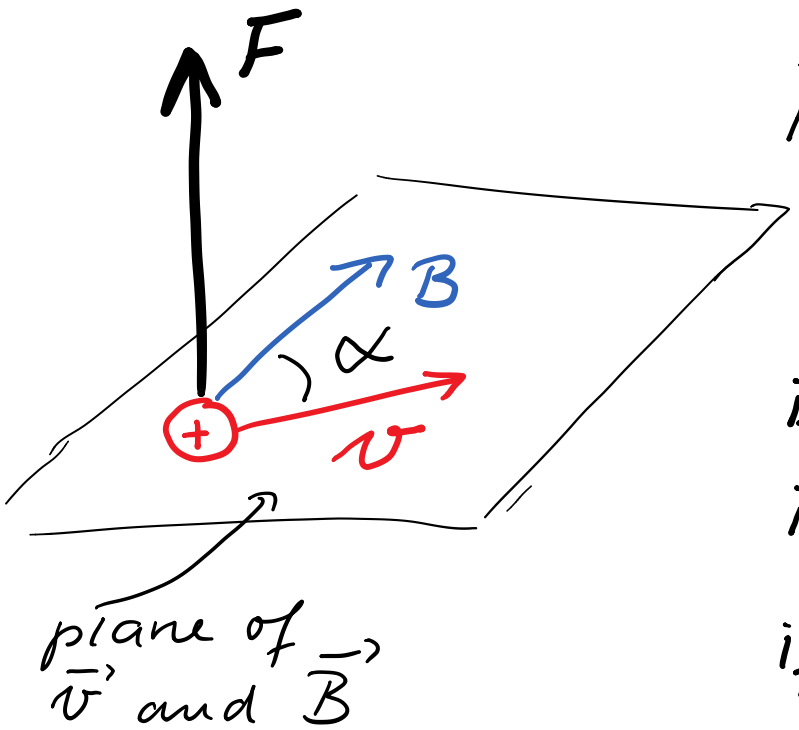
Lecture 25: Magnetic force

- Force on moving charged particles
- Mass spectrometer

Force on moving charges



Observe:

$\vec{F} \perp \vec{v}$

$\vec{F} \perp \vec{B}$

$$F = |q| v B \sin \alpha$$

if $\vec{B} \parallel \vec{v}$: $F = 0$

if $v = 0$: $F = 0$

if $\vec{B} \perp \vec{v}$: $F_{max} = |q| v B$

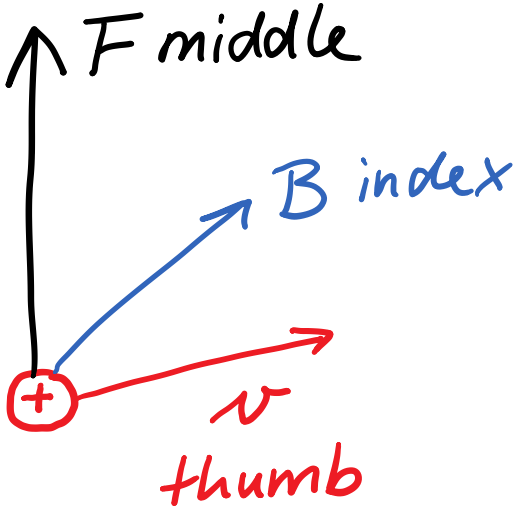
Direction of force: right hand rule

Thumb = $q\vec{v}$

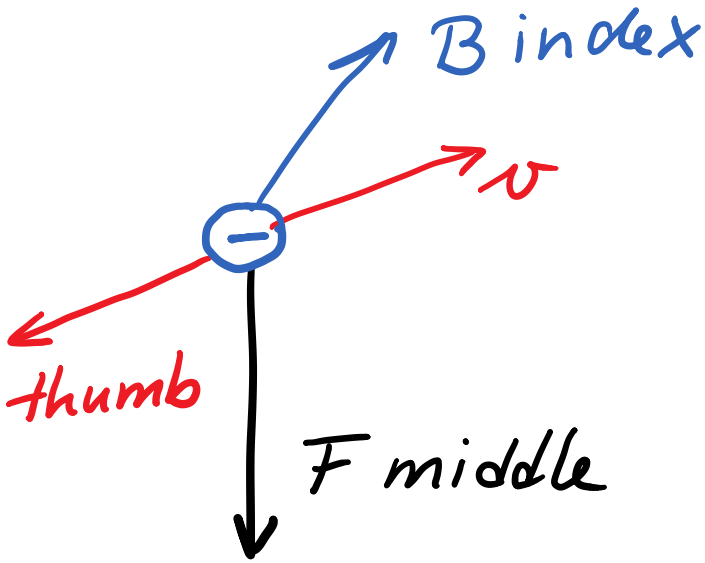
Index = $\vec{B}$

Middle = $\vec{F}$

watch sign!

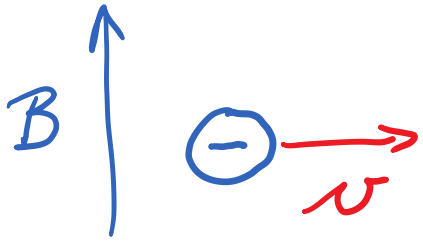


Positive charge

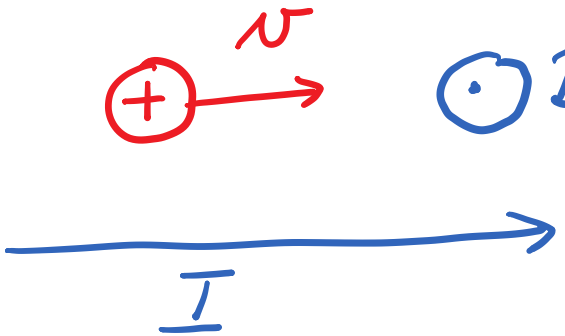


Negative charge

Examples



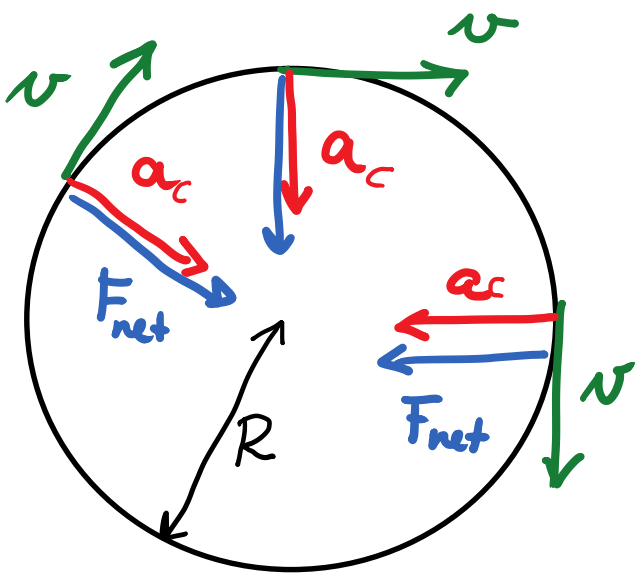
$\otimes$ $\vec{F}$ into the board



Phys 1145:

Uniform circular motion

Motion in a circle with constant speed



Caution:
velocity is a vector and has magnitude and direction
$\Longrightarrow$ constant *speed* does not mean constant *velocity*. There will be acceleration!

