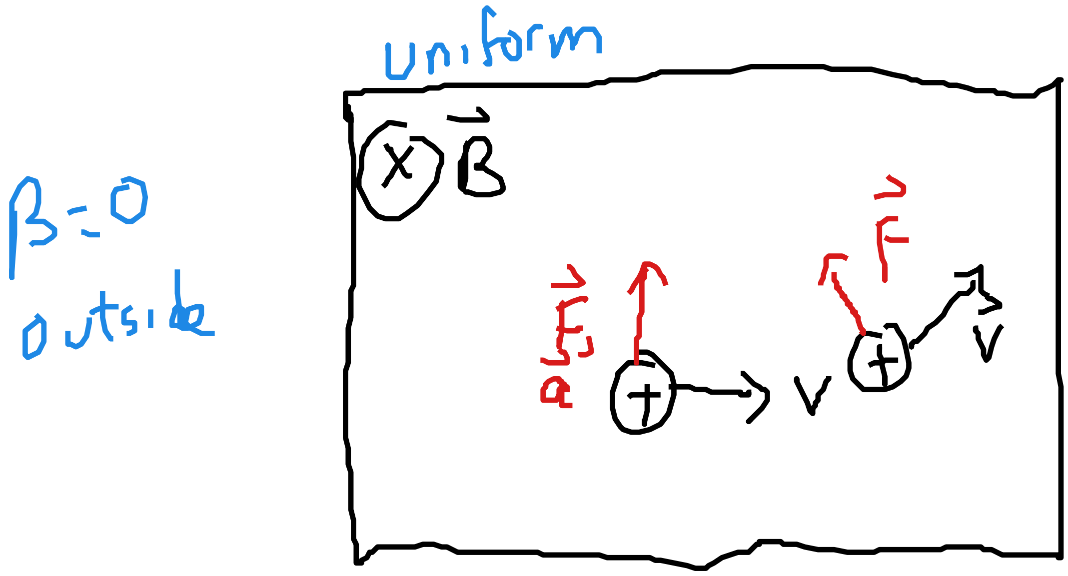
# Force on moving charges due to a magnetic field

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

$\vec{F}$ is $\perp$ to $\vec{v}$ & $\vec{B}$

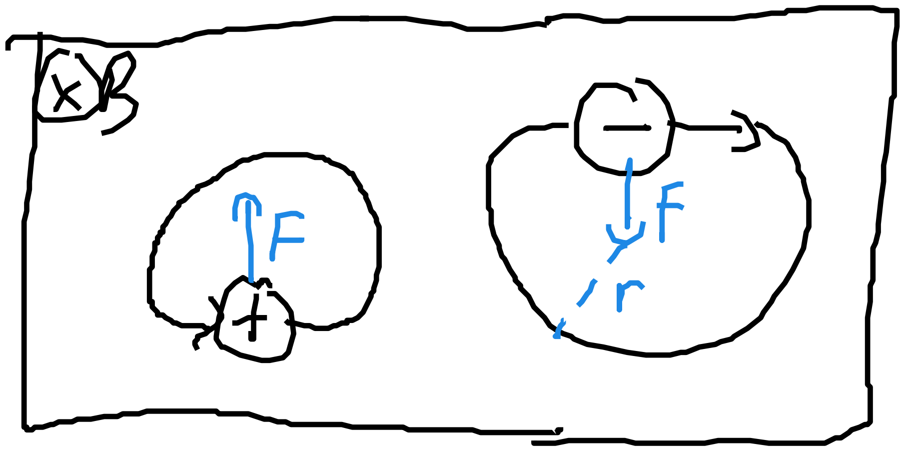
$$\vec{v}_f = \vec{v}_i + \vec{a}\Delta t$$




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

$\vec{a}$ is centripetal

Uniform Circular Motion




moves in a circle

$$a = \frac{v^2}{r}$$ centripetal acceleration

$$\vec{F} = q\vec{v} \times \vec{B} = qvB \quad (v, B \perp)$$

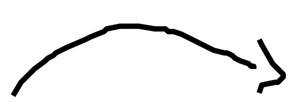
$$qvB = ma$$

$$qvB = m\frac{v^3}{r}$$

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

← momentum

← strength of interaction

Strong interaction  weak 

# Time to Orbit

$$T = \frac{d}{v} = \frac{2\pi r}{v} = \frac{2\pi}{\cancel{v}}\frac{m\cancel{v}}{qB}$$

