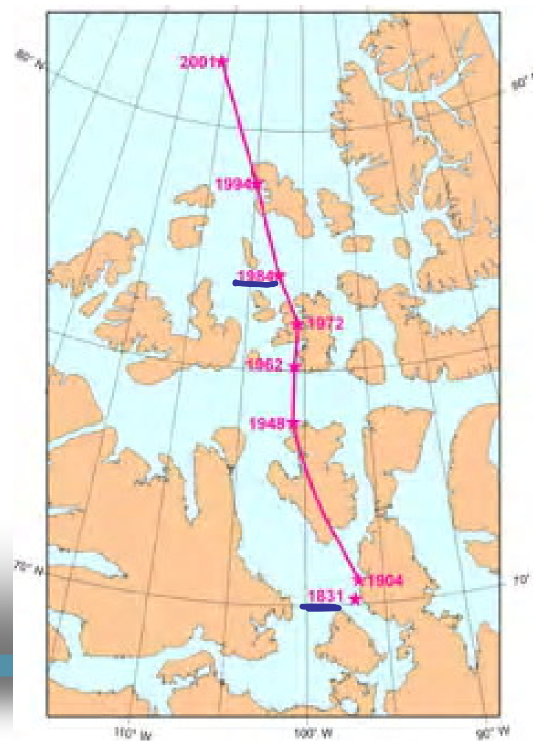
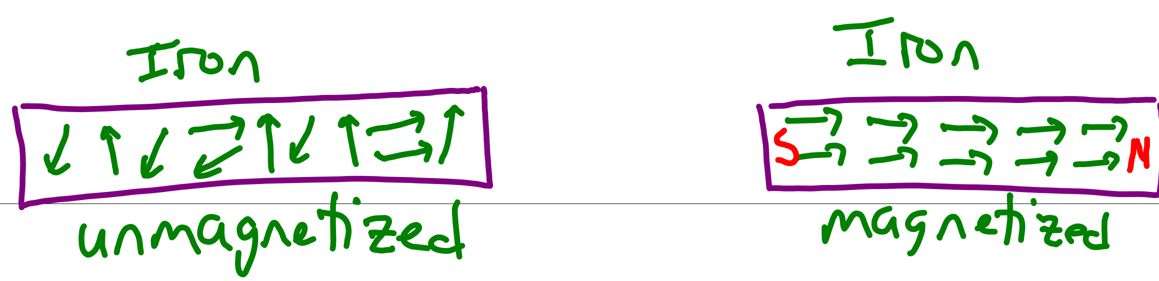
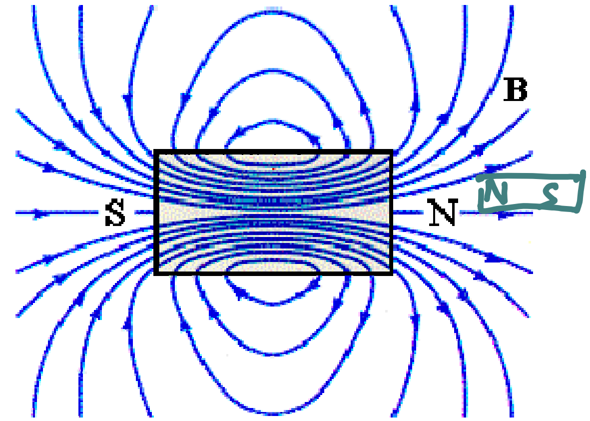
# Magnetism




