Basic Principle of Electromagnetism

Magnetic Fields Produced by Currents

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Oersted's Discovery
Basic Principle of Electromagnetism
(RHR-2)
Magnetic Fields Produced by Currents

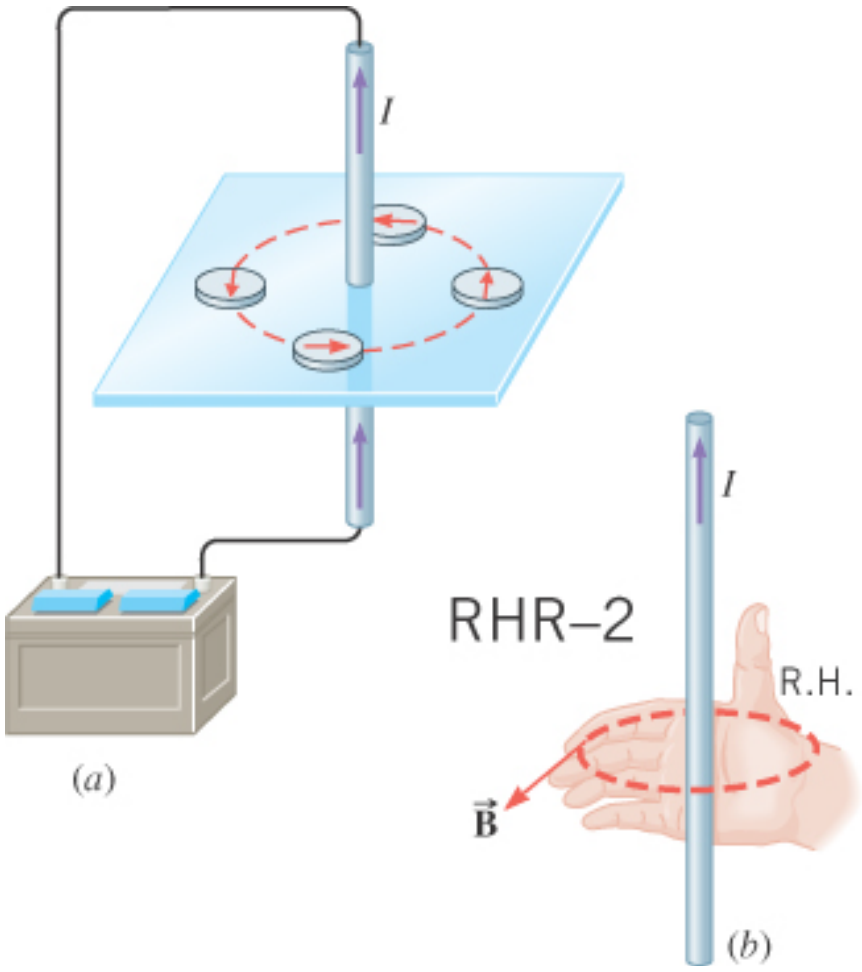
- **Currents in wires produce magnetic fields**

- Whenever electrons move through a conductor, a magnetic field is created in the region around the conductor.

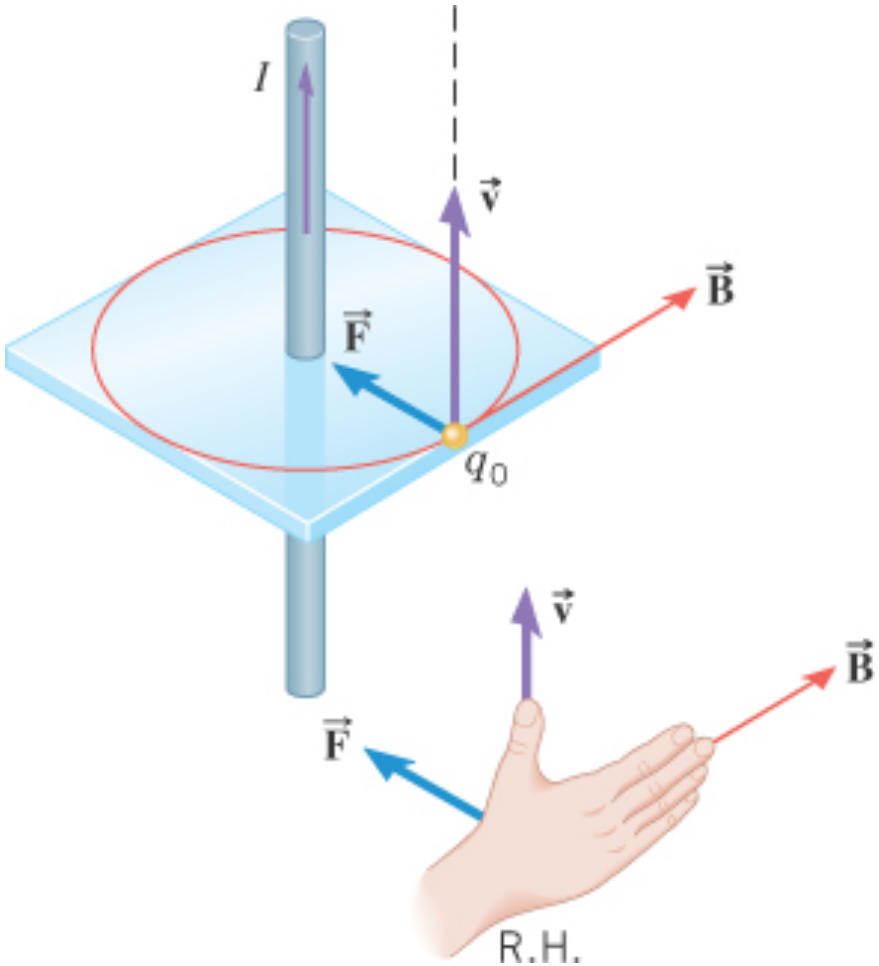
- An aid in remembering the relationship between the direction of the magnetic field lines and the direction of the electron flow is the Right-Hand Rule No. 2. (RHR-2)