$$a_c = \frac{v^2}{R}$$

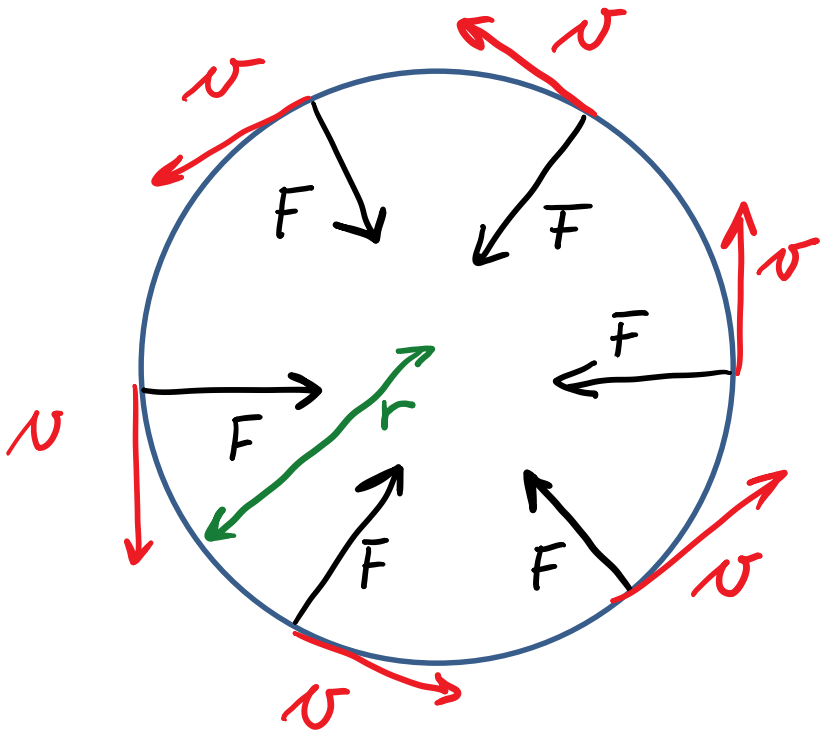
Centripetal acceleration

Directed **towards center** of the circle

Circular motion in uniform magnetic field

$\vec{F} \perp \vec{v}$ $\Rightarrow$ changes direction

if B = const. and $\vec{v} \perp \vec{B}$: uniform circular motion at constant speed

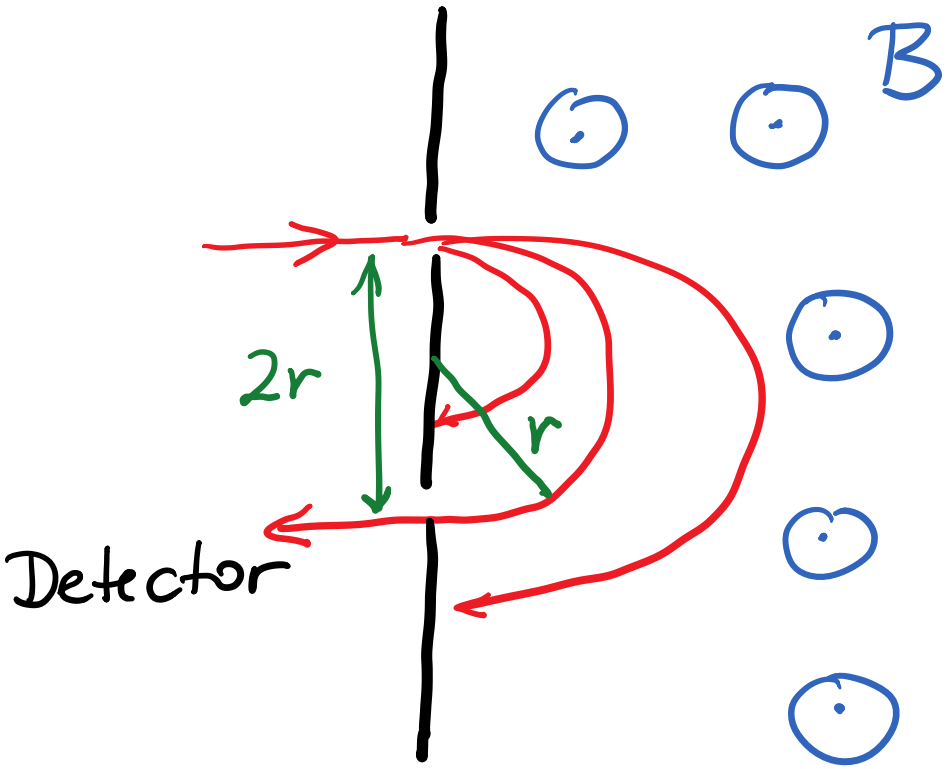


$$F = |q| v B \overbrace{\sin 90^\circ}^{1}$$

$$F = m a_c = m \frac{v^2}{r}$$

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

Application: Mass Spectrometer



$$F = |q| v B = m \frac{v^2}{r}$$

$$r = \frac{mv}{|q|B}$$

Ions of different masses
follow paths of different radii