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

period of oscillation

$$\boxed{f = \frac{1}{T} = \frac{qB}{2\pi m}}$$

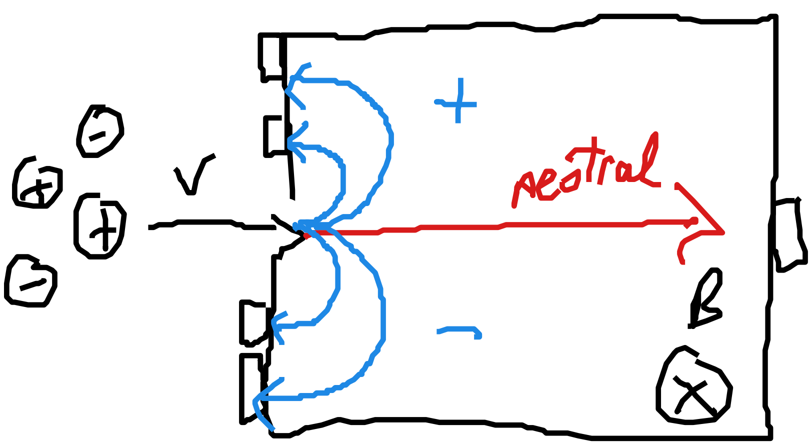
"cyclotron" frequency

$$\boxed{\omega = 2\pi f = \frac{qB}{m}}$$

angular velocity/frequency of charge

This is useful for identifying particles

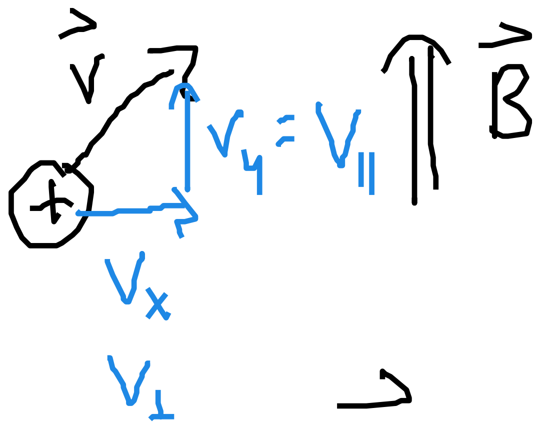
$$\frac{qB}{m} = \underbrace{\frac{q}{m}}_{\text{constant for any particular particle type}} B$$

