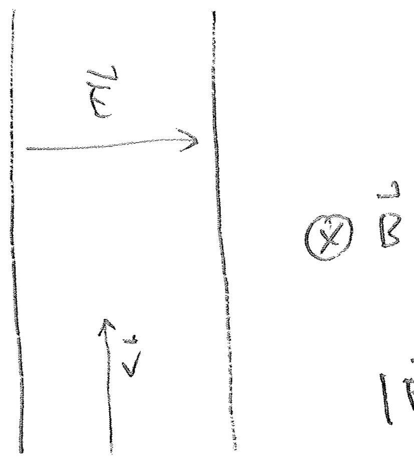
$$\frac{mv^2}{r} = qvB$$

$$r = \frac{mv}{qB}$$

$$\frac{m}{q} = \frac{Br}{v} \qquad v = \frac{E}{B}$$

$$\frac{m}{q} = \frac{rB^2}{E}$$

$$\boxed{r = \frac{mv}{qB}}$$



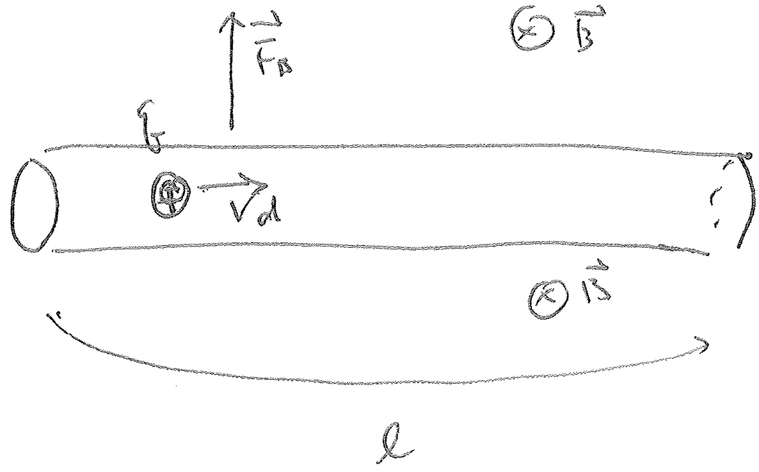
WHAT VELOCITY IS REQUIRED FOR PARTICLE TO GO THRU STRAIGHT?

$$|\vec{F_e}| = |\vec{F_B}|$$

$$|q\vec{E}| = |q\vec{v} \times \vec{B}|$$

$$qE = qvB$$

$$v = \frac{E}{B} \left(= \frac{|\vec{E}|}{|\vec{B}|} \right)$$



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

FORCE ON ONE CHARGE

$$\vec{f}_B = q\vec{v}_d \times \vec{B}$$

TOTAL FORCE ON A WIRE WITH LENGTH ℓ

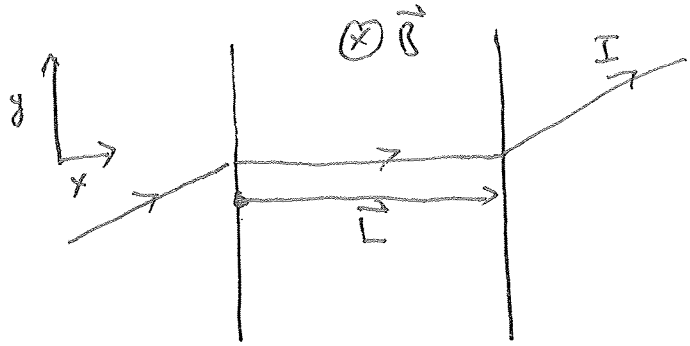
n: DENSITY OF CHARGE
A: CROSS SECTIONAL AREA
ℓ: LENGTH OF WIRE IN MAGNETIC FIELD

