

a charge at rest feels nothing from B , a charge on the move feels everything

Electric force

$$qE$$

acts on any charge, moving or not

combines into

Magnetic force

$$qv \times B$$

acts only on a **MOVING** charge, and only across its velocity

combines into

Lorentz force

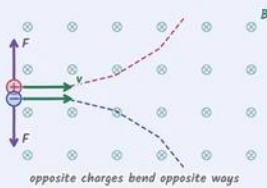
$$F = qE + qv \times B$$

both together, the complete force on a charge

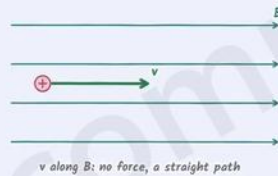
drop v to zero and the magnetic term vanishes on its own: a still charge only ever answers to E

The magnetic force, said precisely

- $F = qvB \sin \theta$, θ is the angle between v and B
- direction from $v \times B$: right-hand rule, then flip it for a negative charge
- always perpendicular to v : it can only turn a charge, never speed it up
- does **zero work**, so speed and kinetic energy never change



a + and a - fired across B into the page bend opposite ways, each push F at right angles to v and to B



v along B : no force, a straight path
 v along B : no push, a straight path

Circular motion in a uniform field

magnetic force supplies the centripetal force

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

radius of the circle

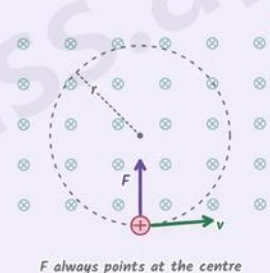
$$r = \frac{mv}{qB}$$

period, independent of speed

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

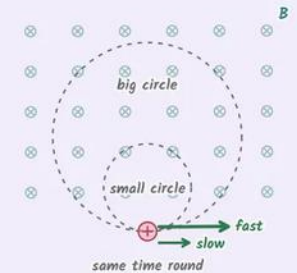
cyclotron frequency

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



F always points at the centre

v along the tangent, F always aimed at the centre: the geometry behind $r = mv/qB$



a fast and a slow charge leave one spot: bigger circle for the fast one, the same time round

faster particles just ride bigger circles in the same time T , that's the whole trick a cyclotron uses

angle between v and B ?

$$\theta = 0^\circ \text{ or } 180^\circ$$

no force

v parallel or antiparallel to B , $F = qvB \sin \theta = 0$

$$\theta = 90^\circ$$

circular path

F is always centripetal, radius stays fixed

$$\theta \text{ neither } 0^\circ, 90^\circ \text{ nor } 180^\circ$$

helical path

component along B is untouched, component across B circles

the along- B velocity never changes, only the across- B part ever gets bent