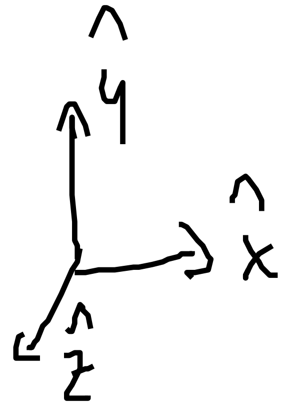



$$r = \frac{mv}{qB} = \frac{m}{q}\frac{v}{B} = \frac{1}{q/m}\frac{v}{B}$$

bigger $q/m$, smaller radius

If $\vec{v} \not\perp \vec{B}$




$$\vec{B} = B\hat{y}$$

$$\vec{v} = v_x\hat{x} + v_y\hat{y}$$

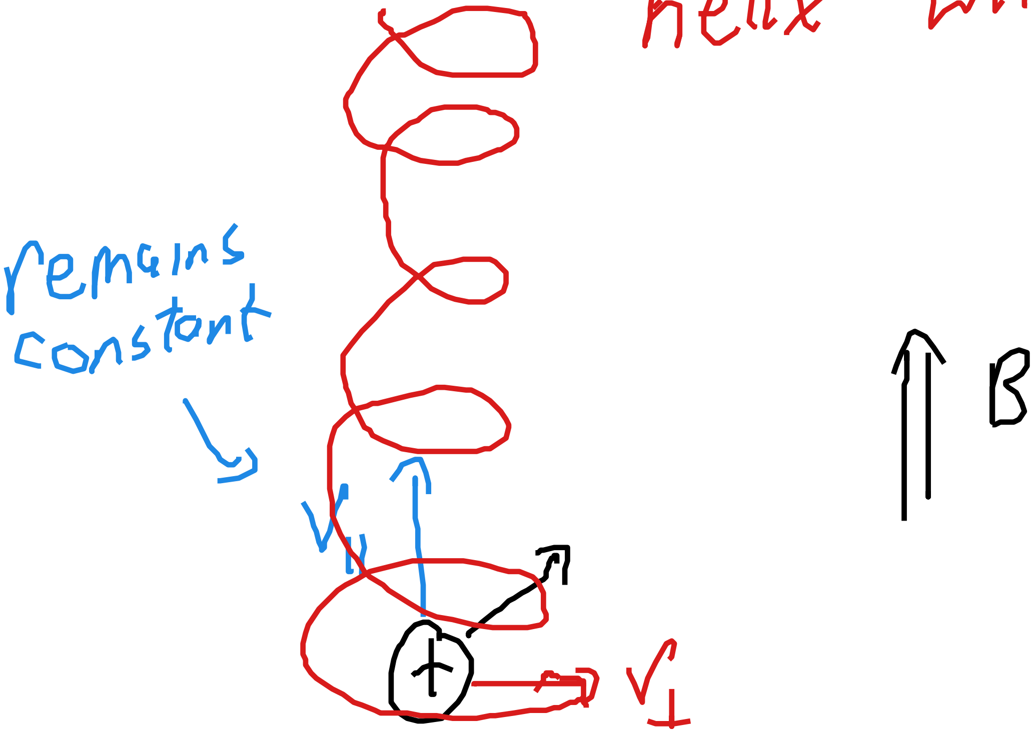
$$\vec{v} \times \vec{B} = (v_x\hat{x} + v_y\hat{y}) \times B\hat{y}$$

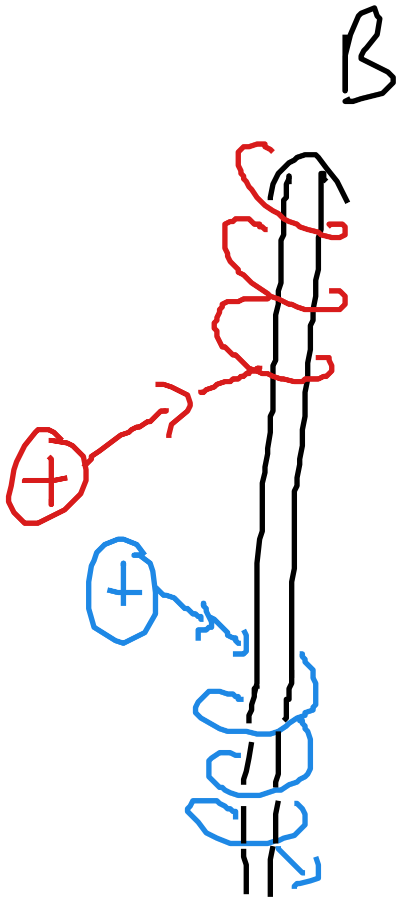
$$= v_x B(\hat{x} \times \hat{y}) + v_y B\underbrace{\cancel{(\hat{y} \times \hat{y})}}_{0}$$

