

## Torque on a Loop and Mass Spectrometers

Sections 20-9, 20-12  
Torque on a Loop

$$F = lIB$$

$$= aIB$$

$$F = aIB$$

$$\Sigma F = \odot$$

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

$$= rF \sin \theta$$

$$\tau_{\text{right}} = rF \sin \theta$$

$$= (b/2) aIB$$

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

$\left. \vphantom{\begin{matrix} \tau_{\text{right}} \\ \tau_{\text{left}} \end{matrix}} \right\} \text{working together}$

$$\Sigma \tau = 2(b/2) aIB$$

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

$$\Sigma \tau = BIA$$

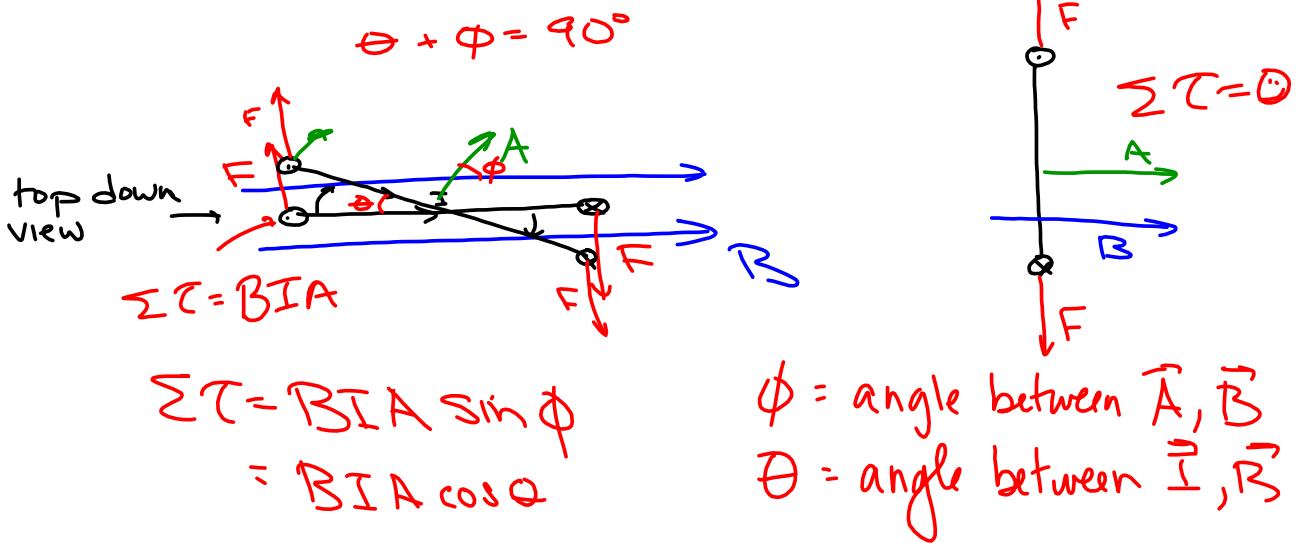
Instead of one loop, what if there are N loops?

$N \text{ loops} \Rightarrow N \times \text{force on each side}$   
 $\therefore N \times \text{torque}$

$$\Sigma \tau = \underline{N} \underline{BIA}$$

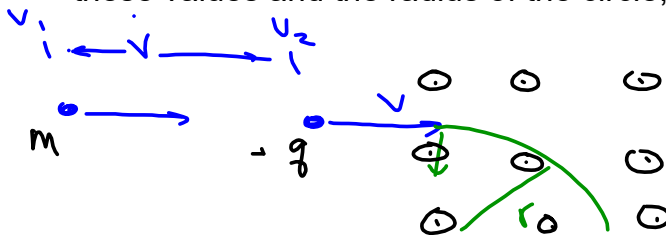
$$NIA = M$$

↑  
magnet dipole  
moment



## 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,  $r$ .



The diagram shows a particle of mass  $m$  and charge  $q$  being accelerated through a potential difference  $V$ . The particle then moves in a circular path of radius  $r$  in a magnetic field  $B$  perpendicular to its velocity  $v$ . The magnetic field is represented by a grid of circles with dots, indicating it is directed out of the page. The particle's path is a green arc with radius  $r$ .

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

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

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

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

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

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

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

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