

Big Picture

Magnetic fields are caused by the spinning of individual electrons. In objects that do not exhibit any magnetic properties, the spin of the electrons is random so there is no net magnetic field. In objects that do exhibit magnetic properties, the electrons' spins have been aligned with each other so that they create a net magnetic field. Magnetic fields are similar to electric fields in that they interact with charged objects, but it is important to remember that magnetic fields only interact with charged objects when they're moving perpendicular to the direction of the field (if it's not moving perpendicular, use the component of the object's motion that is perpendicular).

Key Terms

Electromagnetism: The relationship between electricity and magnetism - the two come hand in hand, since electric currents produce magnetic fields!

Magnetic Field: The region surrounding a magnetic source in which the magnet has a detectable magnetic force. Magnetic materials and electrical currents both can create magnetic fields. SI units: T



Both magnetic and electric fields store energy and can be thought of as vector force fields that move particles in specific directions.

Magnetic Field Lines: Invisible lines that indicate the magnetic field of an area. They have a direction and point away from the north pole towards the south pole. Similar to electric fields, the density of the magnetic field lines indicates the strength of the field. In the picture below, we can see the magnetic field is strongest near the poles of the magnet.

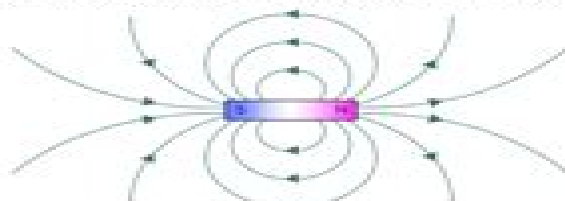


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Magnetic Flux: Measures how much magnetic field passes perpendicularly through a given area. We can think of it as how many magnetic field lines pass through the region. SI units: Wb

Solenoid: A coil of wires with turns that generates a uniform magnetic field.

Calculating Magnetic Fields

Magnetic Field of a Wire

$$B = \frac{\mu_0 I}{2\pi r}, \quad B = \text{magnetic field at a distance } r \text{ away from the wire}$$

$$\mu_0 = \text{permeability of free space } (= 4\pi \times 10^{-7} \frac{\text{T} \cdot \text{m}}{\text{A}})$$

First Right Hand Rule:

To find the direction of the magnetic field around a wire, point your thumb in the direction of the current and curl your fingers - that is the direction of the magnetic field!



Test Taking Tip: It may seem obvious, but remember to use your right hand! If you use your left hand to write, it is easy to forget and accidentally use your left hand.

Electromagnetic Induction: When a current is induced in a conductor moving through a magnetic field.

To induce a current in a wire, we must change the magnetic flux. To do so, we can change the magnetic field, change the wire's orientation/area, or move the wire out of the magnetic field.

Inductance: The resistance of a wire to a change in current. SI units: H

Self Inductance: When the current in a wire changes, it creates a back emf, an induced voltage that opposes any change in current.

Mutual Inductance: The current in one coil of wire affects the current in another (induces an emf).

Inductors: Inductors resist changes in current by creating a back emf. They are usually no more than a coil of wires that wrap around a magnetic core.

Faraday's Law: The induced emf is proportional to the rate of change of the magnetic flux.

Lenz's Law: The induced current will always flow in the direction that generates a magnetic field to oppose the change in flux.

RL Circuits: Circuit made up of a resistor, inductor, and voltage source.

LC Circuits: Circuit made up of an inductor and a fully charged capacitor.

RLC Circuits: Circuit made up of an inductor, resistor, and fully charged capacitor.

Hall Effect: An effect observed when current passes through a conductor perpendicular to a magnetic field. The magnetic field will exert a force perpendicular to the direction of the current, pushing the electrons to one side of the conductor and creating a potential difference across the two sides of the conductor.

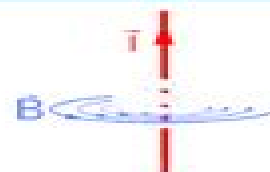


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rules magnetic fields right hand rules the law of Biot Savart Ampere s law Lenz s law Faraday s law AC circuits an
 introduction to Maxwell s equations and more AUTHOR The author Dr Chris McMullen has over 20 years of experience
 teaching university physics in California Oklahoma Pennsylvania and Louisiana and has also taught physics to gifted high
 school students Dr McMullen currently teaches physics at Northwestern State University of Louisiana He has also published
 a half dozen papers on the collider phenomenology of superstring inspired large extra dimensions Chris McMullen earned his
 Ph D in particle physics from Oklahoma State University and his M S in physics from California State University Northridge
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