Edgenuity

Warm-Up | Magnetic Field and Force

Lesson Question

What is the relationship between magnetic field and magnetic force?

Lesson Goals

- **Analyze** magnetic fields produced by a [current-carrying] wire.
- **Apply** the right-hand rule to a current-carrying wire.
- **Use** the right-hand rule to determine the [direction] of the magnetic force.
- **Solve** problems involving magnetic forces and magnetic fields.

Words to Know

Fill in this table as you work through the lesson. You may also use the glossary to help you.

tesla	the SI unit for magnetic field strength
right-hand rule	a system to find the direction and force of the magnetic field
direct relationship	a relationship between two variables whereby both variables increase or decrease together

Magnetic Field Lines

- A magnetic field is a region where a magnetic force is exerted on electrical charges or objects containing certain metals.
- Magnetic poles are at the [ends] of a magnet, where the magnetic field is strongest.
- Magnetic field lines spread out from the [north] pole, around the magnet, and back into the south pole.
  - Magnetic field lines form [closed loops].

Instruction | Magnetic Field and Force

Slide 2

Magnetic Fields

- A magnetic field (*B*) acts like a [force] vector.
  - Exerts a magnetic force in a specific direction
- A tesla (T) is the SI unit of a magnetic field.
  - $1\,\mathrm{T} = 1\left[\frac{\mathrm{N}}{\mathrm{C}\cdot\mathrm{m/s}}\right] = 1\frac{\mathrm{N}}{\mathrm{A}\cdot\mathrm{m}}$

Magnetic Fields around Current-Carrying Wires

- A current-carrying wire generates a [cylindrical] magnetic field around itself.
- The strength of the magnetic field has a **direct relationship** to the amount of current and is [inversely] proportional to the distance from the wire.

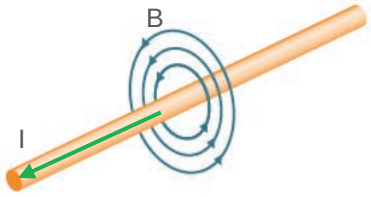
Direct Relationship	Inversely Proportional
$I = B$ $2I = 2B$	$d = B$ $2d = \frac{1}{2}B$

Instruction | Magnetic Field and Force

Slide 4

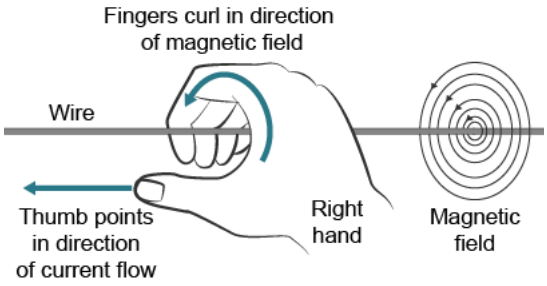
Magnetic Field Direction

- The direction of the magnetic field depends on the direction in which the current flows.
  - The magnetic field will reverse when the current is reversed.



Right-Hand Rule for Magnetic Fields

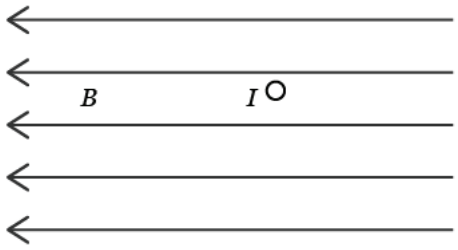
- The **right-hand rule** is a system to find the direction of a magnetic field.
  - The thumb points in the direction the current flows.
  - The fingers curl in the direction of the magnetic field.



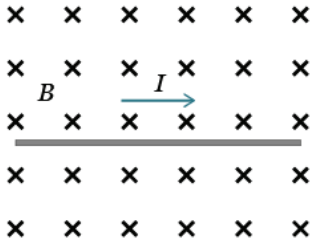
Instruction | Magnetic Field and Force

Slide 4

How to Represent Magnetic Fields and Currents



- The magnetic field points to the left.
- The current flows [out] of the screen.



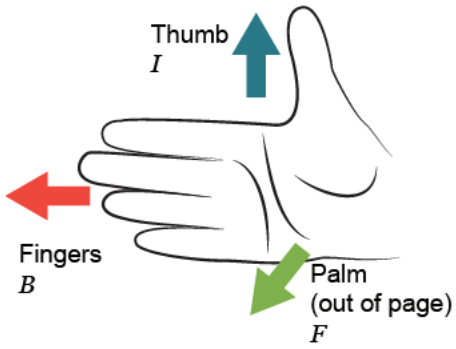
- The magnetic field points into the screen.
- The current flows to the [right].

Slide 7

Right-Hand Rule for Magnetic Force

A magnetic field applies a force on a charge in a direction that is perpendicular to the directions of both the magnetic field and the [velocity] of the charge.

