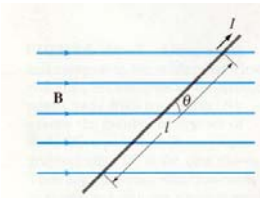
2 – Magnetism

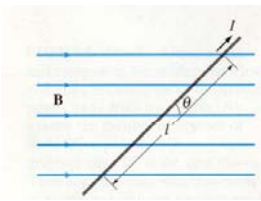
Magnitude of the Force

- Of the Magnetic Field
- On the Wire
- With the current flow
- F∝I
- F ∝ℓ,
  - Where ℓ is the length of wire
- F ∝B
- F ∝sinθ, where θ is the angle between B and I



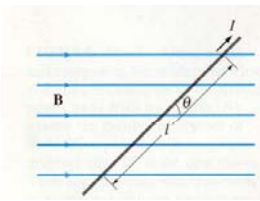
Magnitude of the Force

- When I ⊥ B, then force is at the strongest.
- When I ∥ B, then there is no force at all.
- $F = BI\ell \sin\theta$



Magnitude of the Force

- When is F_{max} = Zero?
  - When the current, I, is parallel to the field, B.
- If current in the straight wire is ⊥ to the field
  - sinθ = sin 90⁰ = 1
  - $F_{max} = BI\ell$
- So
- $B = \frac{F_{max}}{I\ell}$



Units of Magnetic Field

- 1T = 1 Tesla
- $1T = 1\frac{N}{Am} = \frac{Weber}{m^2}$
- An Aside
  - 1 Gauss = 1G = 10^{-4}T
  - The Magnetic Field of the Earth at the surface is about ½ G or 5.0×10^{-5}T

Magnetic Field Schematics

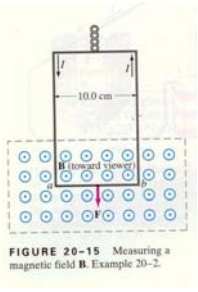
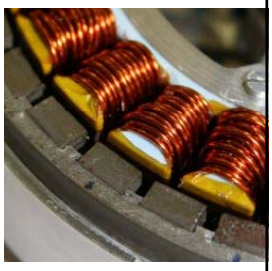


FIGURE 20–15 Measuring a magnetic field B. Example 20–2.

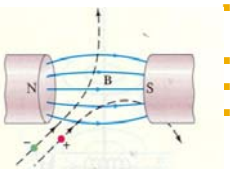
- ⊙ signifies a magnetic field line coming out of the page, toward you
- ⊗ signifies a magnetic field line going into the page, away from you
- imagine an archery arrow. If you look at the tip of the arrow head, you'd see a fine point [dot], rotate it 180° and you see the tail feathers as an x.

Force on an Electric Charge Moving in a Magnetic Field

- A current carrying wire experiences a *force* in a magnetic field.
- Free Moving electrons (not in a wire) also experience a *force* in a magnetic field.
- $F = BI\ell \sin\theta$
- I = #q/t
- $\ell = vt$
- F = B(#q/t)(vt)sinθ
- $F = qvB\sin\theta$



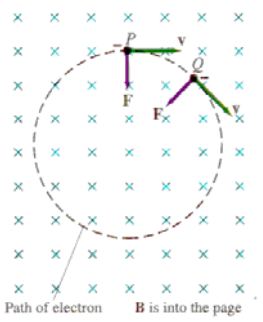
Force on an Electric Charge Moving in a Magnetic Field



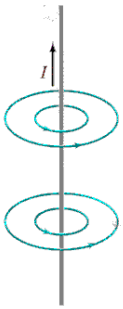
- When the particle moves parallel to the field lines: $\sin\theta = 0$ so $F = 0$
- F_{max} when v⊥B so F_{max}=qVB
- F ⊥ B ⊥ v
- For the right hand rule
  - F is middle finger
  - B is index finger (N to S)
  - I is thumb (v, direction of positive particle)
- An electron is negative
  - LEFT HAND RULE
  - Same fingers

Force on an Electric Charge Moving in a Magnetic Field

- The path of a charged particle moving in a plane ⊥ to a uniform B is a circle.
- Since F ⊥ v, magnitude of v doesn't change, BUT direction does and the particle moves in a circular path with centripetal acceleration.
- F is directed toward the center of a circle at all points.
- Note the electron moves clockwise. How about a proton?



Return to Magnetic Field in a Straight Wire



- Remember that field lines encircle a straight wire.
- B ∝ I/r
  - r<<<ℓ
- $B = \frac{\mu_0 I}{2\pi r}$
- Permeability of Free Space
  - $\mu_0 = 4\pi \times 10^{-7} Tm/A$