- Right-Hand Rule No. 2. : Curl the fingers of the right hand into the shape of a half-circle. Point the thumb in the direction of the conventional current, and the tips of the fingers will point in the direction of the magnetic field.

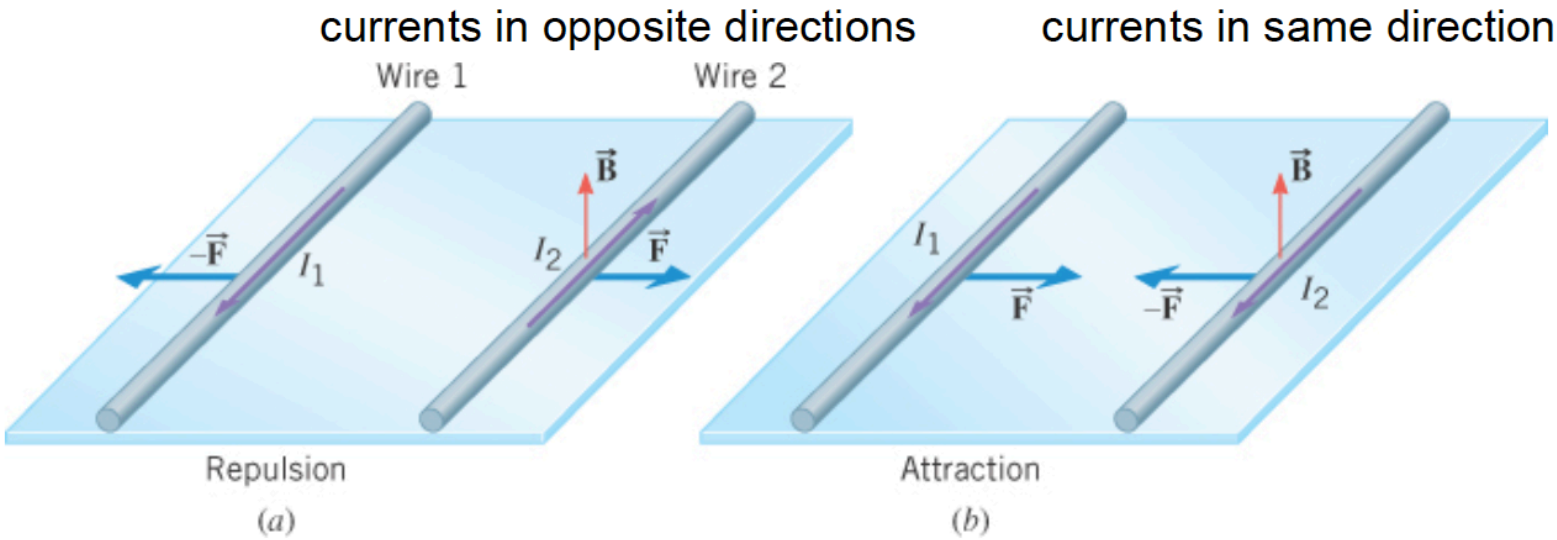
Currents in wires produce magnetic fields. The long current-carrying vertical wire shown will cause a compass needle to deflect in a circular pattern around the wire in a horizontal plane.



