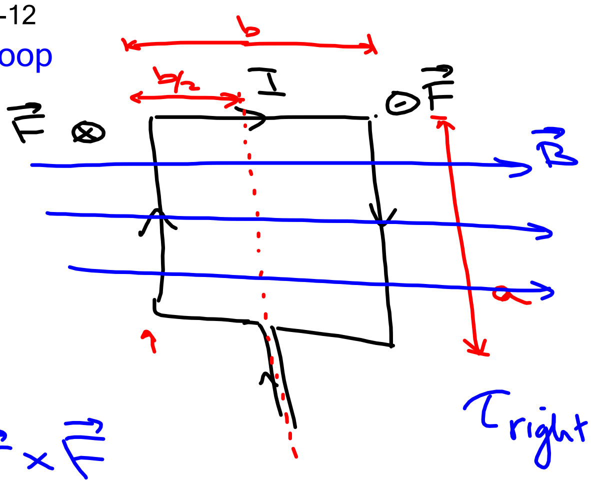
Torque on a Loop and Mass Spectrometers

Sections 20-9, 20-12

Torque on a Loop

$F = lIB$
$= aIB$



$F = aIB$

$\Sigma F =$ ☺

$\tau = \vec{r} \times \vec{F}$
$= rF\sin\theta$

$\tau_{right} = rF\cancel{\sin\theta}^{\,1}$
$= (b/2)\,aIB$

$\tau_{left} = (b/2)\,aIB$

working together

$\Sigma\tau = \cancel{2}(b/\cancel{2})\,aIB$

$= \underbrace{ab}_{Area}\,IB$

$\boxed{\Sigma\tau = BIA}$

Instead of one loop, what if there are N loops?

N loops $\Rightarrow$ N x force on each side

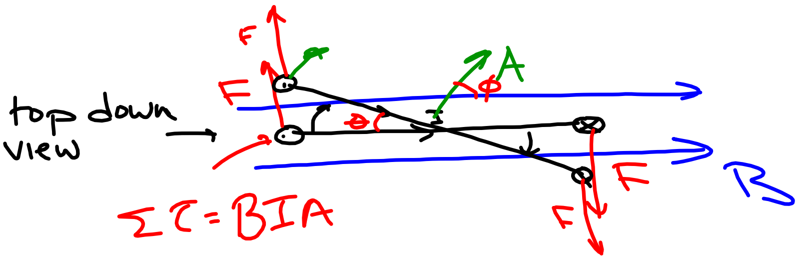
$\therefore$ N x torque

$\Sigma\tau = \underline{N}B\underline{IA}$

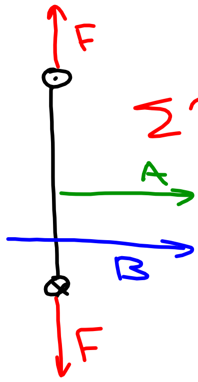
$NIA = \mu$

magnet dipole moment

$\theta + \phi = 90°$



$\sum \tau = BIA$



$\sum \tau = 0$

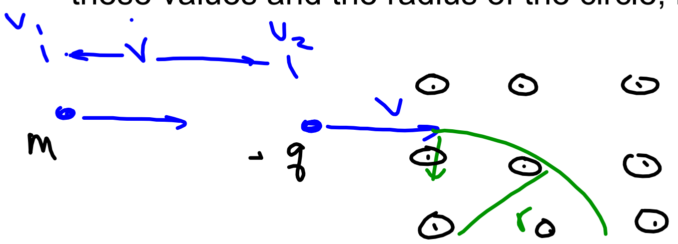
$$\sum \tau = BIA \sin\phi$$
$$= BIA \cos\theta$$

ϕ = angle between $\vec{A}, \vec{B}$

θ = angle between $\vec{I}, \vec{B}$

Mass Spectrometers

We accelerate a charged particle, q, from rest by moving it through a potential difference, V. At this speed we put it in a constant magnetic field, B, perpendicular to v. Determine an expression for the mass, m, in terms of these values and the radius of the circle, r.



$$W = qV = \frac{1}{2}mv^2$$

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

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

$$\frac{mv^{\cancel{2}}}{r} = q\cancel{v}B$$

$$m = \frac{qBr}{v}$$

$$\sqrt{m}\,\cancel{m} = qBr \cdot \sqrt{\frac{\cancel{m}\,1}{2qV}}$$

$$m = \frac{q^{\cancel{2}}B^2r^2}{2\cancel{q}V}$$

$$m = \frac{qB^2r^2}{2V}$$