LAKSHYA BATCH

PW

Magnetism and Matter
Bar Magnet, Magnetic Dipole and field around Magnets

LECTURE - 1

You have to Completely Refuse to be victim of the Circumstances

Choose between Pain of discipline & pain of Regret.

What Seems impossible Today, may one day become your warm up!

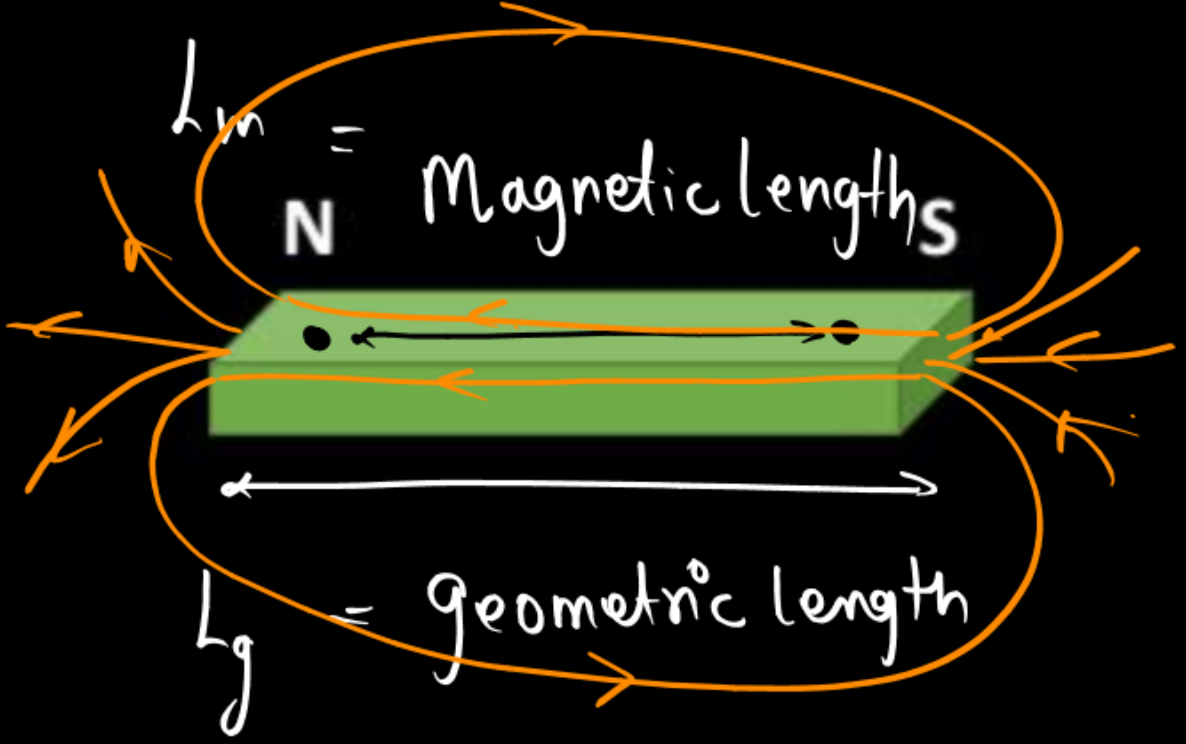
Winners Never Quit & Quitters never win.

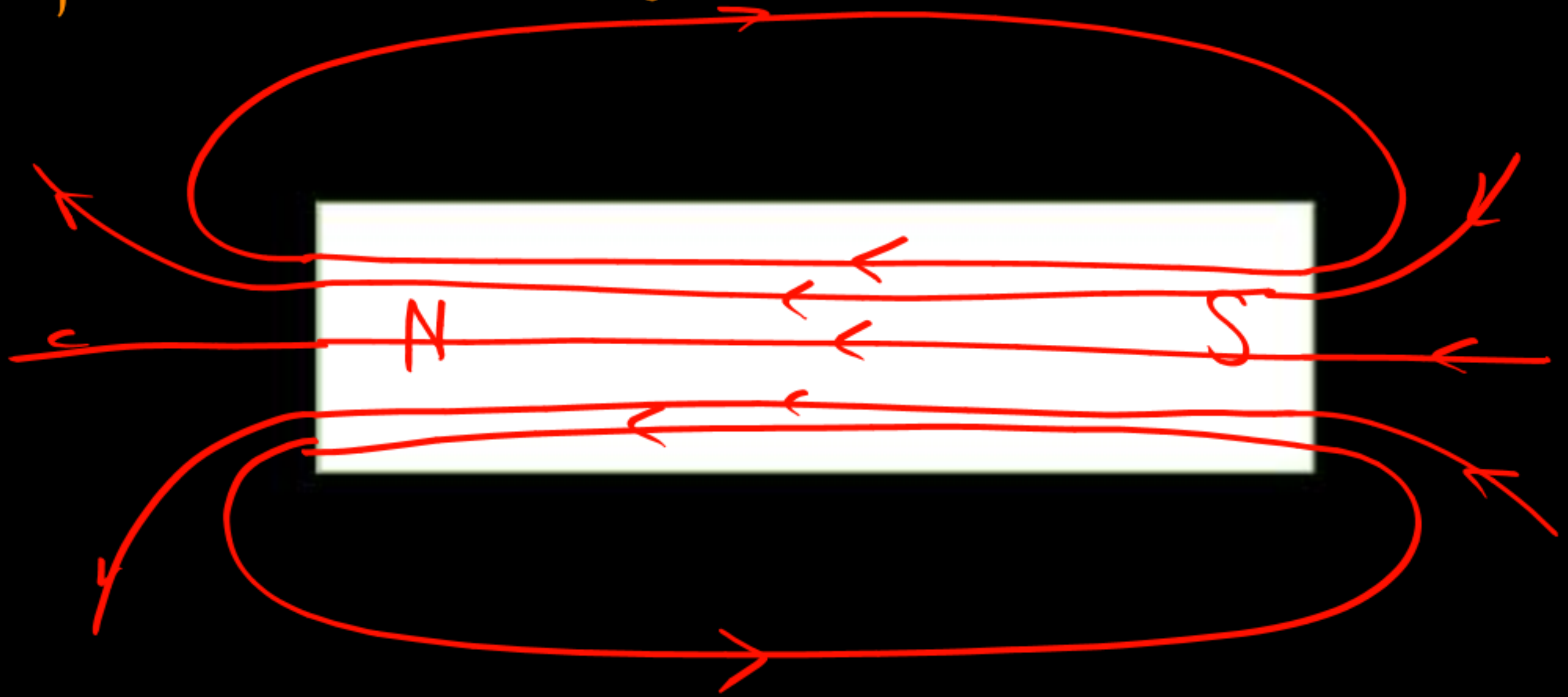
GOALS OF THE DAY

- Bar magnet
- Magnetic field lines properties
- Magnetic dipole moment of bar magnet
- Magnetic field at axial and equatorial points
- Solenoid as bar magnet

BAR MAGNETS AND MAGNETIC FIELD LINES

Magnetic field → Region Around a Magnet in which it Can Exert force on other Magnetic Material