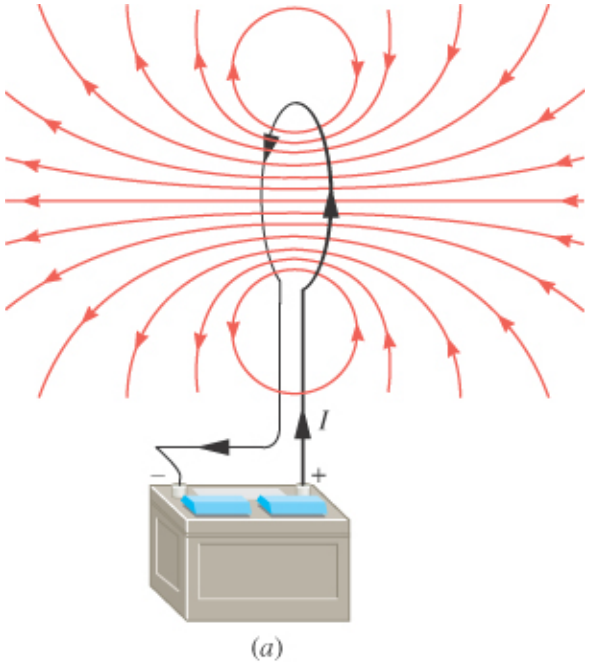
A Current Exerts a Magnetic Force on a Moving Charge



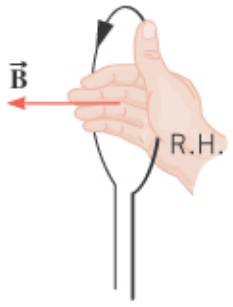
Current carrying wires can exert forces on each other.



The magnetic field at the center of a loop of wire. Find the direction of the B-field at the center by using RHR-2.

