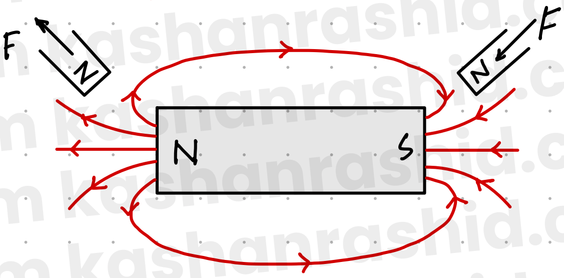
- Magnetism is due to the motion of charge particles.

Magnetic field

- A region in space around a magnet where another magnet, magnetic material or current carrying conductor experiences a magnetic force.

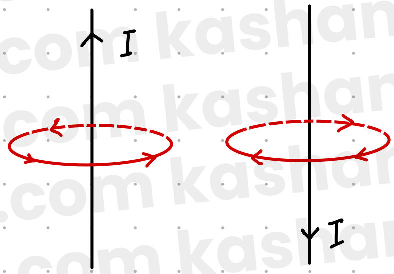
- North pole, South pole
- Unlike poles attract and like poles repel.



- Direction of field lines tell the direction of force on a North pole.

- Gap between field lines tell the strength of field. less gap means strong field and vice versa.

Magnetic field around a current carrying conductor.



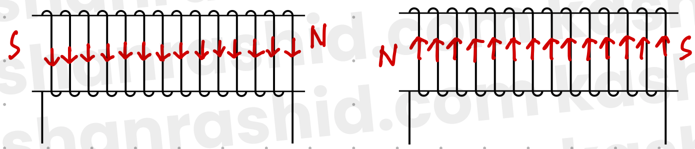
Right Hand Grip Rule

Straight Wire

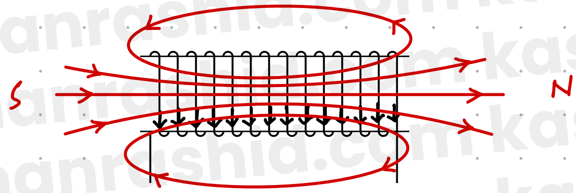
Thumb: Current
Curl of Fingers: Magnetic field

Coil of wire

Thumb: North pole
Curl of Fingers: Direction of current.



Magnetic field around a coil



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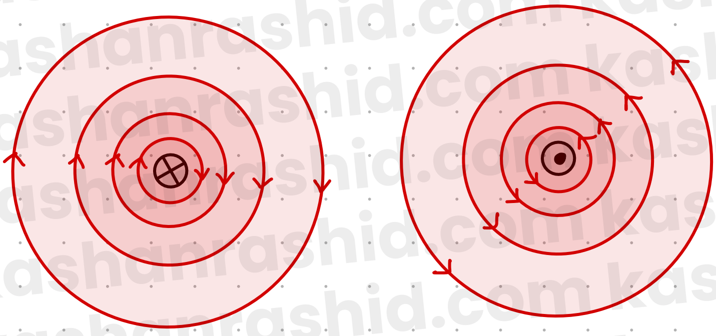
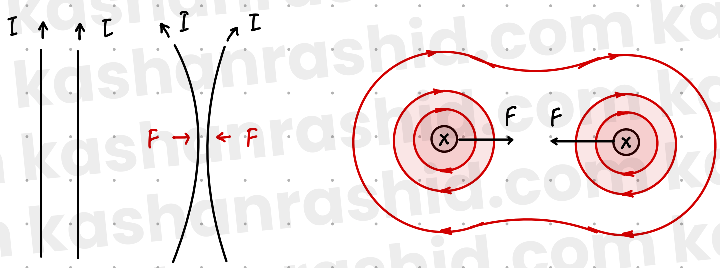
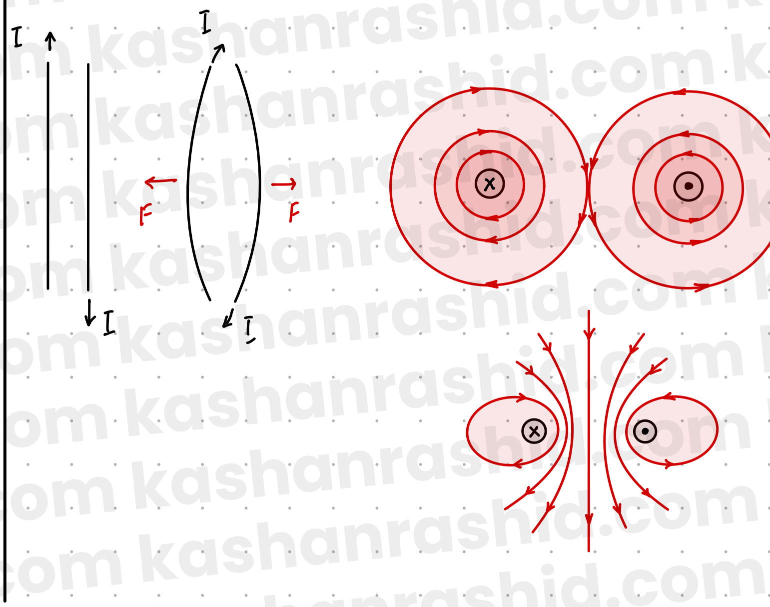