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

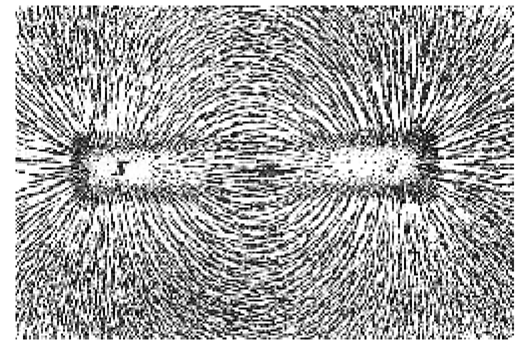


# Magnetic Fields




- Magnetic poles are found in

  pairs



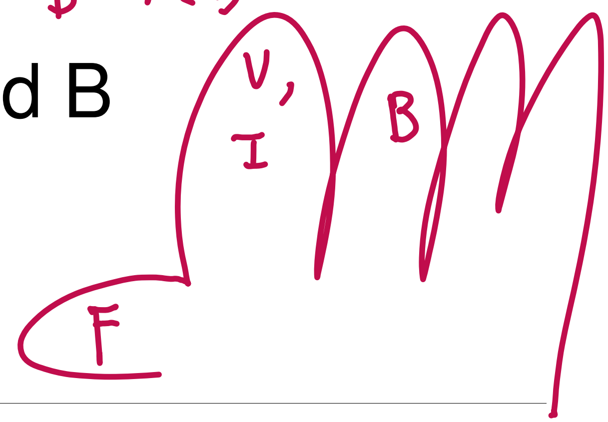
- Magnetic field lines go from

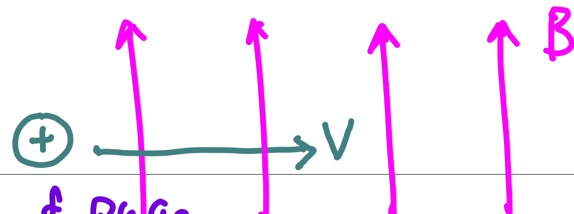
  from N to S outside of the magnet.

  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

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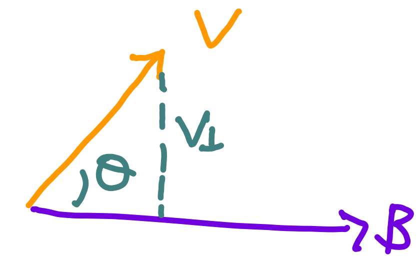
# Force on Moving Charge

- $F_B = q \cdot v \times B$ ✓

  q – charge (C)
  v – velocity (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



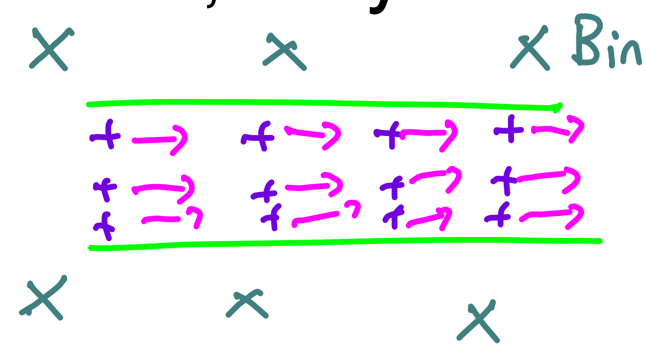

- When is F zero? v = 0 or v // B
- When is F a maximum/minimum? v ⊥ B
- Units of B-field? Tesla, $T = \frac{N}{C(\frac{m}{s})} = \frac{N}{A \cdot m}$

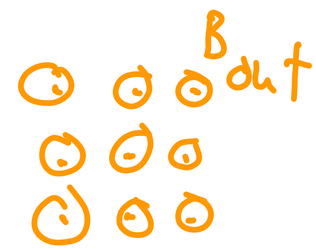
# E-Field vs. B-field, force on charge

- Differences
  - The electric force is direction of E-field, the magnetic force is $\perp$ 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

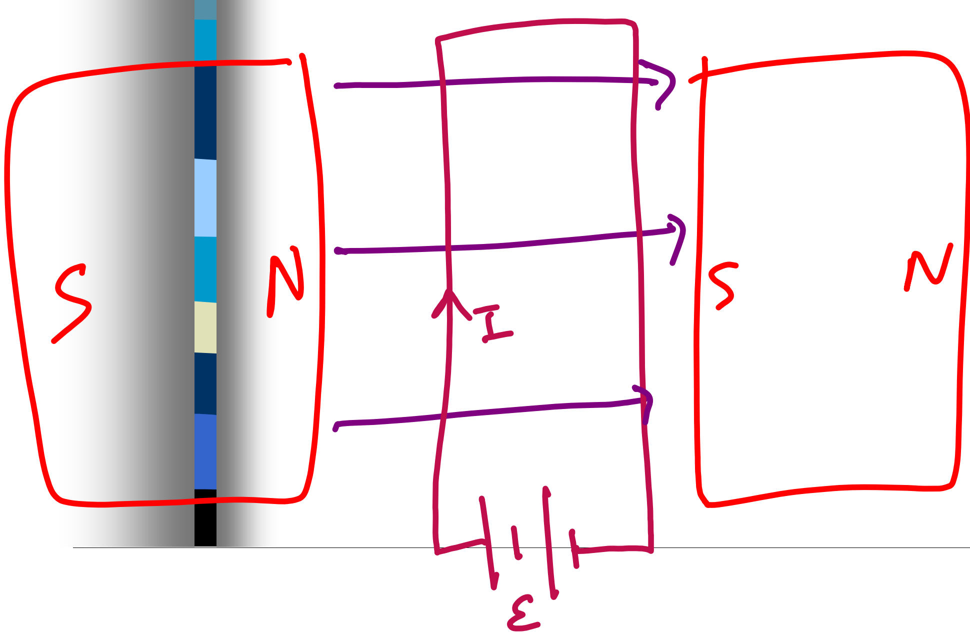
- A magnetic force acts of which sides?

