

Magnetic Fields due to Electric Current

a moving charge feels a field, a current makes one: cyclotron to solenoid on one thread



Charge in motion

q, v

a current is just many such charges together

→ produces

Lorentz force

$$F = q(v \times B)$$

always perpendicular to both v and B

→ produces

Circular path

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

a centripetal force that never speeds the charge up

run it back: a fixed R and B tell you the momentum $mv = qBR$, the cyclotron formula

The Lorentz force *

on a charge q moving with velocity v

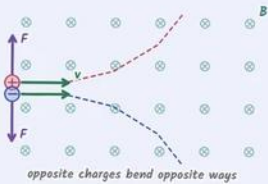
$$F = q(v \times B)$$

magnitude

$$F = qvB \sin \theta$$

with an electric field also present

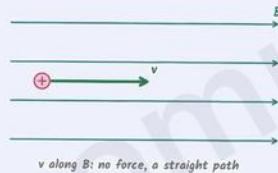
$$F = qE + q(v \times B)$$



opposite charges bend opposite ways

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

zero force when v is parallel to B , or the charge is at rest: no v - B mismatch, no force

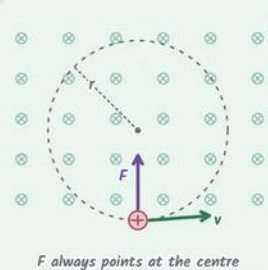


v along B : no force, a straight path

v along B : no push, a straight path

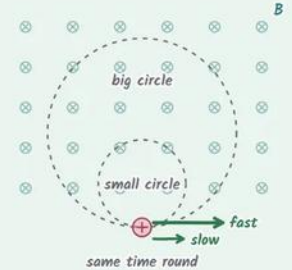
Circular motion in a uniform field *

- magnetic force stays perpendicular to velocity: direction changes, speed never does, zero work done
- constant force, always perpendicular to v : exactly uniform circular motion, magnetic force as centripetal force
- $qvB = \frac{mv^2}{R}$ gives $R = \frac{mv}{qB}$: radius shrinks for stronger B or slower charge



F always points at the centre

v along the tangent, F always aimed at the centre, the same size all the way round



same time round

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