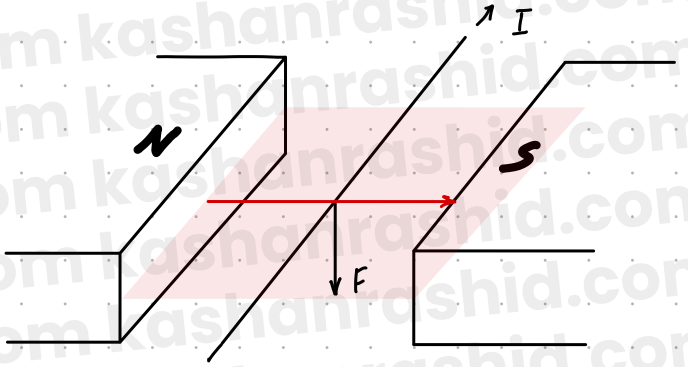
- ☑ concentric circles
- ☑ increasing gap b/w circles
- ☑ correct direction of arrows

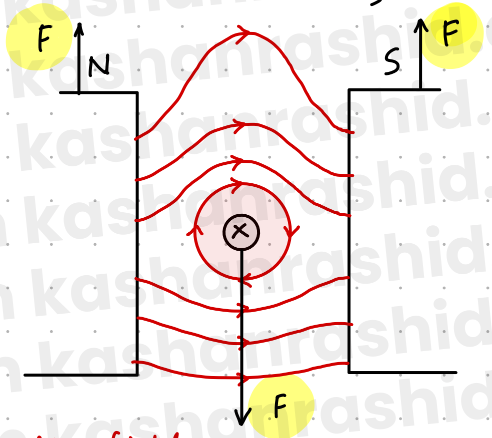
- Like currents attract
- Unlike currents repel.





Force on a current carrying conductor in a magnetic field



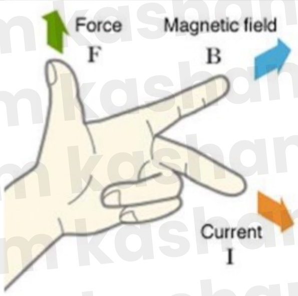
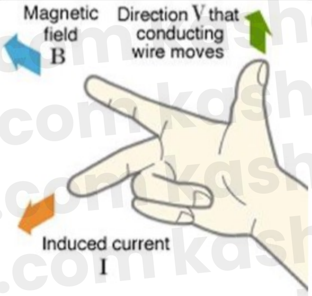


- Due to the interaction of magnetic fields of conductor and permanent magnet, a force is produced on the conductor which acts perpendicular to direction of current and magnetic field.