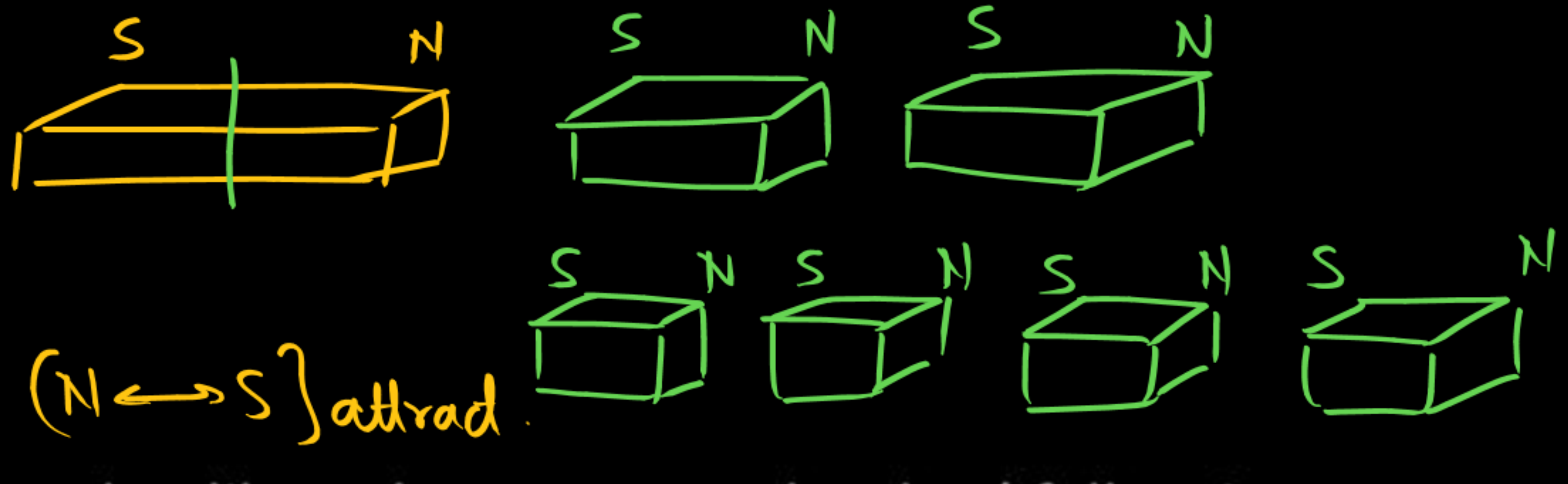
$$\frac{L_m}{L_g} = \frac{5}{6}$$

Cross-Sectional ↗

Properties of Bar Magnet

- A freely suspended Bar magnets Points in (north south) direction (magnetic meridian)? we will Study in Earth Magnetism.

