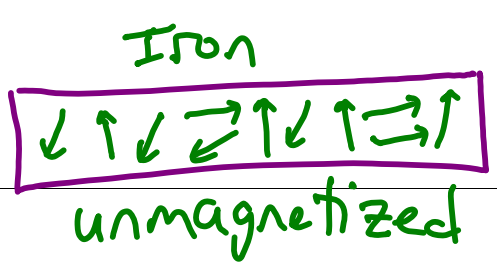
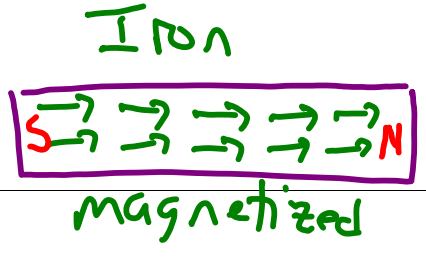
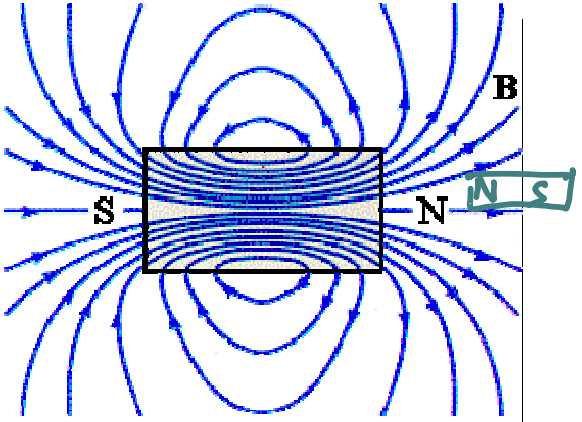
Magnetism

"Heavier-than-air flying machines are impossible." Lord Kelvin, president, Royal Society, 1895.

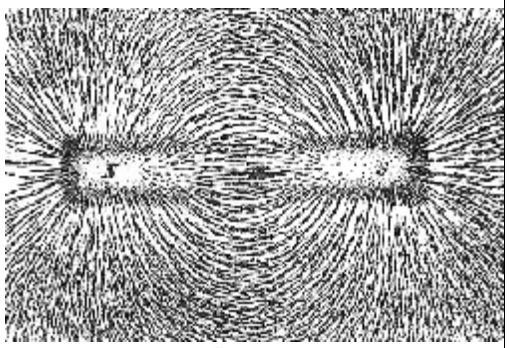




Magnetic Fields

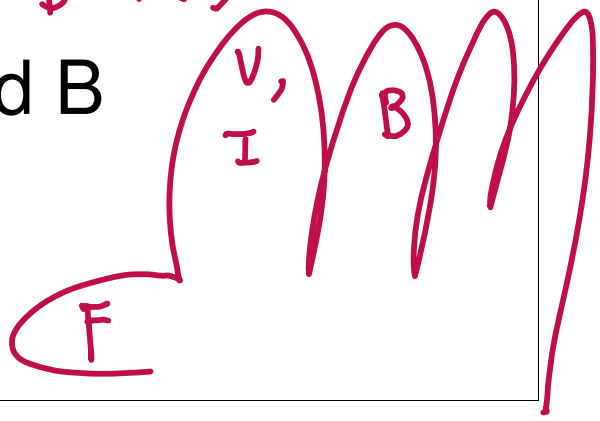


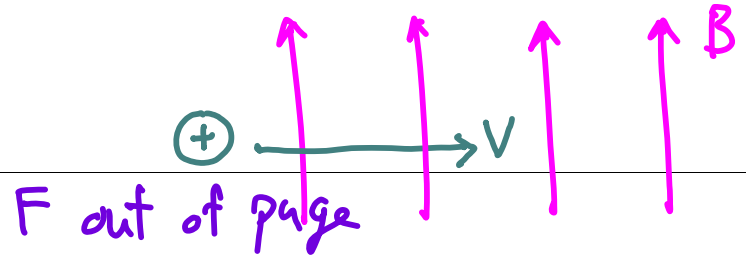
- Magnetic poles are found in
  pairs



- Magnetic field lines go from
  from N to S outside of the magnet.
  Indicate direction of force on a North pole.
- Right hand rule for force on a moving charge in a B-field
  - Four fingers towards v
  - Palm facing B and curl toward B
  - Thumb is direction of F