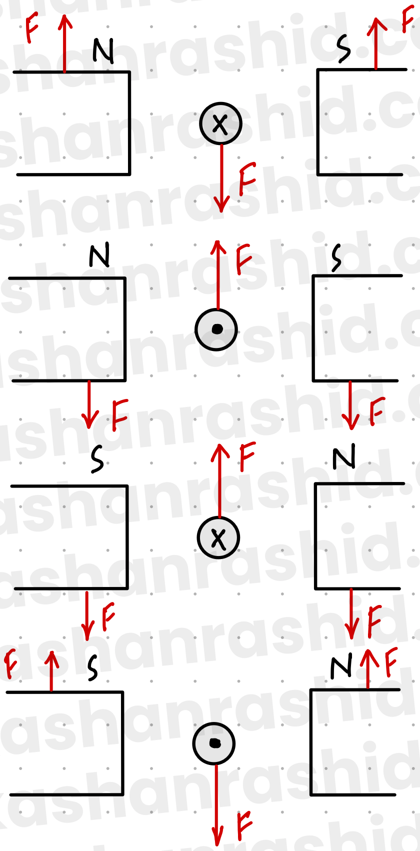
- Force is also experienced by the magnet which is equal in magnitude but opposite in direction. (Newton's 3rd Law)

Flemming's Left Hand Rule

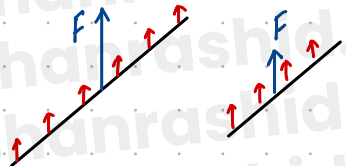
Thumb: Force (F)
First Finger: Magnetic Field (B)
Second Finger: Current (I)

Fleming's Left-Hand Rule	Fleming's Right-Hand Rule
Thumb: Force on a conductor (F) First Finger: Magnetic field (B) Second Finger: Current (I) It can be memorized as FBI in the order of thumb, first finger and middle finger.	Thumb: Applied force on wire (F) First Finger: Magnetic field (B) Second Finger: Induced Current (I) It can be memorized as FBI in the order of thumb, first finger and middle finger.
Known: Magnetic field & current	Known: Applied force & Magnetic field
Unknown: Force on conductor	Unknown: Induced current
Cases of Application: DC motor, moving charges in magnetic field.	Cases of Application: AC Generator
	

Flemming's left Hand Rule is applied when a force is produced using magnetic field and current.



- $F \propto I$
- $F \propto l$ → length in field



combining both proportionalities

$F \propto Il$ → $F = BIl$ → $B = \frac{F}{IL}$

where B is magnetic field strength or **Magnetic Flux Density.**

Magnetic Flux Density (B)

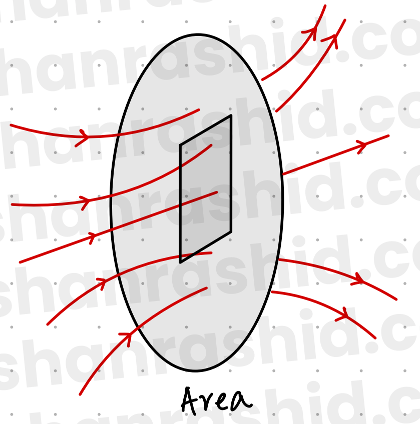
It is the force per unit length on a conductor carrying unit current normal to the magnetic field.

$$B = \frac{F}{IL}$$

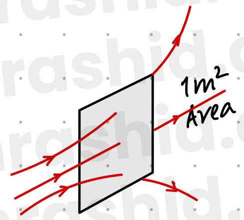
SI Unit: Tesla (T)

Define the Tesla (1T)

It is the magnetic flux density when a wire of 1m carrying 1A of current experiences 1N of force when placed normal to magnetic field.



Magnetic Flux (ϕ) is the total magnetic field crossing an area.

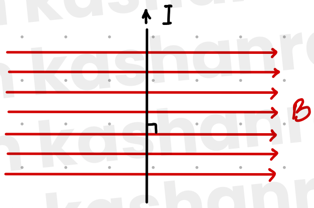


(B) magnetic flux density is magnetic field in a unit area (1m²)

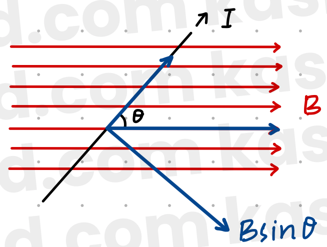
$$\phi = B \times A$$

- ϕ → Magnetic flux → SI Unit: Weber (Wb)
- B → Magnetic flux density → SI Unit: Tesla (T)
- A → surface area through which field passes → SI Unit: m²

$T = Wb/m^2$



max force when $\theta = 90°$



Force on the conductor is due to the component of magnetic field that is at 90° to the conductor.

$F = (B\sin\theta) IL$

$F = BIL\sin\theta$

where θ is the angle between the conductor and magnetic field.