- Monopoles do-not exist

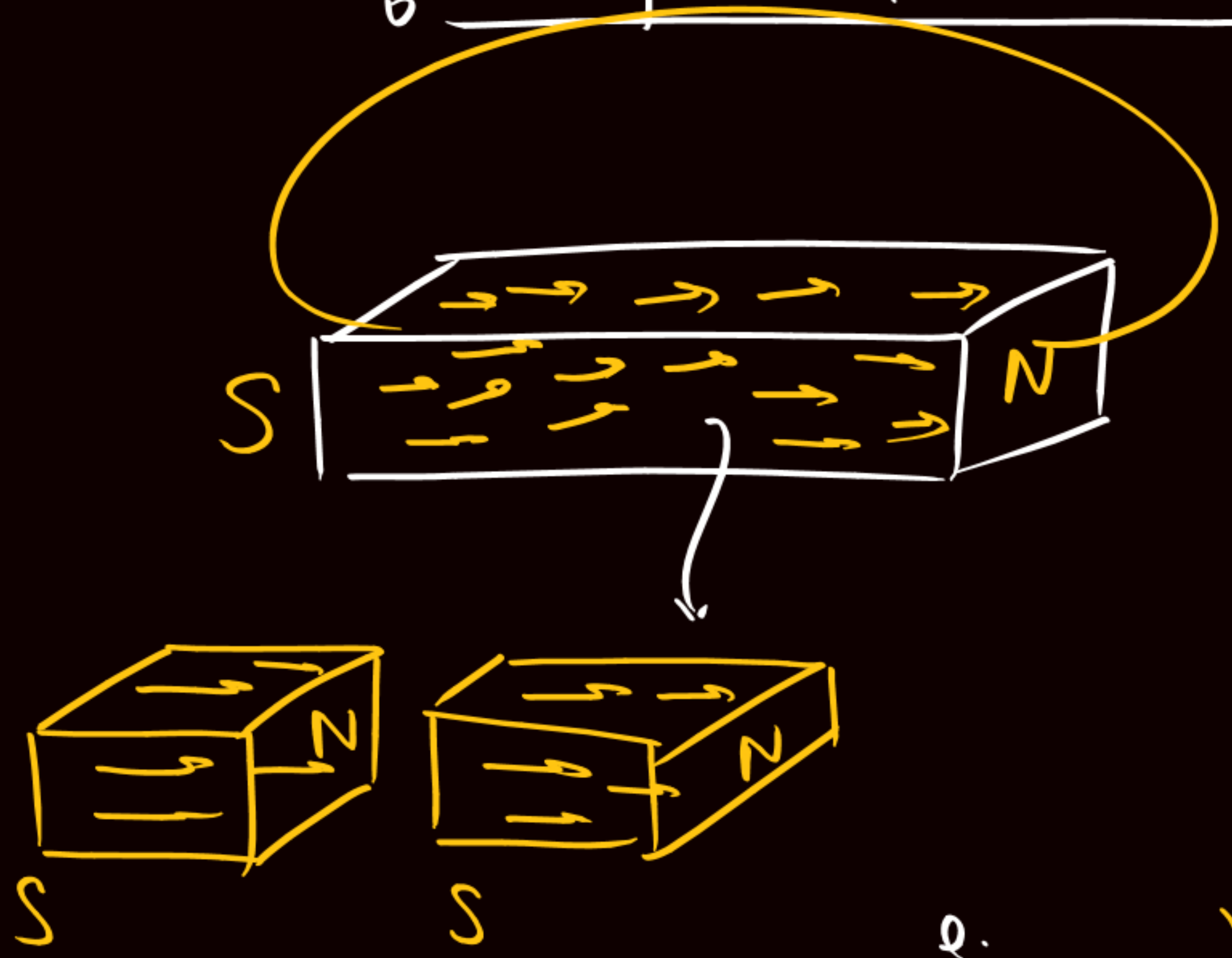


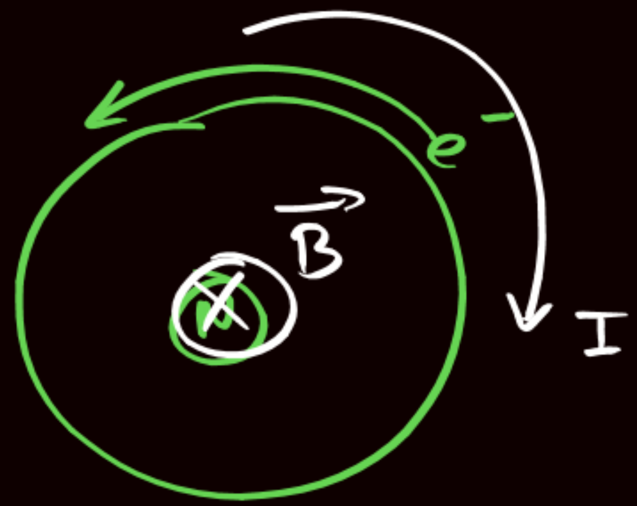
N ⟷ N, S ⟷ S } Repel (N ⟷ S } attract

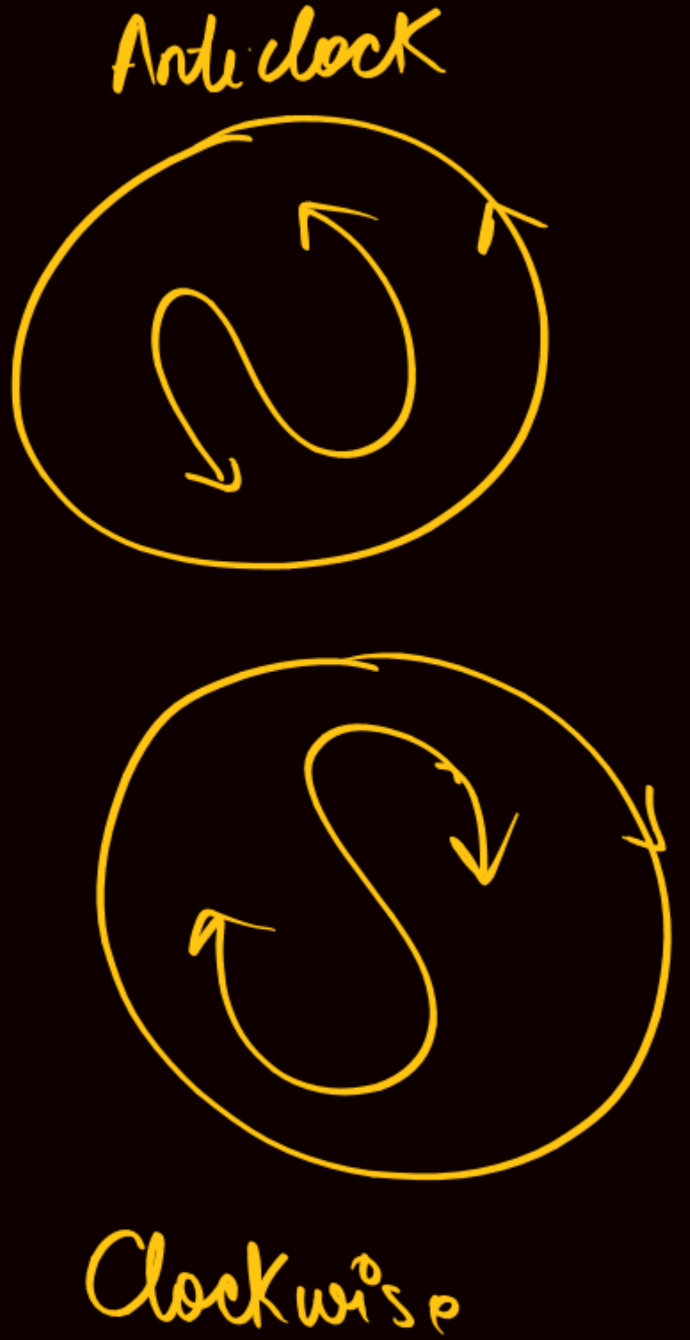
- Like poles repel each other and unlike poles attract each other(follow inverse square law)

- On hammering, on heating or cooling, magnet loses its magnetic property.

Monopoles do-not Exist







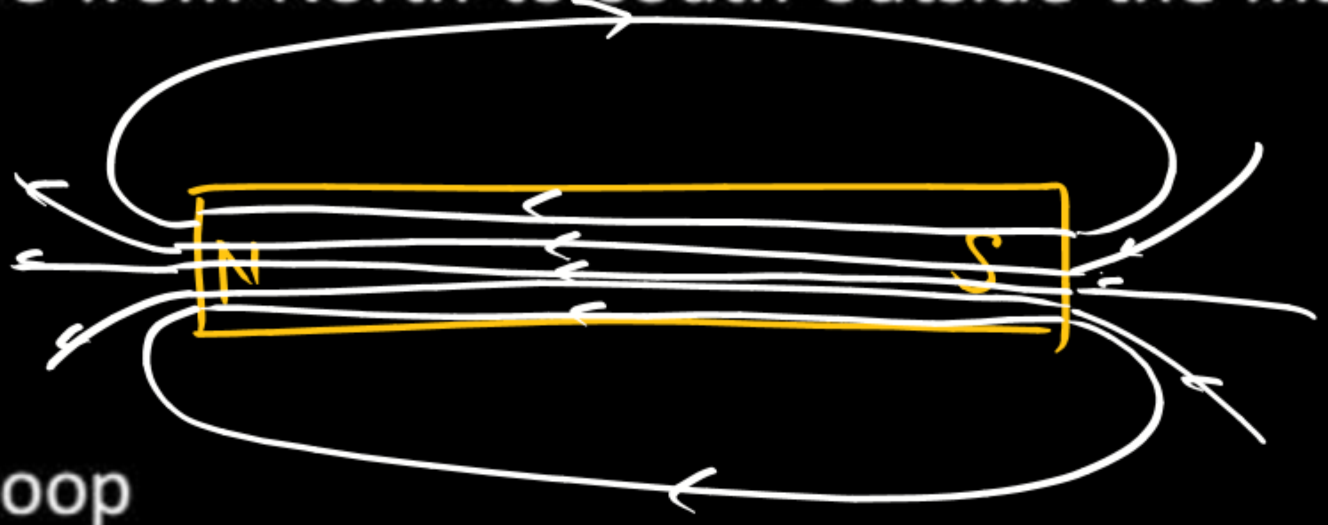
↓

Current → MF

PROPERTIES OF MAGNETIC FIELD LINES

- Magnetic field lines are the line of magnetic force tangent to which the force will act

- Magnetic field lines move from North to south outside the magnet and south to north inside the magnet



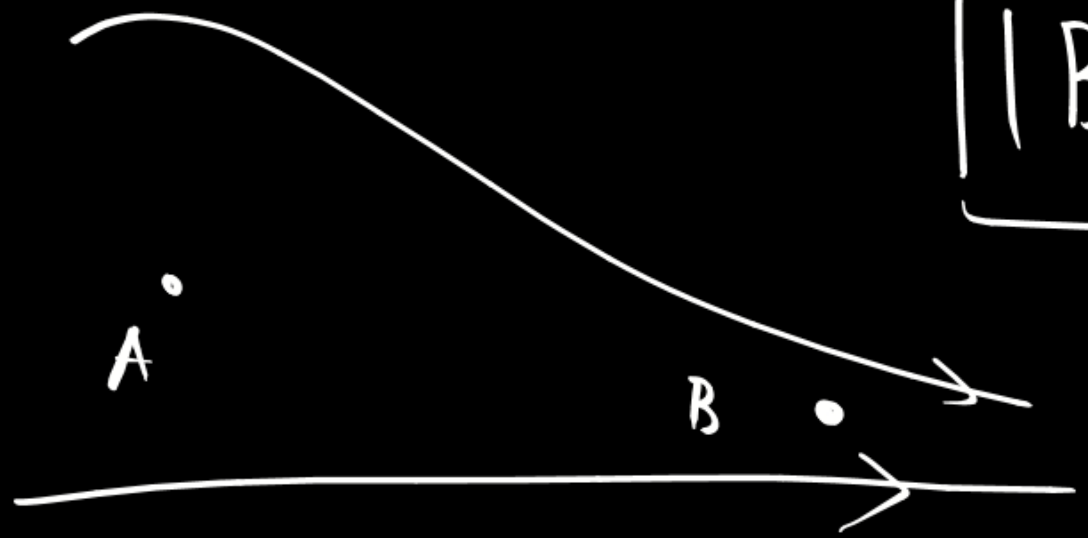
- They Always form Close loop

- They are always continuous and differentiable curves.

