Current and Magnetism

Forces Caused by Moving Charges

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Current Carrying Wires

- The magnetic fields around two current carrying wires placed next to each other will interact, causing a force between them.
  - When parallel conductors carrying charge in the same direction are placed near each other, they are _____ to one another.
  - When the charges in the conductors are flowing in the opposite direction, the wires are _____ from one another.

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Current Carrying Wires

- The strength of this magnetic force can be found by using the equation:

Where

$k = 1 \times 10^{-7}\ N/A^2$

l = the length of the conductors

I_1 and I_2 = current flowing through the two wires

d = the distance between the conductors

- Notice that the direction of the current will determine if it is a repulsive or attractive force

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Example Problem

- The force between two wires each with a current of 8.0 A is 3.4×10^{-4} N. If each wire is 170 cm long, what is the distance between the wires?

- Answer: d = 0.064 m

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A Wire in a Magnetic Field

- The magnetic field around a current carrying wire can interact with an existing magnetic field causing a _____ on the wire.
- The _____ of the force on the wire can be found by using the Third Right Hand Rule.

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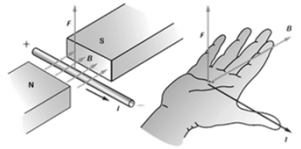
Third Right Hand Rule

- Place your _____ in the direction of the magnetic field and your thumb in the direction of the current.
- Your _____ will show the direction of the force on the wire.



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Size of the Force on a Wire in a Magnetic Field

- To find the size of the force on a current carrying wire, we can use:

where
  - B is the magnetic field strength in Teslas
  - I is the current in Amps
  - L is the length of the wire in the B-field

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Sample Problem

- A 45 cm wire carrying 3.0 A of current to the right is placed in a 0.55 T magnetic field directed upward. What is the size and direction of the force on the wire?

(F = .7425 N)

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Common Magnetic Fields

- Here are a few common magnetic fields and their strengths:

TABLE 24–1 Typical Magnetic Field	
Source and Location	**Strength (T)**
Surface of neutron star (predicted)	10^8
Strong laboratory electromagnet	10
Small bar magnet	0.01
Earth's magnetic field	5×10^{-5}

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Forces on Single Charges

- A single charge moving through a magnetic field acts like a _____ in a wire and therefore will have a _____ applied to it.
- The direction of the force on the charge can be found by using the Third Right Hand Rule.
  - It will be the _____ direction for a positive particle.
  - It will be the _____ direction for a negative particle.

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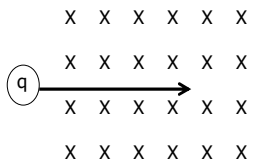
Forces on Single Charges

- Use the Right Hand Rule to find the direction of the force on the charged particle.



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Third Right Rule Examples

- **Protons**
  - Example #1
    - Current: Right
    - B-Field Lines: Into
    - Force: _____
  - Example #2
    - Current: Down
    - B-Field Lines: Left
    - Force: _____
- **Electrons**
  - Example #3
    - Current: Up
    - B- Field Lines: Out of
    - Force: _____
  - Example #4
    - Current: Left
    - B-Field Lines: Down
    - Force: _____

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Forces on Single Charges

- The size of the force can be found by using the equation:

where:

- B is the magnetic field strength in Teslas
- q is the size of the charge in Coulombs
  - Remember protons and electrons have a charge of $\pm 1.6 \times 10^{-19}$ C.
- v is the velocity of the charge in m/s

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Sample Problem

- An electron is shot upward at 4.0×10^{6} m/s through a 0.35 T magnetic field that is directed toward the left. What is the size and direction of the force on the electron?

($F = -2.24 \times 10^{-13}$ N)

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