

# MAGNETISM & MATTER

## BAR MAGNET

Iron filings on sheet bar magnet  
 Particular pattern formed is following  
 conclusion:



- Poles  $m_1$  &  $m_2$   $\rightarrow$  net  $\vec{E}$   $\rightarrow$  net change of electric dipole
- $\rightarrow$   $\rightarrow$
- Poles - North pole (+ve) & South pole (-ve)
- For dipole, poles point towards geographic north & south pole.
- Like poles - repel
- Unlike poles - attract
- Poles never separated. monopoles exist

## MAGNETIC FIELD LINES

- imaginary curve, tangent to any point gives direction of magnetic field at that point.
- MFL of bar magnet (or solenoid carrying current), close loop because  $\vec{E}$ .
- Electric field lines - open loop like  $\vec{E}$ .
- Outside magnet - Field line direction  $N \rightarrow S$
- inside -  $S \rightarrow N$
- 2 field lines never intersect each other. at point of intersection, 2 tangents become. this means 2 directions of magnetic field at same point, which is not possible.



- MFL come out & go into magnetic matter at any angle.
- Electric field lines conducting surface is normal to  $\vec{E}$ .



## POLE STRENGTH

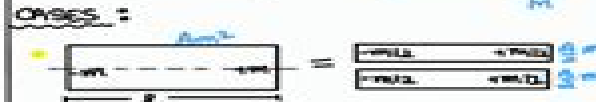
- Just like electric charges, a magnetic charge (also a pole strength)  $m_1 \rightarrow$  North Pole  $\rightarrow$   $m_2 \rightarrow$  South pole
- $m =$  pole strength
- $m \propto$  area
- $M = m_1 m_2$  [following electrical analogy]  $\rightarrow$  in charge & field  $\vec{E}$ .

unit (pole strength / magnetic charge) = Ampere-metre  
 $M = m_1 m_2$   
 $M \propto$  magnetisation

- magnetic monopoles exist
- magnetic field lines - continuous & form closed loops
- In contrast, electric field lines begin on +ve charge & terminate on -ve charge

## MAGNETIC DIPOLE MOMENT OF BAR MAGNET

Equal to pol of any 2 pole strength & separation b/w 2 poles.  
 $M = m_1 r$  [distance from  $S \rightarrow N$  pole]  
 shortest dist b/w poles  
 direction:  $-m$  to  $+m$



$\frac{1}{M} \times 100 = \left(1 - \frac{2}{3}\right) \times 100 = \left(1 - \frac{2}{3}\right) \times 100$   
 MAGNETIC FIELD DUE TO BAR MAGNET  
 1. at axial point  
 $\vec{E}_A = \frac{\mu_0 q_1 q_2}{4\pi r^3}$   
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## 11. Normal Dislocation



$\vec{E}_2 = \frac{\mu_0 q_1 q_2}{4\pi r^3}$   
 $\frac{\partial \vec{E}}{\partial \vec{E}} = 2$   
 $\vec{E}_A \cdot \vec{E}_A < -1$



TORQUE ON MAGNETIC DIPOLE  
 $\vec{\tau} = \vec{M} \times \vec{B}$   
 $\tau = MB \sin \theta$   
 $\tau = 0$  at  $\theta = 0$   
 $\tau = 0$  at  $\theta = \pi$   
 $\tau_{max} = MB$  at  $\theta = \pi/2$

WORK DONE IN ROTATING A DIPOLE IN UNIFORM MAGNETIC FIELD  
 $dW = -dW_{mag} = -MB \sin \theta d\theta$   
 $PE = -MB \cos \theta$   
 MIN PE  $\rightarrow$  at  $\theta = 0$   
 MAX PE  $\rightarrow$  at  $\theta = \pi$

OP POINTS:  
 $\frac{d\tau}{d\theta} = 0$  at  $\theta = 0$   
 $\frac{d\tau}{d\theta} = 0$  at  $\theta = \pi$   
 $\tau = 0$  at  $\theta = 0$   
 $\tau = 0$  at  $\theta = \pi$

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**Jianjun Gao**



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