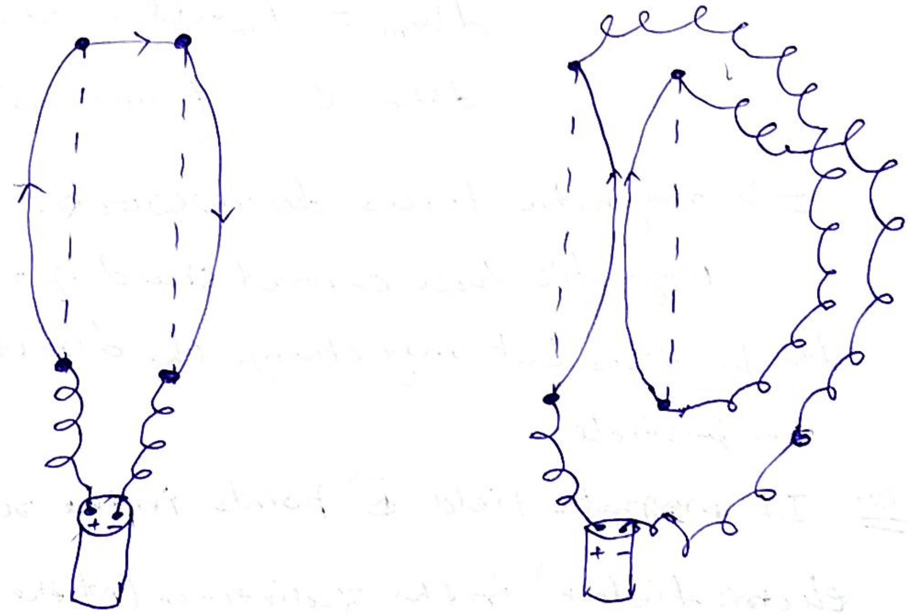
Magnetostatics-I

Electrostatics — stationary charges produces only an electric field $\vec{E}$ in the space around it.

→ Source charges is at rest (test charge need not to be)

Source charge

→ If we set an experiment in which we take two wires and hang them from the ceiling, keeping distance between them a few centimeters. Now if we turn on a current such that it passes up one wire and back down the other, the wire repel one another. If current are in same direction between the wires, they attract each other.



Current in opposite direction → Repulsion

Current in same direction: attraction

→ The above phenomena of attraction and repulsion of parallel and antiparallel currents respectively happens because moving charges inside the wires generate magnetic field $\vec{B}$.

Lorentz force law: The magnetic force on a charge Q moving with velocity $\vec{v}$ in a magnetic field $\vec{B}$ is given by

$$\boxed{\vec{F}_m = Q(\vec{v} \times \vec{B})}$$

$\vec{F}_m$ is Lorentz force

If in addition to magnetic field $\vec{B}$, electric field $\vec{E}$ is also present, the magnetic force $\vec{F}_m$ is given by

$$\boxed{\vec{F}_m = Q[\vec{E} + (\vec{v} \times \vec{B})]}$$

Work: If charge Q moves an amount $d\vec{l} = \vec{v}dt$ the work done is given as

$$dW_m = \vec{F}_m \cdot d\vec{l} = Q(\vec{v} \times \vec{B}) \cdot \vec{v}dt$$

$$dW_m = 0 \quad (\text{since } (\vec{v} \times \vec{B}) \cdot \vec{v} = 0)$$

⇒ magnetic forces do no work.

Magnetic force cannot speed up or slow down the particles but may change the direction of the particle.

Q. If magnetic field $\vec{B}$ points in the x-direction and electric field $\vec{E}$ in the z-direction (at the right angle to the magnetic field $\vec{B}$) and a particle at rest is released from the origin, what path will it follow?