☑ $\theta = 0°$, $\sin 0° = 0$ and $F = 0$

☑ $\theta = 90°$, $\sin 90° = 1$ and $F = F_{max} = BIl$

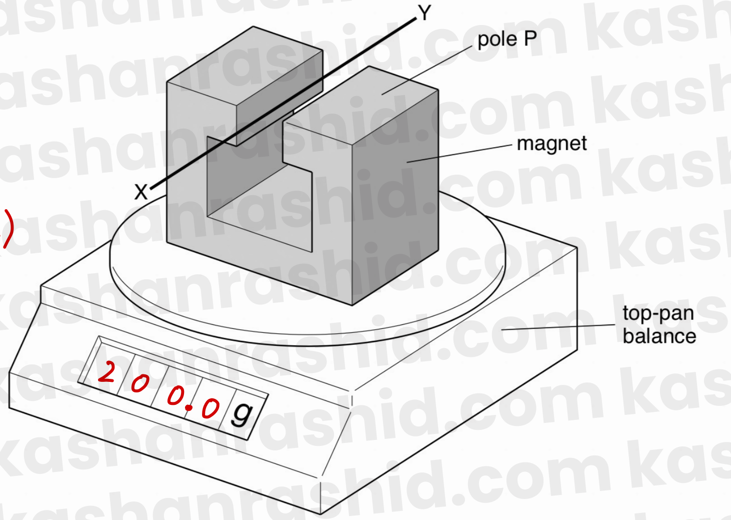
Experiment to determine Magnetic Flux Density

$F = BIL$

$B = \frac{F}{IL}$ → force on conductor (??)

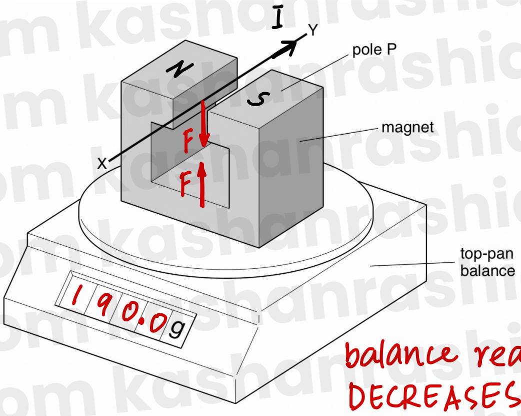
I → current (Ammeter)

L → length of conductor inside the field (meter rule / tape measure)

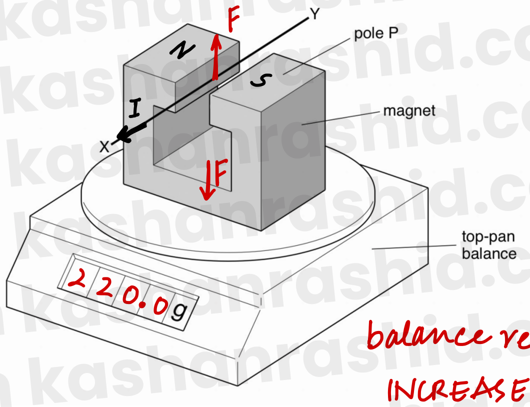


- When no current flows, the reading on mass balance is due to the weight of magnet alone. [m_1 : actual mass of magnet]

- When current flows, a force is exerted on the conductor as well as the magnet. These forces are equal in magnitude but opposite in direction. [Newton's 3rd Law]

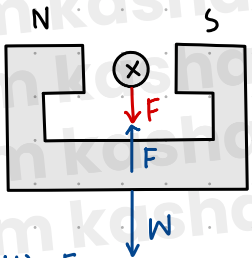


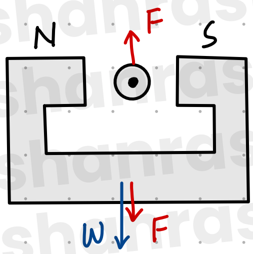
balance reading DECREASES!



balance reading INCREASES!

"Flemming's Left Hand Rule will tell the direction of force on conductor."