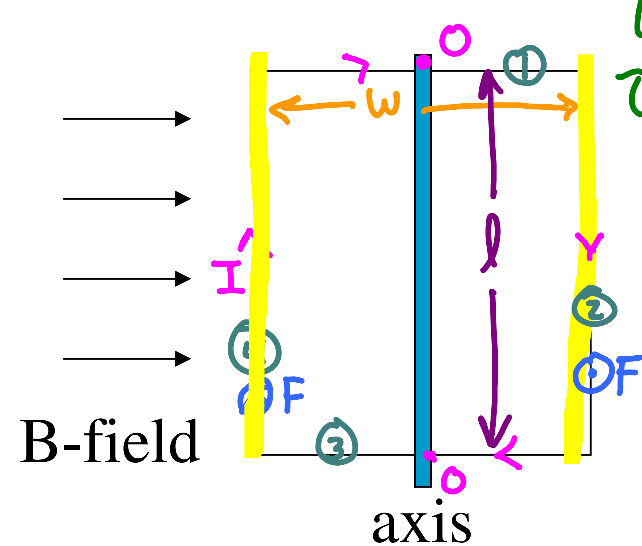
  2 & 4

- What is the magnitude and direction of these forces?

  $F = I\,l \times B$
  $= I l B$

- Now find torque about point O.

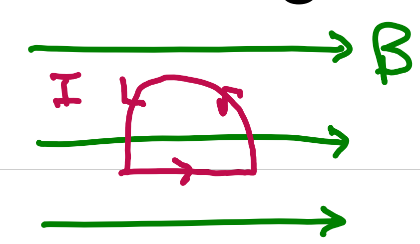




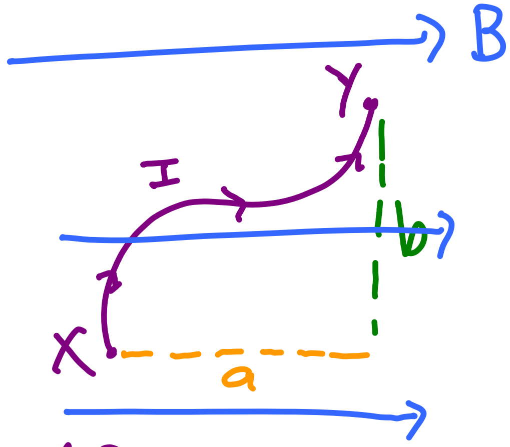

$\tau = r \times F$
$\tau = \frac{w}{2}(I l B) \cdot 2$
$= I B l w$
$= I B A$
$= I A \times B$

# 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. $F = 0$

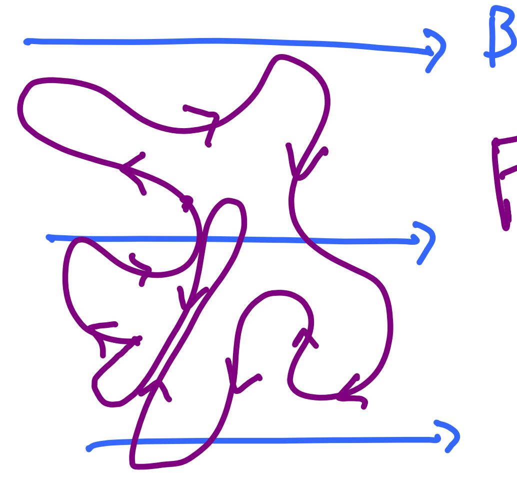


1. #1




$F = I l B = I B b$

#2




$F = 0$