F- force
V- velocity
B- magnetic field



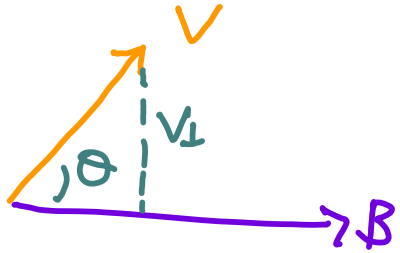


Force on Moving Charge

- $F_B = q \cdot v \times B$ ✓

q - charge (C)
v - velocity ($\frac{M}{s}$)
B - magnetic field strength (T)

- $F_B = q \cdot v \cdot B \sin\theta$
  - where θ is the smaller angle between v & B



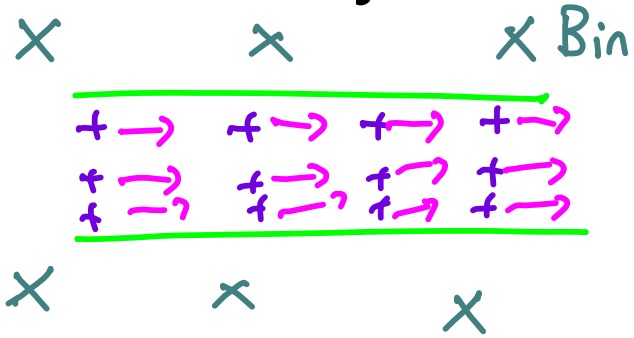
- When is F zero? $V = 0$ or $V \parallel B$
- When is F a maximum/minimum? $V \perp B$
- Units of B-field? Tesla, $T = \frac{N}{C(\frac{M}{s})} = \frac{N}{A \cdot m}$

E-Field vs. B-field, force on charge

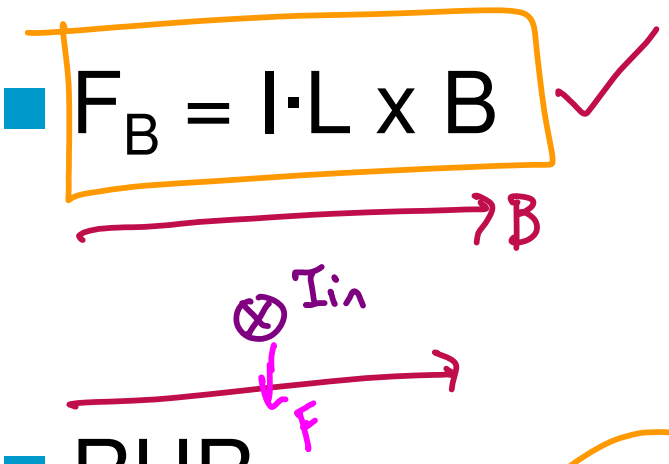
- Differences
  - The electric force is direction of E-field, the magnetic force is ⊥ to B-field.
  - Which force requires the charge to be moving? F_B
  - Which force does work on the particle? F_e , $W_B = 0$, $W = \int F \cdot dx$
  - Can the magnetic force alter the speed or KE of the particle? No, only changes direction

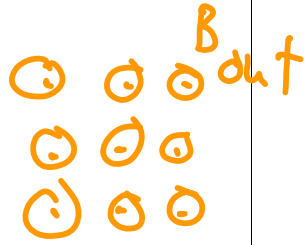
Force on Current-Carrying Wire

- Are the charges moving in a current-carrying wire? YES
- If they are in a magnetic field, they must experience a force