$$\vec{F}_{TOTAL} = q\vec{v}_d \times \vec{B}\,(nA\ell)$$

$$I = nqv_dA$$

$$\boxed{\vec{F} = I\vec{L} \times \vec{B}}$$

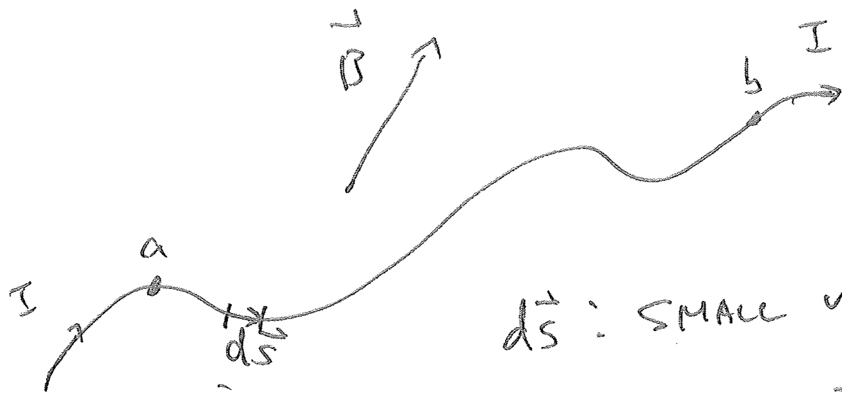
$$\vec{F} = q\vec{v} \times \vec{B}$$



$$\vec{F} = \hat{y}\,ILB$$

$$\vec{F} = I\vec{L} \times \vec{B}$$

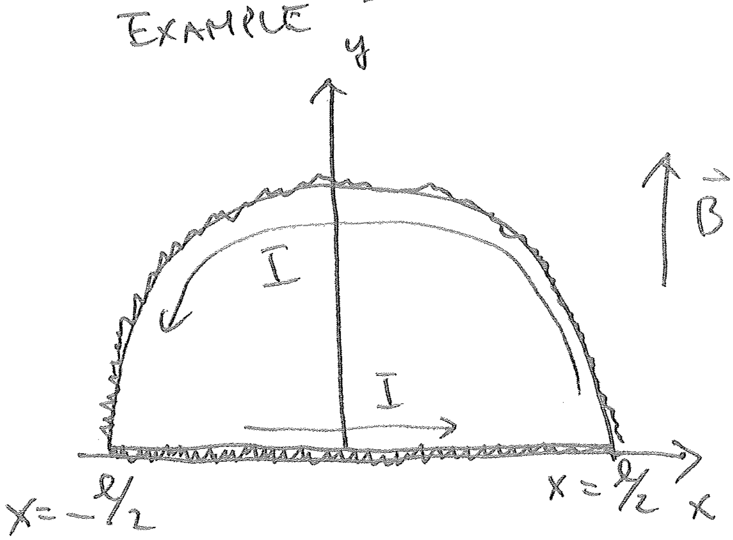
WHAT ABOUT LF



$d\vec{s}$: SMALL VECTOR (SEGMENT)

$$d\vec{F} = I\, d\vec{s} \times \vec{B}$$

EXAMPLE



WHAT'S THE TOTAL FORCE?

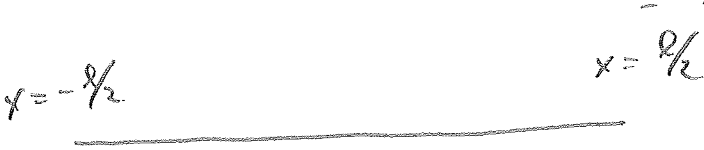
STRAIGHT SEGMENT

: ~~PATH SEGMENT~~

CURVED SEGMENT

STRAIGHT SEGMENT: $F = I\vec{L} \times \vec{B} = I\ell\hat{x} \times \hat{y}B$

$$= I\ell B\hat{z}$$

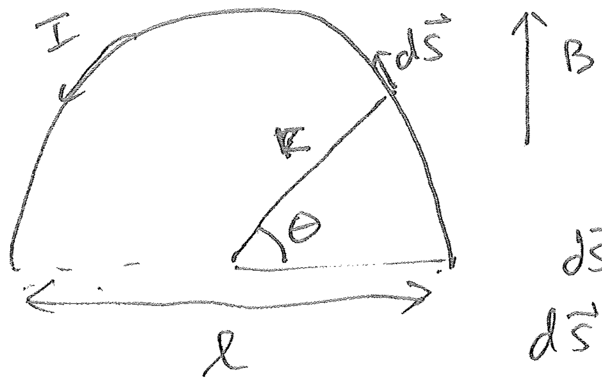


$$\vec{ds} = dx\,\hat{x}$$

$$d\vec{F} = I\,d\vec{s} \times \vec{B}$$
$$= I\,dx\,\hat{x} \times B\hat{y}$$
$$= IB\,dx\,\hat{z}$$

$$\vec{F} = \int d\vec{F} = \int_{-\ell/2}^{\ell/2} IB\,dx\,\hat{z} = IBx\Big]_{-\ell/2}^{\ell/2}\hat{z}$$
$$= IB\ell\hat{z}$$