→ Tangent to these line we get dir of magnetic field

They has to be continous

- Magnetic field intensity is inversely proportional to spacing between lines



$$|B_A| < |B_B|$$

- The no of magnetic field lines are Proportional to strength of magnetic pole

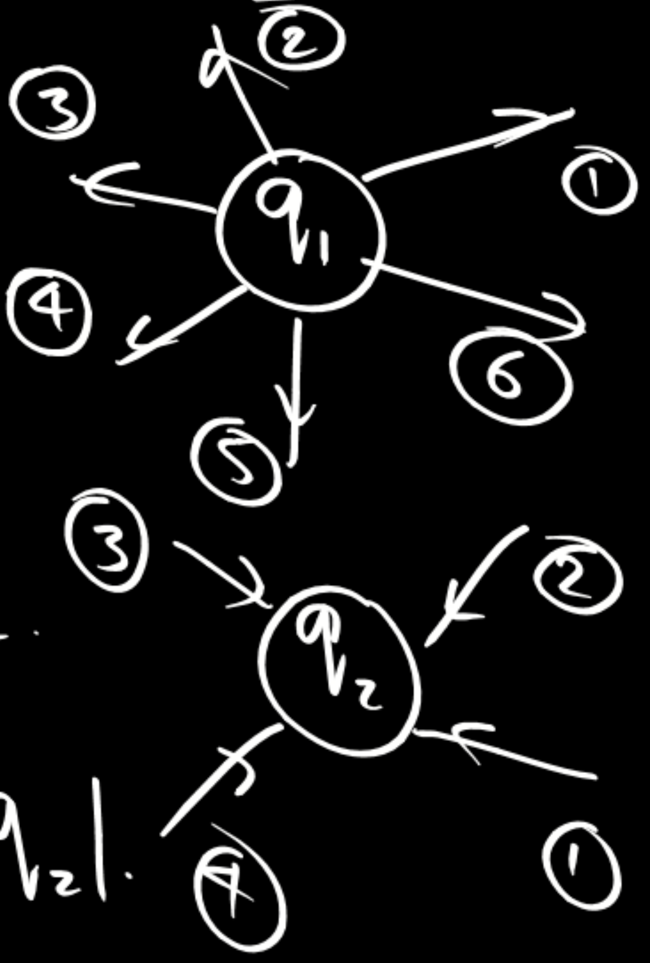
Electro

$q_1 = +ve$

$$\frac{q_1}{q_2} = \frac{6}{4} = \frac{3}{2}$$

$q_2 = -ve$

$|q_1| > |q_2|$



- They can never intersect each other

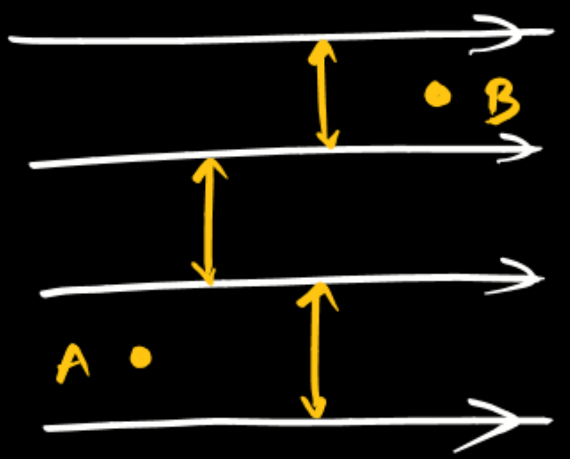
because if they do, at a point of intersection if a monopole is placed, it will Experience two forces & Cannot move in two dir.

$|B_A| = |B_B|$, $\hat{B}_A = \hat{B}_B$ — Spacing ↓ — $|B_A| = |B_B|$, $\hat{B}_A \neq \hat{B}_B$

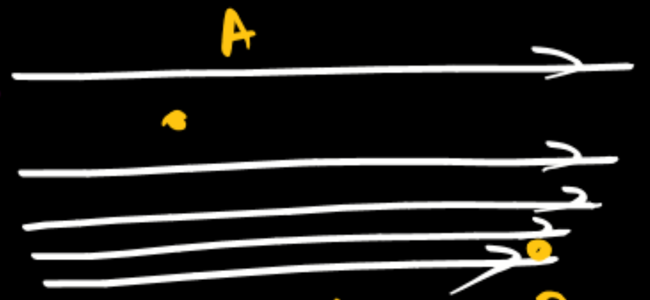
- A magnetic field is uniform only when magnitude and direction is same

↓ (space)

(uniform)



Case.1



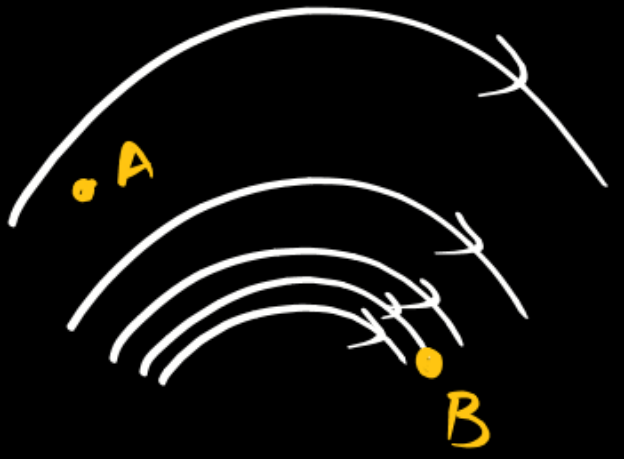
$|B_B| > |B_A|$

$\hat{B}_B = \hat{B}_A$

Case.2

(X)

Case.3



Case.4

Spacing ↓

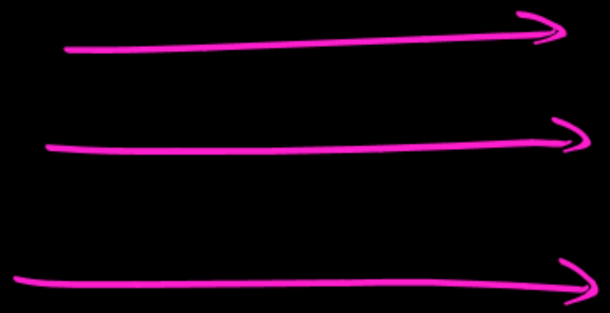
Magnitude ↑

$|B_B| > |B_A|$

$\hat{B}_A \neq \hat{B}_B$

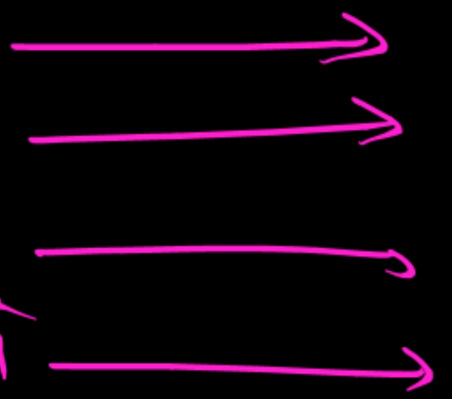
- A magnetic field in constant when is not varying with time

(wrt time)



