17: Magnetic Fields

Key Physics Terms

- **Charge**: A fundamental intrinsic property of matter that gives rise to the attractions and repulsions between electrons and protons.
- **Electron** A small, light negative particle. Electrons orbit around the nucleus of the atom.
- **Current**: An electrical charge flowing past a given point per unit of time.
- **Magnetic domains**: Microscopic areas in a ferromagnetic material where the magnetic fields are aligned.
- **Ferromagnetic materials**: A group of materials which can be made into strong permanent magnets by aligning the magnetic domains so there is a net magnetic field.
- **Magnetic Field Lines**: Lines showing the shape and extent of a magnetic field around a permanent magnet or a moving charged object.
- **Pole**: The end of a magnet, poles always occur in pairs, north and south. Likes poles repel, unlike poles attract.
- **North Pole:** The end of a magnet which points towards geographic north when the magnet is freely suspended.
- **Centripetal Force**: A center seeking force for an object moving in a circular path. A charge moving in a plane perpendicular to a uniform magnetic field will experience such a force and as a result will travel in a circular path.
- **Mass Spectrometer**: A device that magnetically separates charged ions according to their mass.

Variables Used

- I=current
- F_B = magnetic force
- L = length of current carrying wire
- B = magnetic field strength
- r = radial distance from wire
- θ = angle
- q = electric charge
- v = velocity
- μ_o = permeability of free space

Key Formulas and Constants

- $F_B = BiL \sin\theta$
- $F_B = qvB \sin\theta$
- $B = \mu_o i/2\pi r$
- $\mu_o = 4\pi x10^{-7}$ Tm/A

Typical Key Metric Units

- Charge: Coulombs, C
- Current: Amperes, Amps, A
- Force: Newtons, N
- Length: meters, m
- Distance: meters, m
- Magnetic field: Teslas, T
- Velocity: meters per second, m/s

Magnetic Fields Problem Solving Tips

These tips will make it easier to solve any physics problems.

- Thoroughly read the entire problem.
- Draw a diagram if needed, especially for a circuit.
- Identify all given information.
- Identify the quantity to be found.
- Select appropriate formula(s) that incorporate what you know and what you want to find.
- Convert units if needed.
- Do any mathematical calculations carefully.

Typical Magnetic Force Problem

Example: A 2.0 m household wire carries a current of 15 A perpendicular to the Earth's magnetic field of 5.0 $x10^{-5}$ T. What is the magnitude of the force exerted on this wire?

$F_B = BiL \sin\theta$

$F_B = (5.0 \times 10^{-5}\ T)(15\ A)(2.0\ m) \sin 90^o$

$F_B = 1.5 \times 10^{-3}\ N$

A relatively small force that would be difficult to detect.

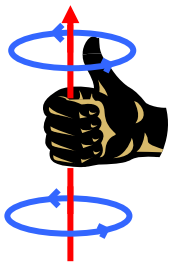
Right Hand Rule (RHR)

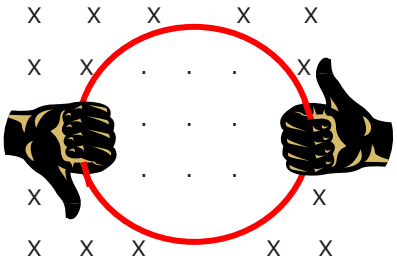
The RHR can be used to find:

A. The magnetic field produced by a current in a straight wire or loop.
B. The force on an electric current due to a B field.
C. The force on a positive electric charge due to a B field.

When using the rule:

1. The fingers extend or curl in the direction of the B-Field.
2. The outstretched thumb points in the direction of conventional current, or of a positively charged particle moving in the B-field.
3. A line perpendicular to the palm indicates the direction of the magnetic force.





Magnetic Field Direction Notation

A field that goes out of the plane of the page or screen:

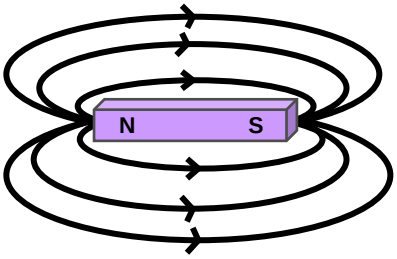
. . . . .
. . . . .
. . . . .

A field that goes into the plane of the page or screen:

X X X X X
X X X X X
X X X X X

Think of these two notations as the ends of an arrow. If it is coming towards you, the point is visible. If it is going away from you, the X of the feathers is visible.

All magnetic fields point from North to South. This is analogous to electric fields going from positive to negative.



How to Use This Cheat Sheet: These are the keys related this topic. Try to read through it carefully twice then recite it out on a blank sheet of paper. Review it again before the exams.

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