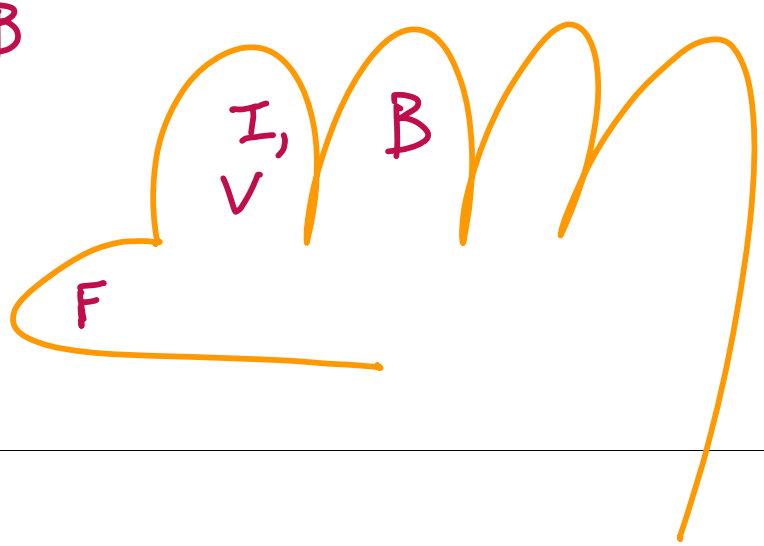


- $F_B = I \cdot L \times B$ ✓





- RHR



Torque on Loop

- A magnetic force acts of which sides?