FORCE ON CURVED SEGMENT



$$d\vec{s} = R\,d\theta\,\hat{\theta}$$

$$d\vec{s} \times \vec{B} = R\,d\theta\,\hat{\theta} \times B\hat{y}$$

$$= RB\,d\theta\,\underline{-\hat{z}}\sin\theta$$

$$d\vec{F} = -IRB\,d\theta\,\hat{z}\sin\theta$$

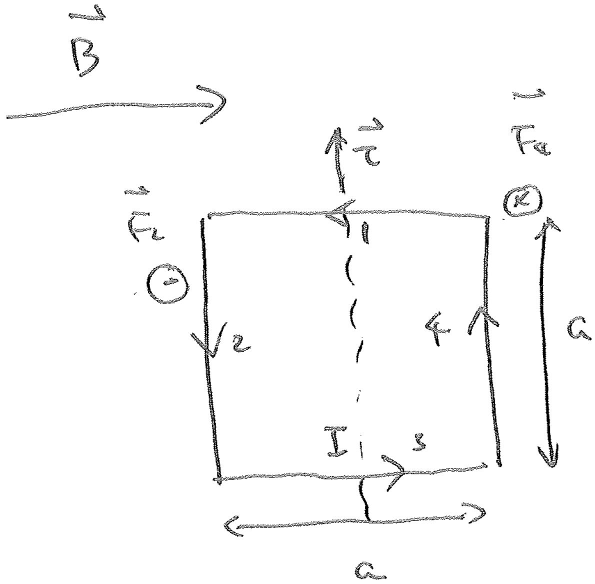
$$\vec{F} = -\int_0^{\pi} IRB\sin\theta\,d\theta\,\hat{z}$$

$$= IRB\cos\theta\Big]_0^{\pi}\hat{z} = -IRB\,2\,\hat{z}$$

$$= -2IRB\hat{z}$$

$$2R = \ell \qquad = -I\ell B\hat{z}$$

TOTAL FORCE $= 0$

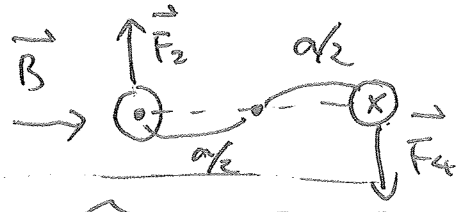


4 SEGMENTS

$\vec{F} = I\vec{L} \times \vec{B}$

FOR SEGMENT 1, 3 : $F = 0$

FOR SEGMENT 2, 4



$\vec{F}_2 = I\vec{L}_2 \times \vec{B} =$ POINTING OUT OF THE BOARD $\boxed{IaB}$

BUT $\vec{F}_{TOTAL} = 0$

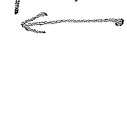
FIND TORQUE

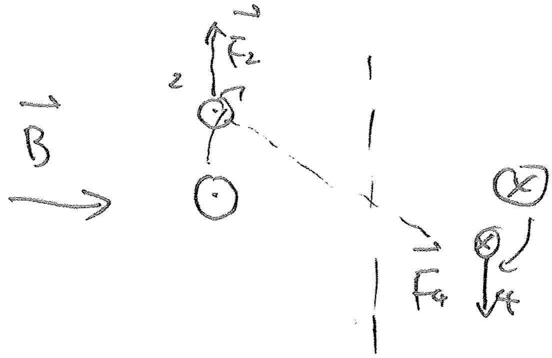
$$|\tau| = \frac{a}{2} \cdot IaB + \frac{a}{2} IaB$$

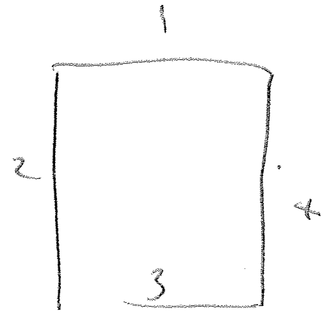
$$= Ia^2B = I\underset{=}{A}B$$

AREA OF LOOP

$\vec{\tau} = \vec{r} \times \vec{F}$

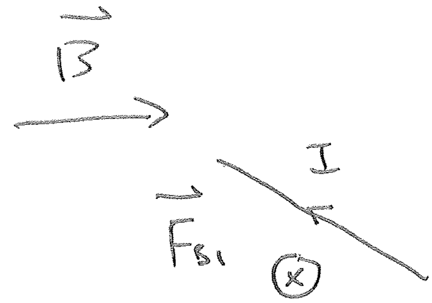






$\vec{B}$

SECTION 1



SECTION 3