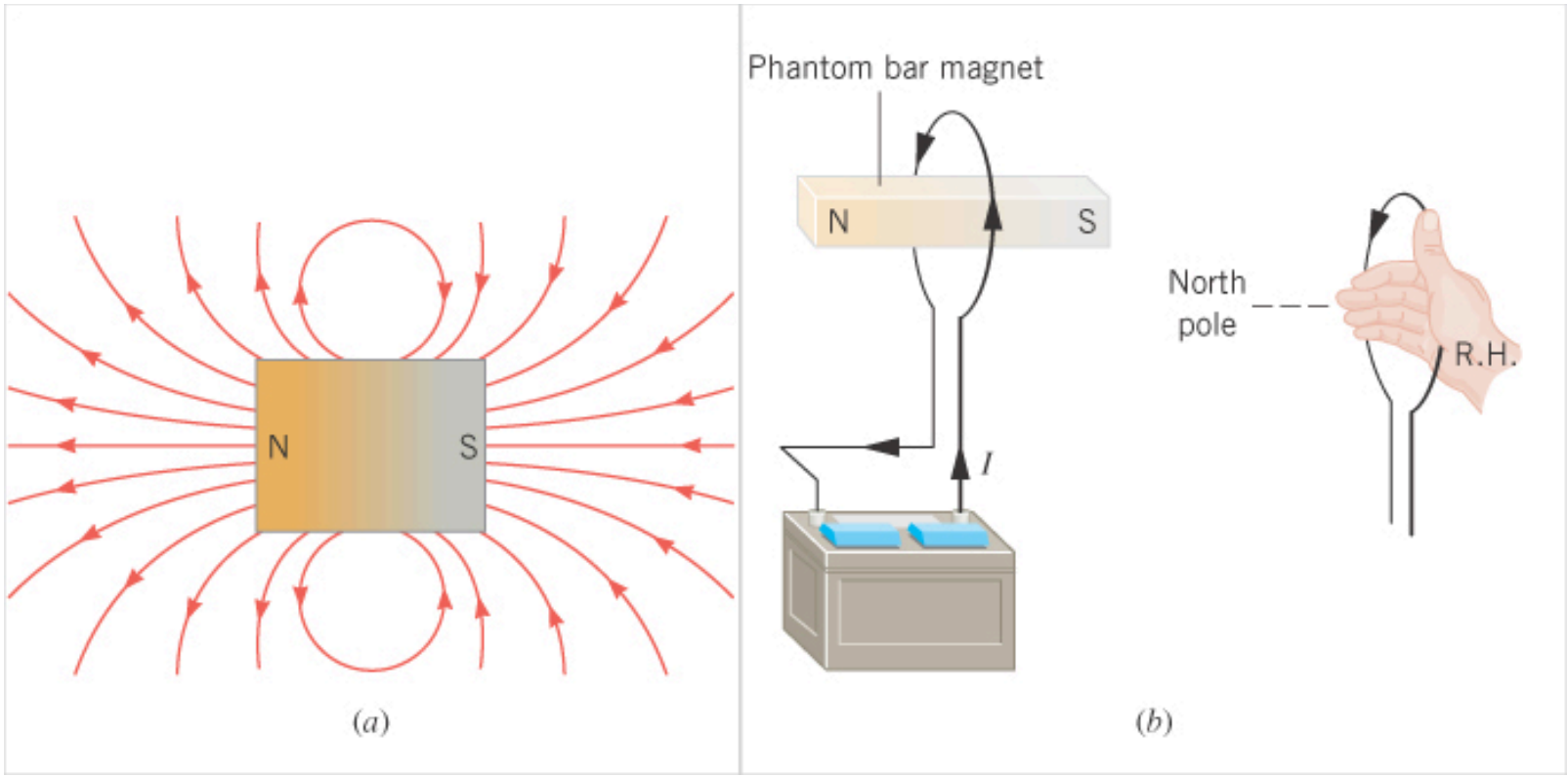


(a)

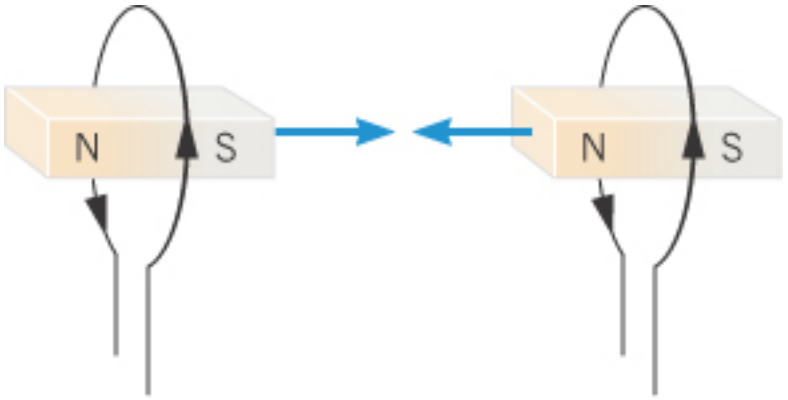


(b)

The field lines around the bar magnet resemble those around the loop.
To find the direction of the “phantom North Pole” of a loop, use RHR-2
and the direction of B at the center is also the direction of the “North Pole.”

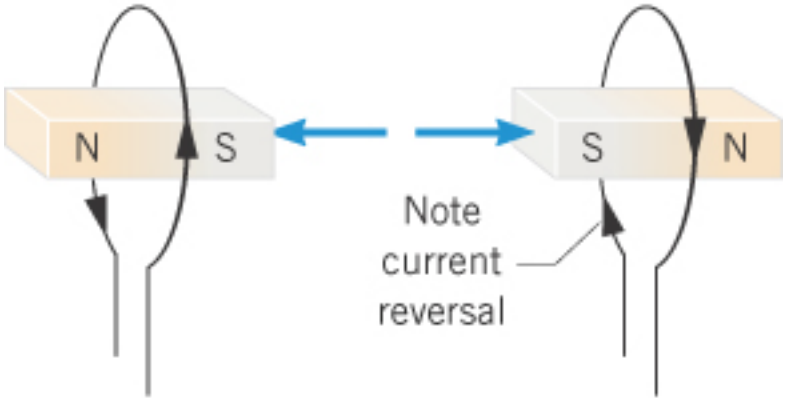


Loop currents in
the same direction,
phantom magnets attract



(*a*) Attraction

Loop currents in
opposite directions,
phantom magnets repel



(*b*) Repulsion

similar behavior as two parallel
current-carrying wires.