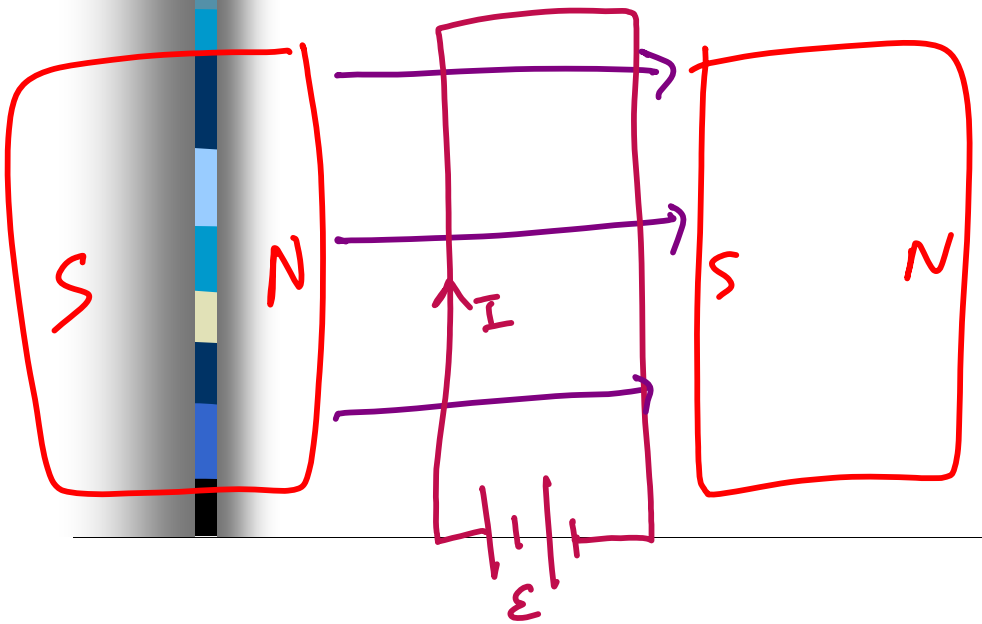
  2 & 4

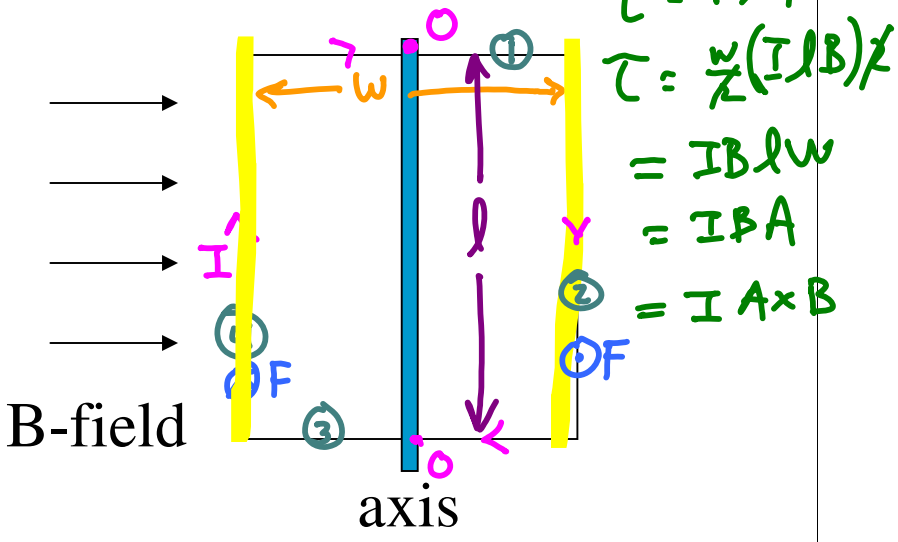
- What is the magnitude and direction of these forces?

  $F = I \ell \times B$

  $= I \ell B$

- Now find torque about point O.





$\tau = r \times F$

$\tau = \frac{w}{2}(IlB)\frac{l}{2}$

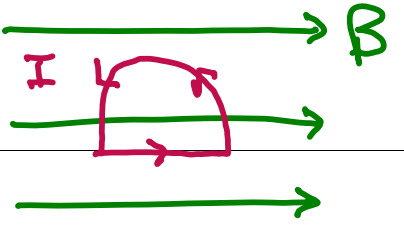
$= IB\ell w$

$= IBA$

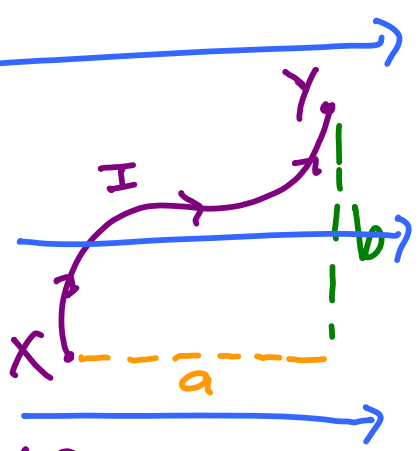
$= I A \times B$

Examples

1. Case 1 and 2.
2. General statement for a closed-loop in a magnetic field. $F_B = 0$
3. An electron in a TV is moving at 8 x 10^6 m/s along the x-axis. A magnetic field of 0.025 T is directed at 60^O to the x-axis in the *xy* plane. Calculate the force and acceleration of the electron. $F = qv \times B$ & $F = ma$, $F = 2.77 \times 10^{-14} N$, $a = 3.1 \times 10^{16} \frac{m}{s}$
4. A semicircle of wire carries 5 A in a magnetic field of 2 T. Find magnetic force on wire. $F = 0$

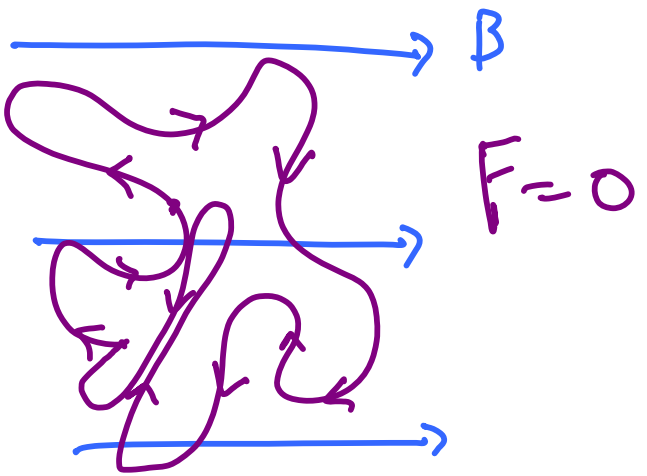


1. #1



$F = I l B = IBb$

#2



$F = 0$