$B = 4t^2 \hat{i}$

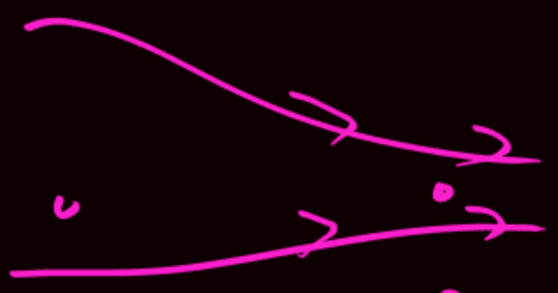
$t = 1s$ $B = 4T\hat{i}$



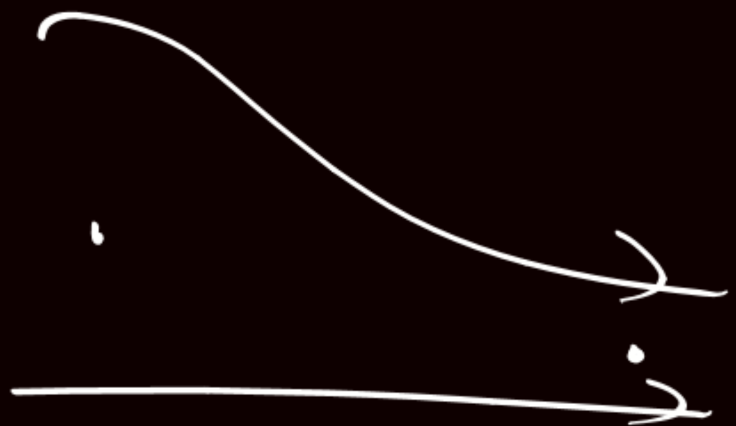
(uniform but Not Constant)

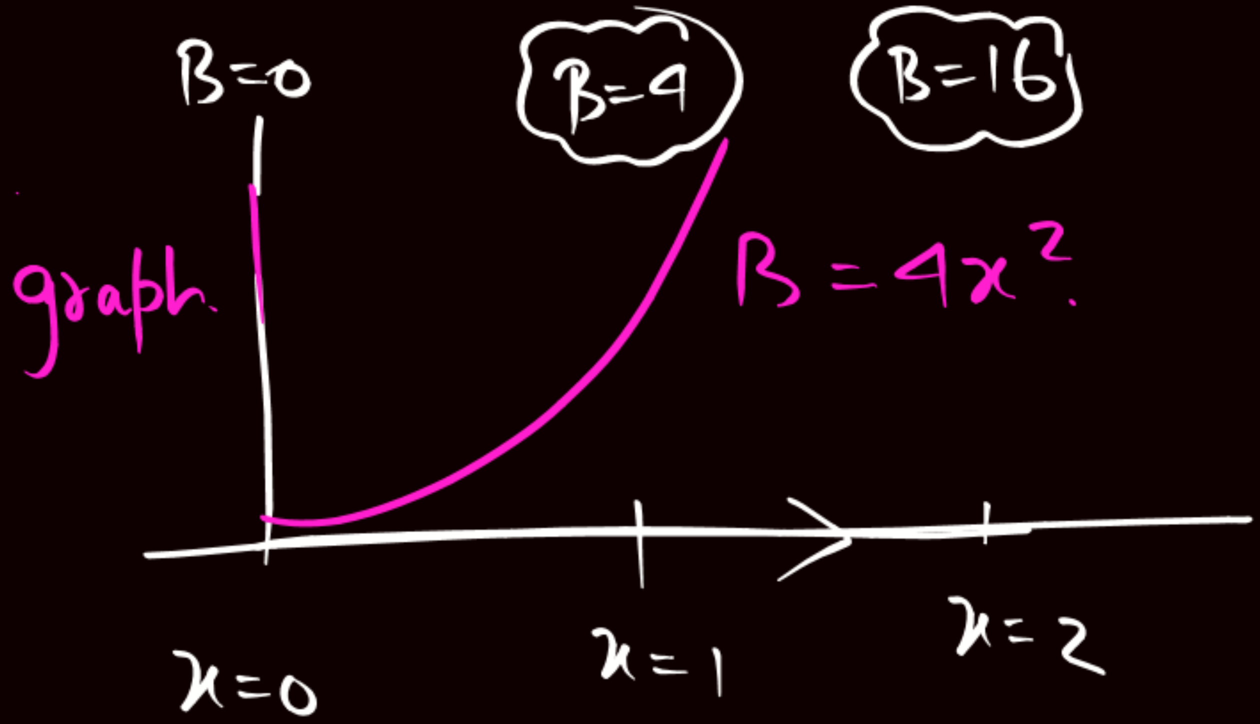
MFL.

$\vec{B} = 4x^2 \hat{i}$.



at diff x, $\vec{B}$ is different





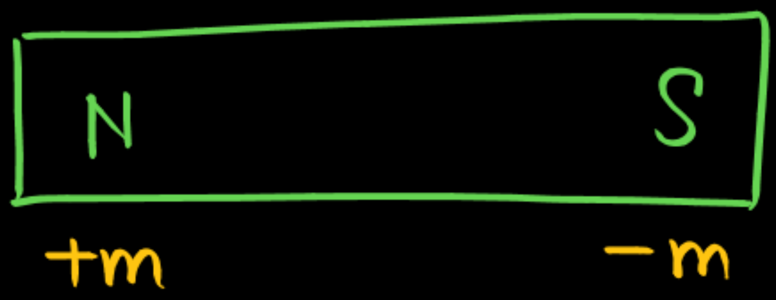
Non-uniform

(Constant)

$t = 0s$

MAGNETIC DIPOLE MOMENT OF BAR MAGNETS

- Pole strength of a magnet:



Every Magnet has two poles

$N = (+m)$
$S = (-m)$
} Pole Strength.

Each poles has a Strength to Exert force on other poles.

① Force of Interaction between two poles.