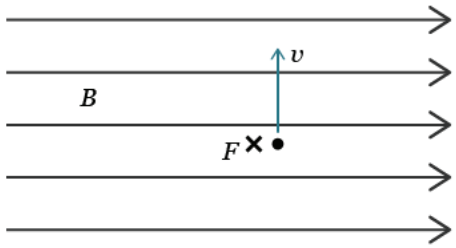
- The [thumb] points in the direction the charge or current is moving.
- The outstretched fingers point in the direction of the magnetic field.
- The palm faces the direction of the [magnetic force] on a positive charge.
  - The back of the hand faces the direction of the magnetic force on a negative charge.



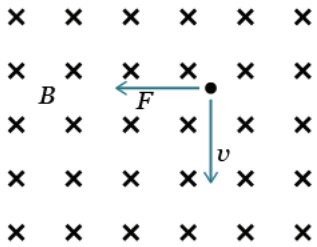
Instruction | Magnetic Field and Force

Slide 7

How to Represent Magnetic Force in a Magnetic Field



Magnetic field points right; force is [into] the screen; a positive charge moves up.



Magnetic field is into the screen; force is to the left; a negative charge moves [down].

Slide 9

Force Due to a Magnetic Field on a Moving Charge

- The force (F) exerted on a [moving] charge by a magnetic field is dependent on:
  - q = the charge of the moving particle
  - v = the velocity of the moving particle
  - B = the [strength] of the magnetic field
  - θ = the angle between the [velocity] vector and the magnetic field vector
- Any variable can be determined by rearranging the formula if the other variables are known.

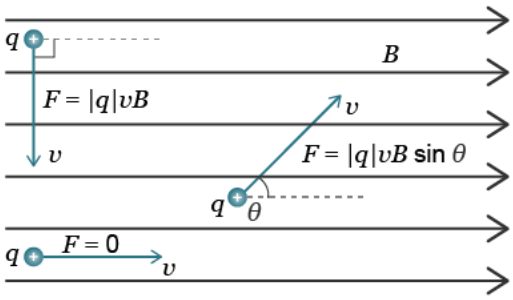
$$F = [\,|q|vB\sin\theta\,]$$

Slide 9

Force Due to a Magnetic Field on a Moving Charge

- A charge moving [parallel] to a magnetic field experiences no force.
- A charge moving perpendicular to a magnetic field experiences the [maximum] amount of force.
  - $F = |q|vB$

$\theta = 90° \rightarrow \sin 90° = 1$



$\theta = 0° \rightarrow \sin 0° = 0$

How to Calculate Magnetic Force

A point charge with 5.0 μC moving at 1.8×10^6 m/s is at a 30° angle to a magnetic field of 1.2×10^{-5} T. What is the magnitude of the force on the charge?

- Given:
  - $q = 5 \times 10^{-6}$ C
  - $v = 1.8 \times 10^6$ m/s
  - $B = 1.2 \times 10^{-5}$ T
  - $\theta = 30°$
- Unknown: F
- Formula to use: $F = |q|vB\sin\theta$

$$F = |q|vB\sin\theta$$

$$F = (5 \times 10^{-6}\ \text{C})(1.8 \times 10^{6}\ \text{m/s})(1.2 \times 10^{-5}\ \text{T})\sin(30°)$$

$$F = \boxed{5.4 \times 10^{-5}\ \text{N}}$$

Summary | Magnetic Field and Force

Lesson Question

What is the relationship between magnetic field and magnetic force?

Answer

(Sample answer) Magnetic fields interact with charged particles to either attract or repel these moving charges depending on their charge, velocity, and location within the magnetic field.

Slide 2

Review: Key Concepts

- A magnetic field is a region where a magnetic force is exerted on electrical charges or objects containing certain metals.
- A current passing through a [wire] generates a magnetic field.
- The right-hand rule can determine the direction of the magnetic field in a wire.
    - When the thumb of the right hand points in the direction of the [current], the fingers curl in the direction of the magnetic field.

Summary | Magnetic Field and Force

Slide 2

Review: Key Concepts

- The force exerted on a moving charge by a magnetic field is dependent on the [charge] and velocity of the particle, as well as the strength of the magnetic field and the angle the charge's velocity makes in relation to the magnetic field.
  - $F = |q|vB\sin\theta$
- The right-hand rule can be used to determine the direction of the [force].
  - When the thumb is pointed in the direction the charge is moving, and the fingers point in the direction of the magnetic field, the palm of the hand faces the direction the force acts on a positive charge.
    - The back of the hand faces the direction of force on a [negative] charge.

Summary | Magnetic Field and Force

Use this space to write any questions or thoughts about this lesson.