$W_{new} = W - F$

$m_2 g = m_1 g - F$

$F = m_1 g - m_2 g$

$\boxed{F = \Delta m g}$ ✓

e.g. $F = \frac{(200-190)}{1000} \times 9.8$

$F = 0.098\ N$

$W_{new} = W + F$

$m_2 g = m_1 g + F$

$F = m_2 g - m_1 g$

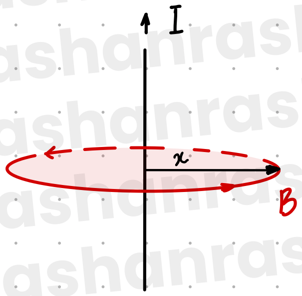
$\boxed{F = \Delta m g}$

e.g. $F = \Delta m g$

$= \frac{(20)}{1000} \times 9.8$

$F = 0.196\ N$

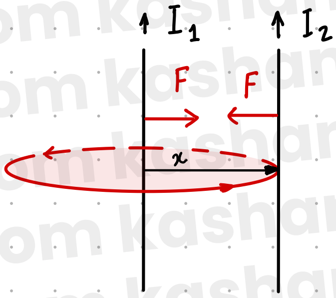
Magnetic field around a straight current carrying conductor



☑ $B \propto I$
☑ $B \propto \frac{1}{x}$ → $B = \frac{\mu_0 I}{2\pi x}$

I : current
x : distance of a point from the center of wire

μ_0 : permeability of free space
$\mu_0 = 4\pi \times 10^{-7}$
{It tells about the ease for vaccum to allow magnetic field to spread}



To determine force on a current carrying conductor due to another conductor,

$F = BIL$

$F = \frac{\mu_0 I_1}{2\pi x} \cdot I_2 L$

$\frac{F}{L} = \frac{\mu_0 I_1 I_2}{2\pi x}$ ← force per unit length

$F \propto I_1 I_2$

• ($F \propto m_1 m_2$)
• ($F \propto q_1 q_2$)

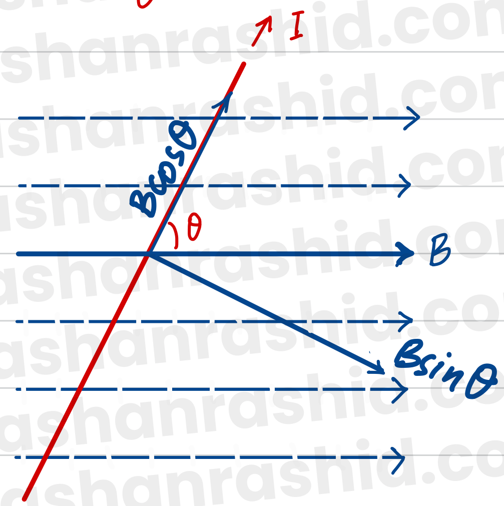
Even if magnitudes of current are different, the force on both of the conductors will be same. This is according to Newton's 3rd Law.

$F \propto I$, $F \propto L$ } $F \propto IL \rightarrow F = BIL$

↓ Magnetic flux density (Magnetic field Strength)

- The force per unit length on a conductor carrying unit current, normal to the magnetic field.

$B = \frac{F}{IL}$ "Tesla"



$F = BIL$

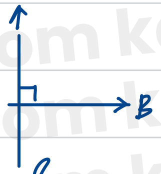
$F = (B\sin\theta)IL$

$F = BIL\sin\theta$

$\theta = 90^\circ$

$\sin 90^\circ = 1$ &

$F_{max} = BIL$



$\theta = 0^\circ$

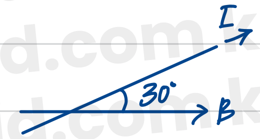
$\sin 0^\circ = 0$

$F = 0$ (No force)

$\theta = 30^\circ$

$\sin 30^\circ = 0.5$

$F = 0.5\,BIL$ or $F = 0.5\,F_{max}$



Define the Tesla! (1T)

$B = \frac{F}{IL}$ ($F \rightarrow 1N$, $I \rightarrow 1A$, $L \rightarrow 1m$)

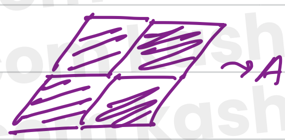
↓ 1T normal to magnetic field

It is the magnetic flux density when a wire of 1m, carrying 1A of current experiences 1N of force, when placed perpendicular to magnetic field.

Magnetic flux → $\phi = B \times A$

ϕ → (Wb) Weber

B → Tesla (T), Wb/m^2



$B = \frac{\phi}{A}$