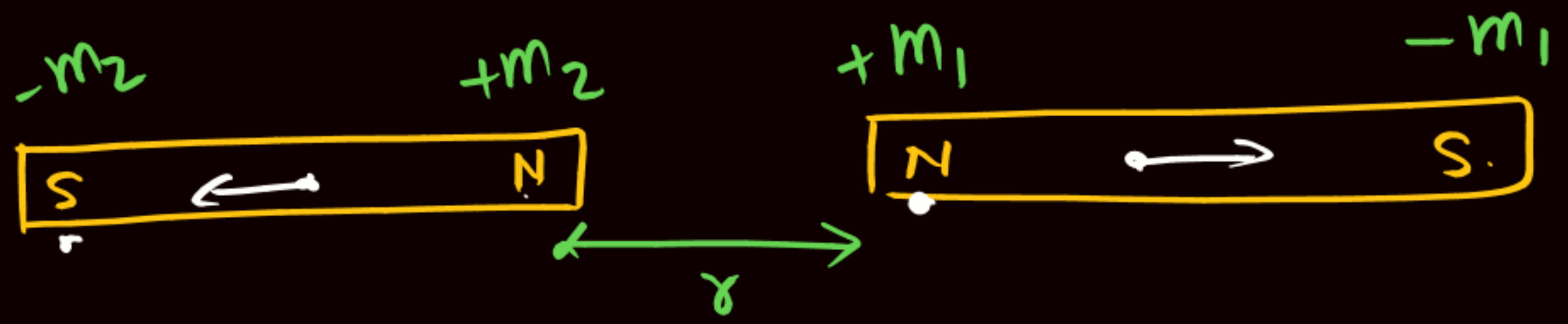
Magnetic Permeability

$\frac{\mu_0}{4\pi} = 10^{-7}$

$f \propto m_1 m_2$

$\propto \frac{1}{r^2}$

$$f = \frac{\mu_0 m_1 m_2}{4\pi r^2}$$

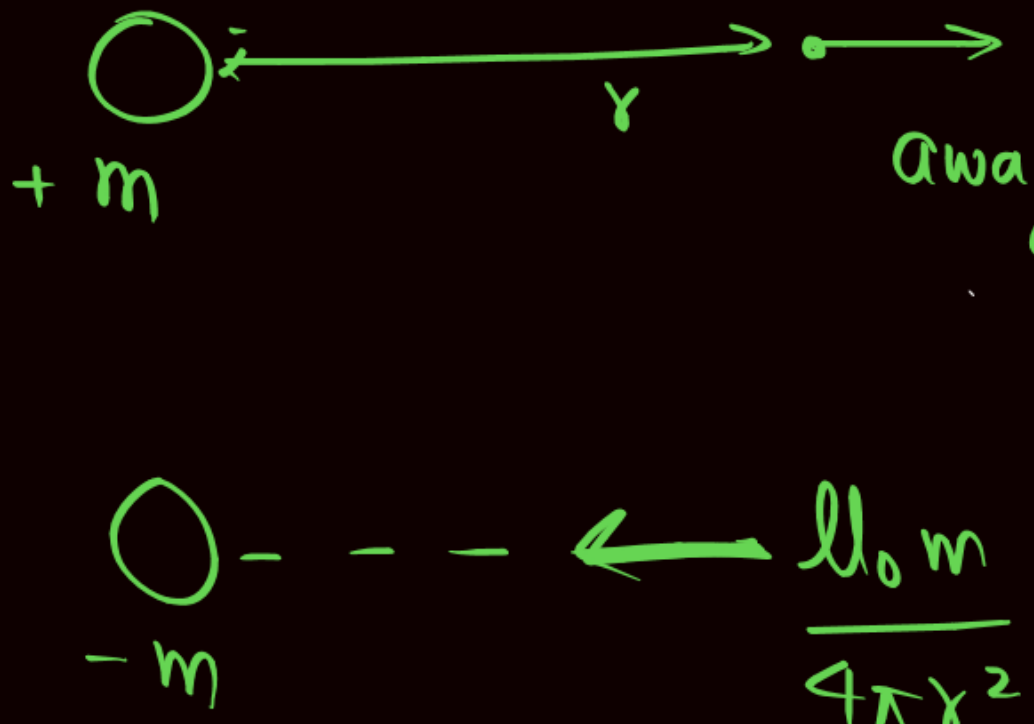


Force between two north pole = $\frac{\mu_0}{4\pi}\frac{m_1 m_2}{r^2}$.

Concept :-

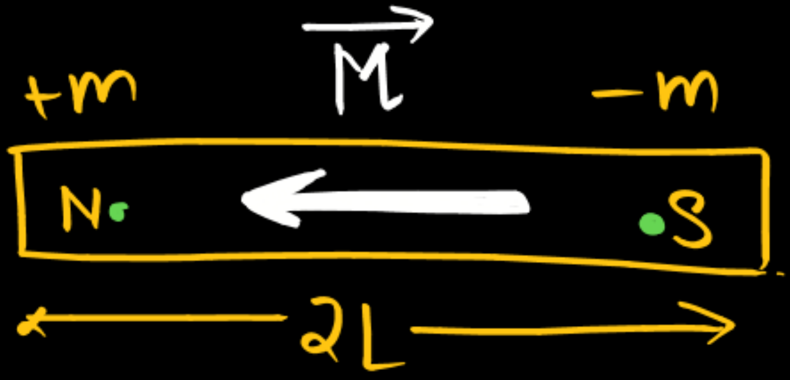
hypothetical Monopoles

- North Pole: $+m$ — away $\frac{\mu_0}{4\pi}\frac{m}{r^2}$.
- South pole: $-m$ — $\frac{\mu_0 m}{4\pi r^2}$.

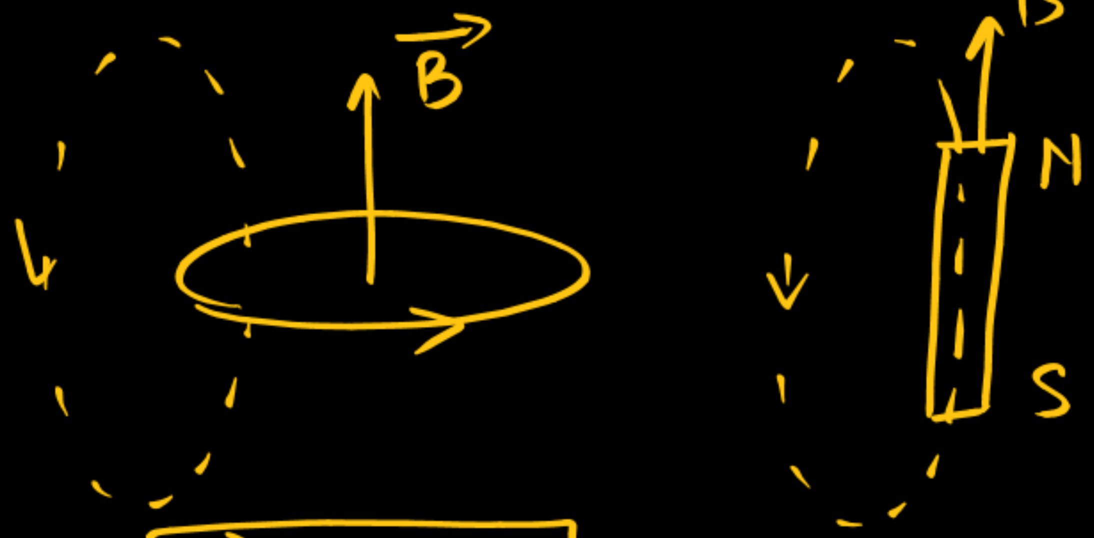


- **Magnetic dipole moment:**

for a bar Magnet



Length between Magnetic poles



$$\vec{M} = I \cdot A$$

$\vec{M}$ = (Strength of Either pole)(Seperation between them).

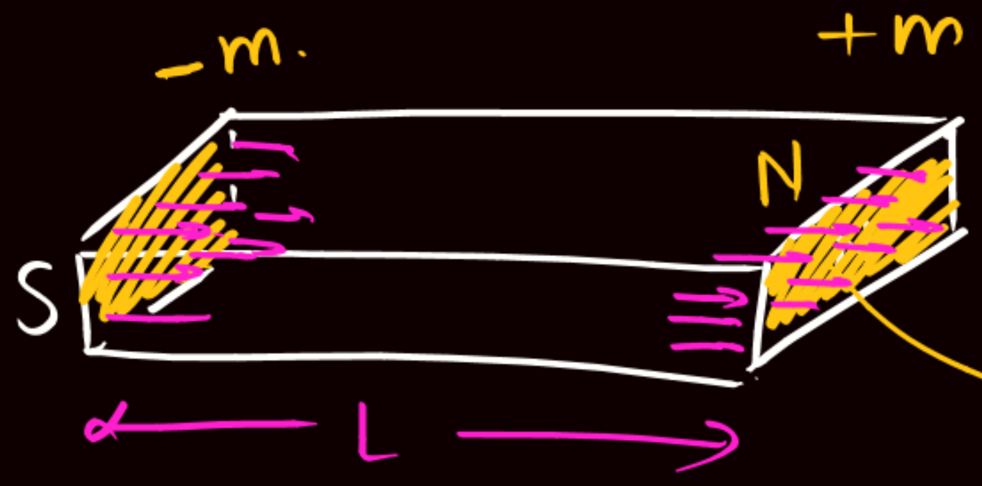
Bar Magnet = $m2L$

$$\vec{M} = m2L$$

direction of Magnetic dipole Moment is from South to North.