$$= v_x B\hat{z}$$

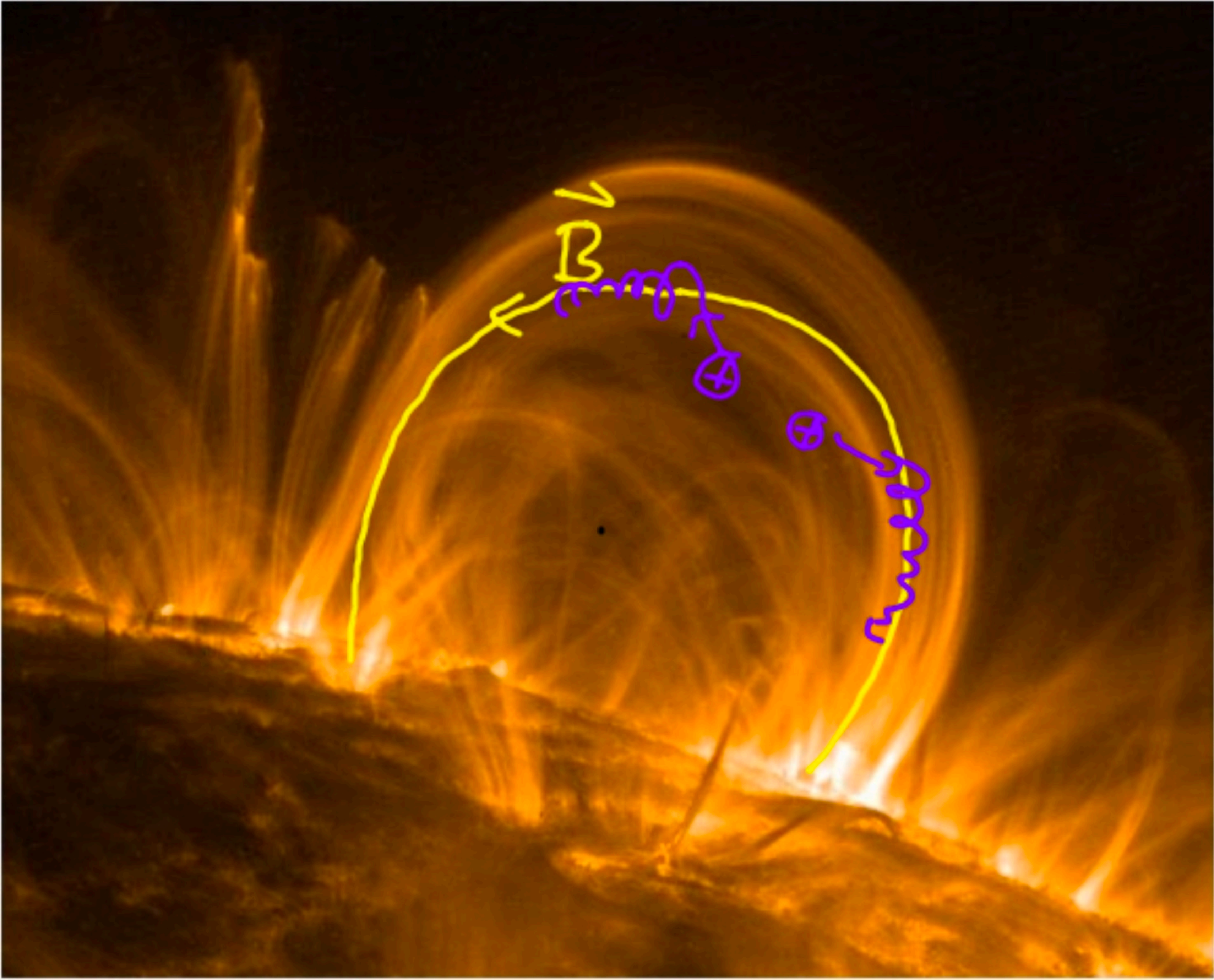
$$|\vec{F}| = q v_x B = q v_{\perp} B$$

helix with radius $r = \frac{mv_\perp}{qB}$



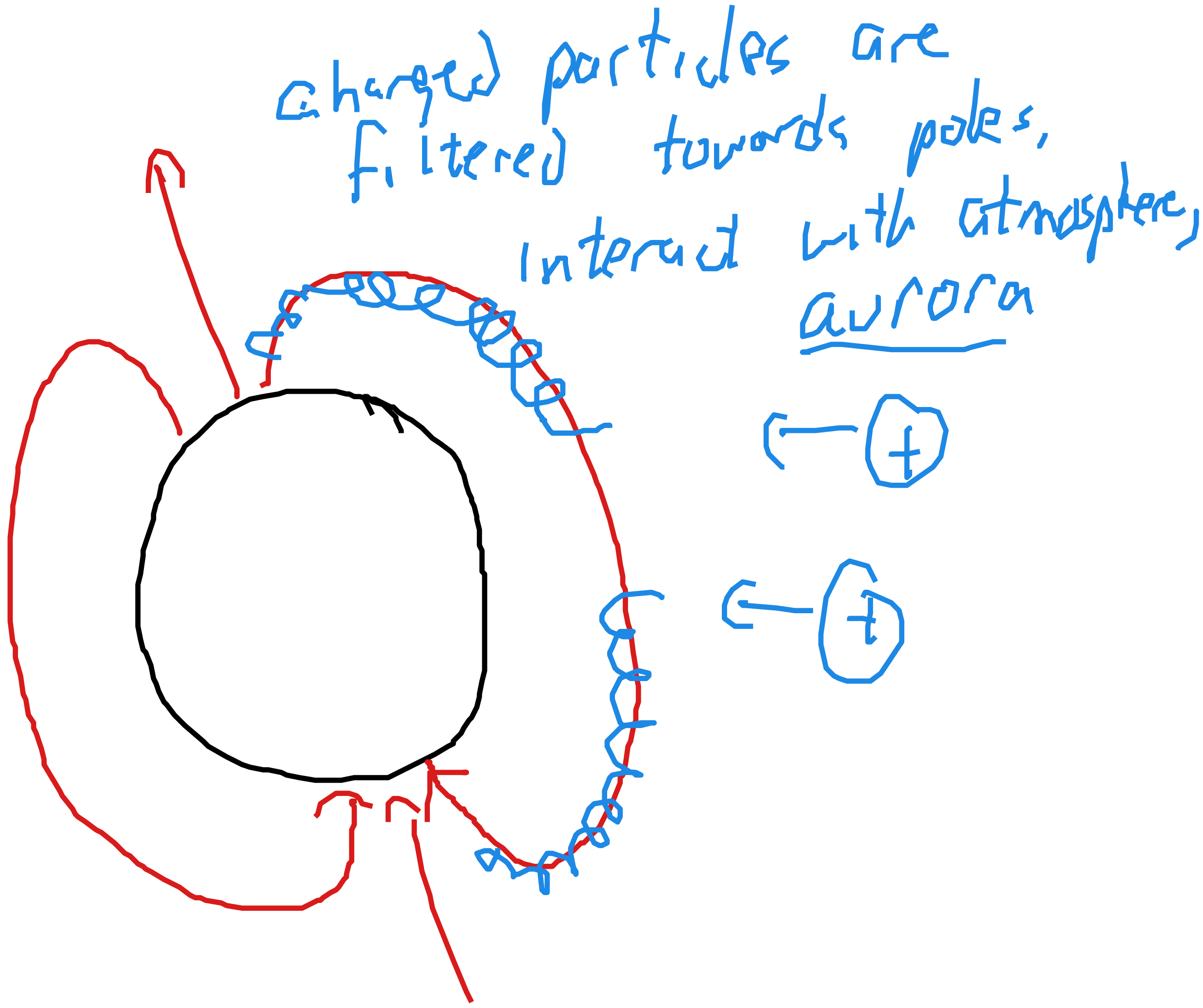




Charges move along the field line in both directions. they become trapped

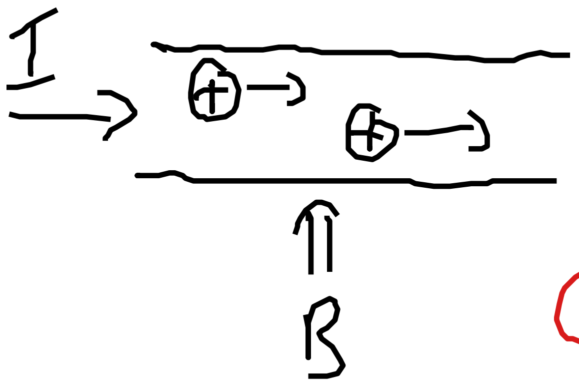


$\vec{B}$

Earth's Magnetic Field traps charged particles in the solar wind

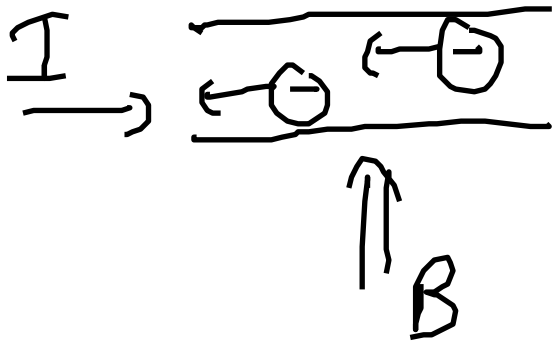


# Moving charge? Current!




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

$\odot \vec F$




$\vec V \times \vec B = \otimes$

$q\vec V \times \vec B$

$\odot \vec F$

Charge carrier does not matter