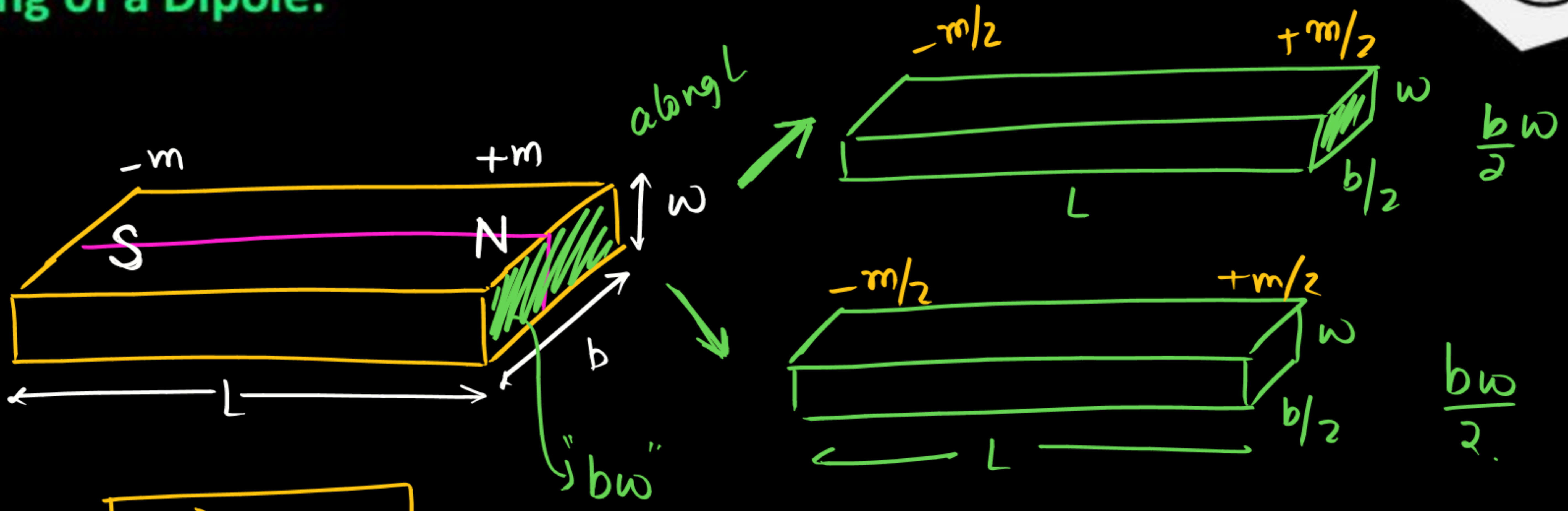
Area ↑ Pole Strength ↑

Magnetic pole Strength $\propto$ Area.



Independent of Length.

- **Cutting of a Dipole:**



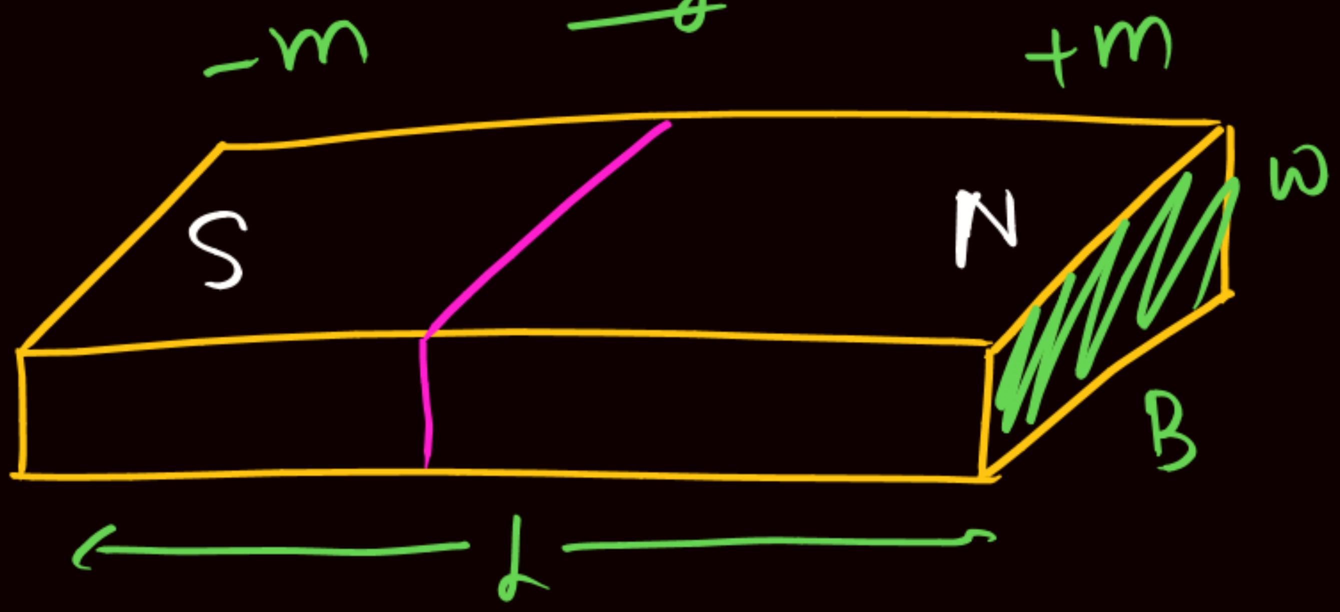
$$\vec{M} = mL$$

Initial

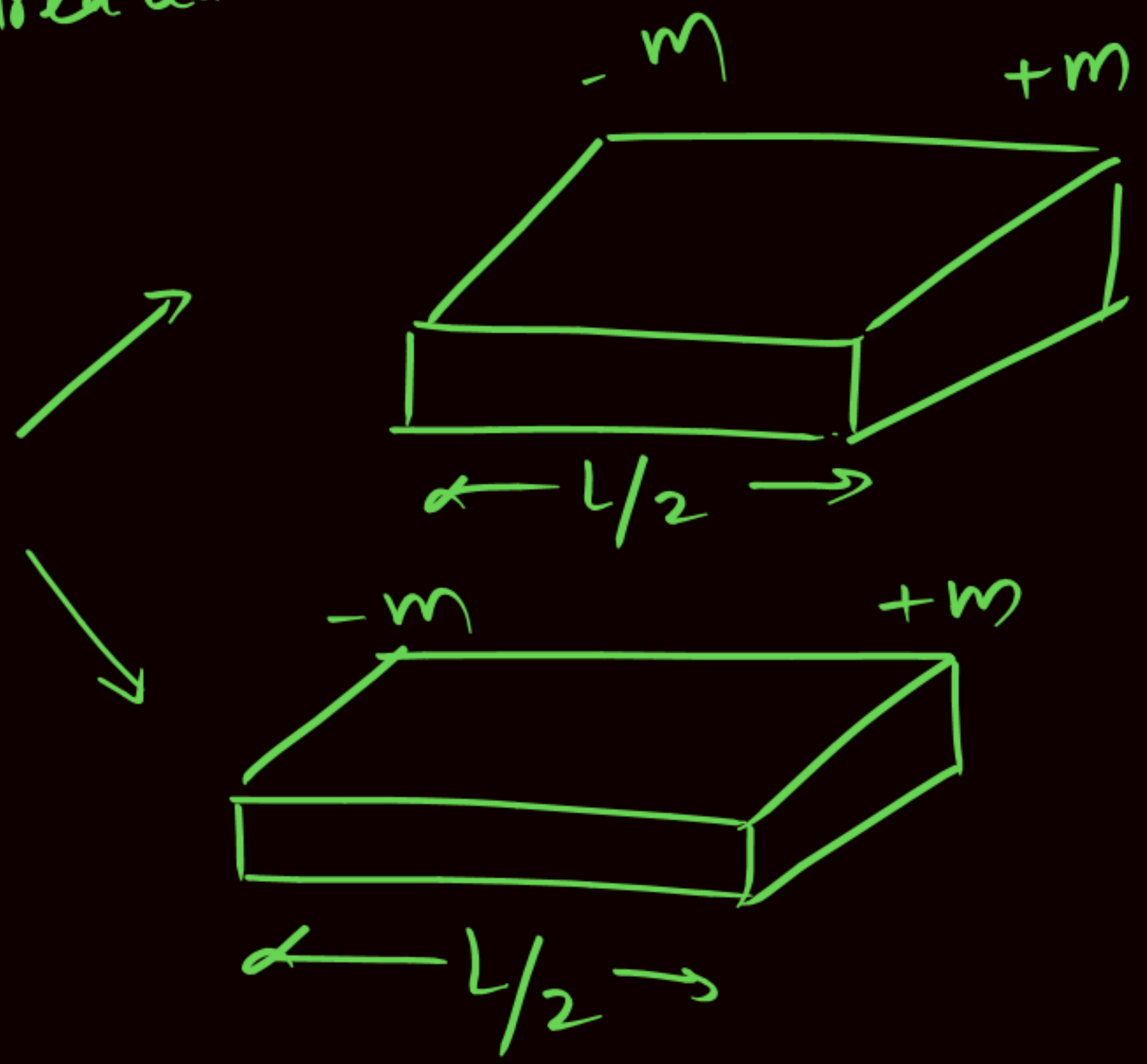
$$\vec{M}_f = \frac{m}{2} L$$

$$\vec{M}_f = \frac{M_i}{2}$$

"Half"



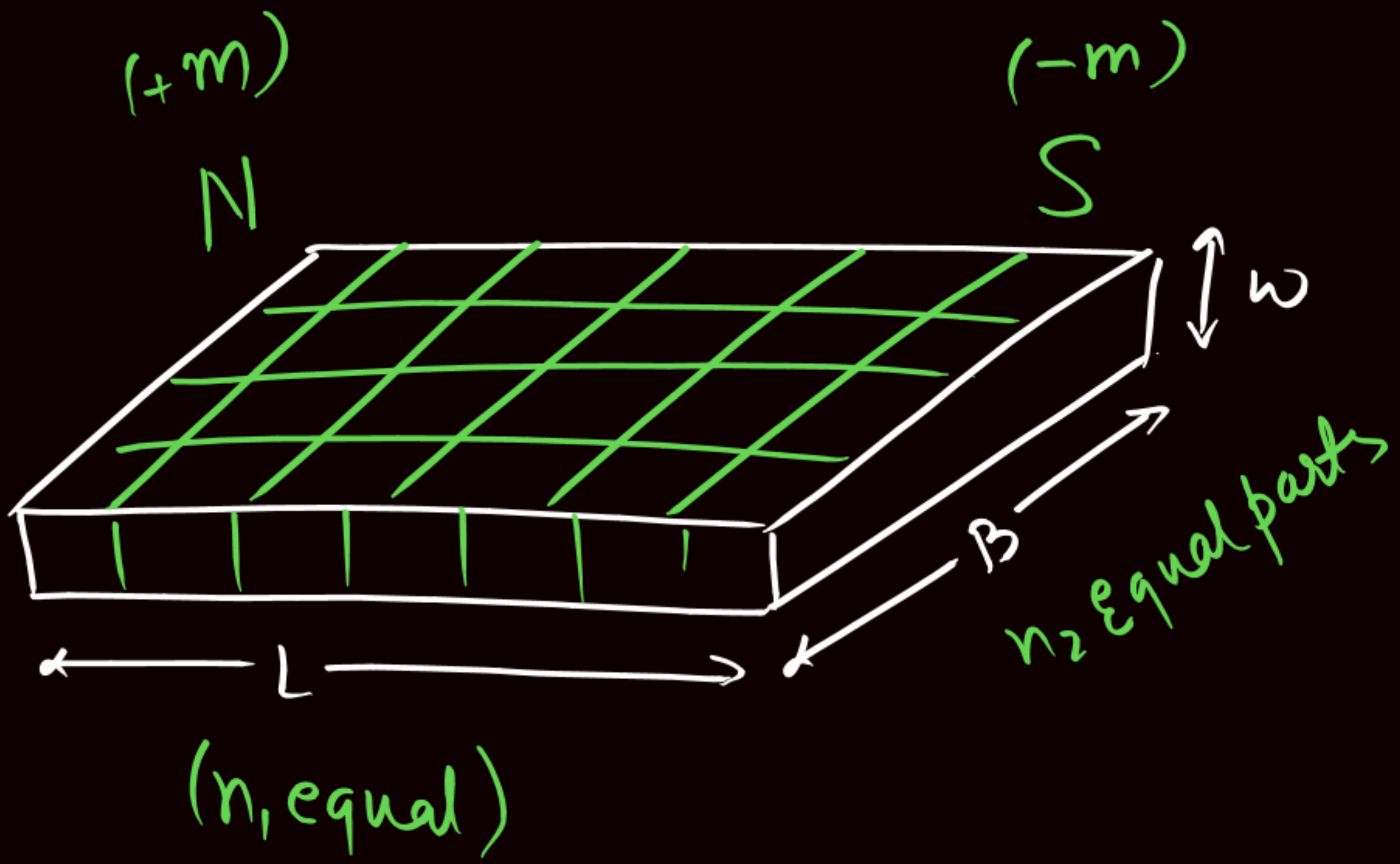
Area Same.

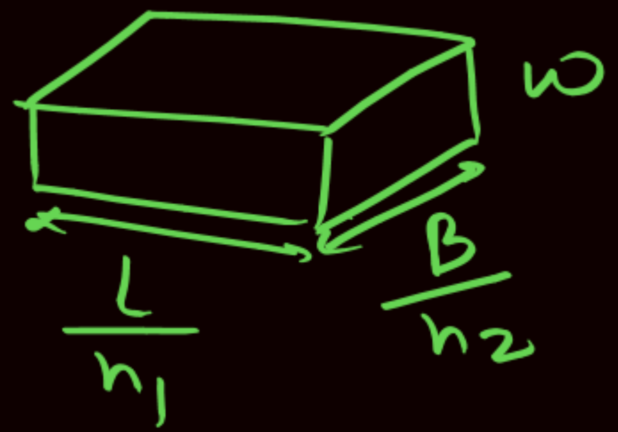


$$\vec{M}_i = (m)L$$

$$\vec{M}_f = (m)\frac{L}{2} = \frac{\vec{M}_i}{2}$$

#





$$\vec{M} = mL$$

Thank You Lakshyians