Ferromagnetic Materials

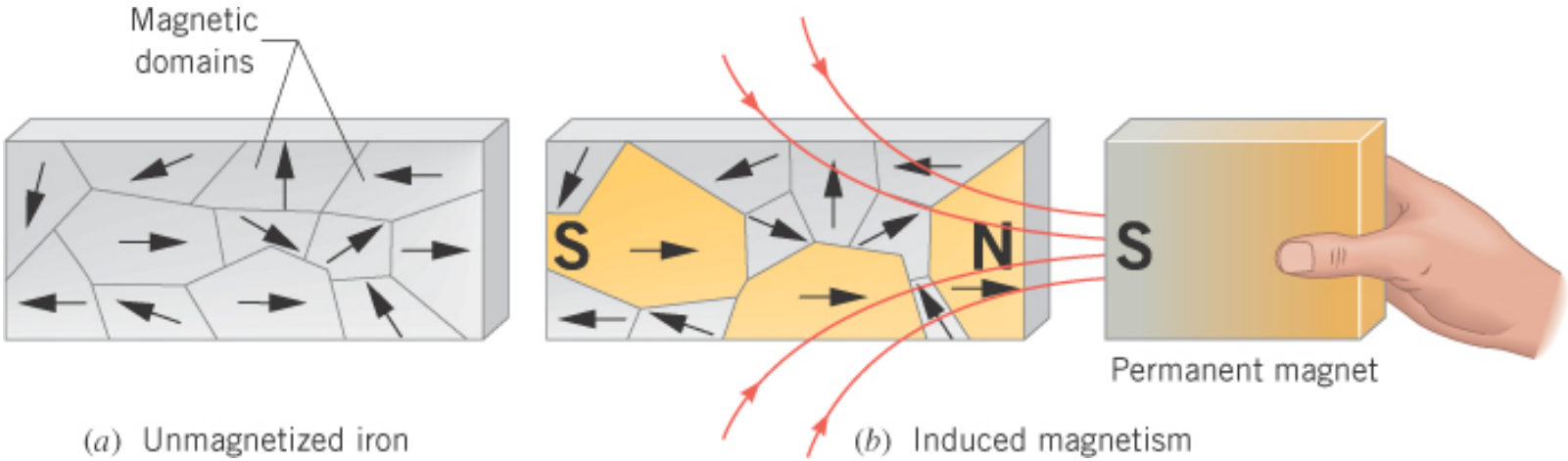
Substances containing iron, nickel or cobalt may be induced to become magnets by being placed in a magnetic field. They are called ferromagnetic materials.

Theory of Domains.

Ferromagnetic materials are composed of a large number of tiny magnetic dipoles. Groups of aligned dipoles form magnetic domains that are normally oriented at random.

In the presence of a magnetic field, the dipoles turn so that most domains are aligned to form a magnet.

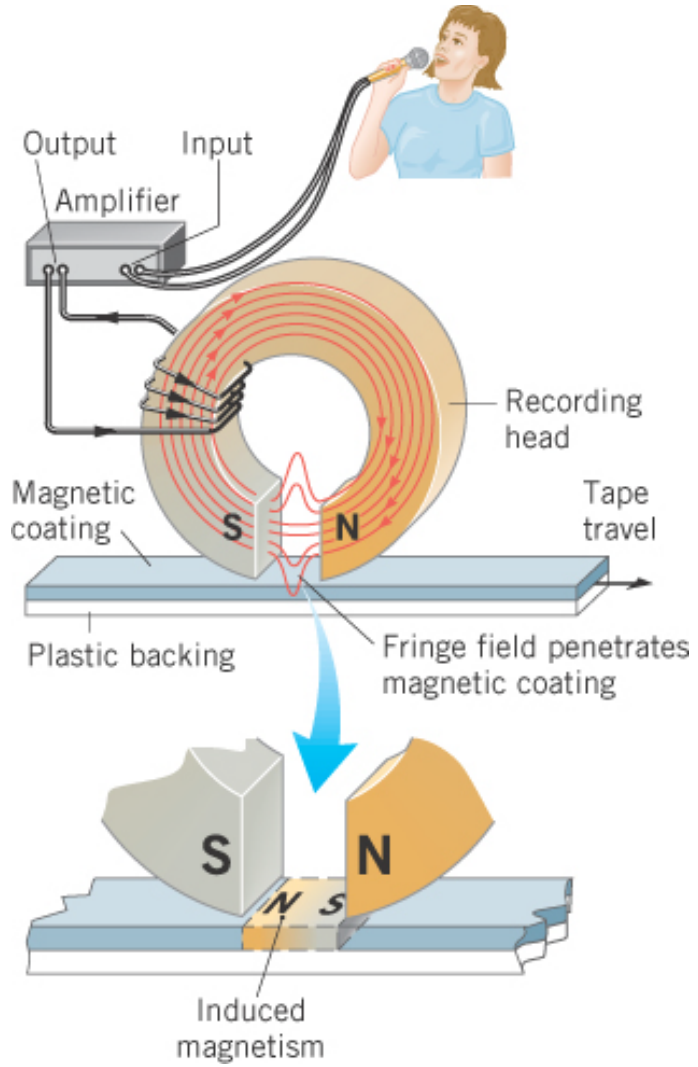
An external magnetic field can induce magnetism in ferromagnetic materials by merging and aligning domains. Depending on the material, the induced magnetism may or may not become permanent.



Putting iron in the center of a solenoid can create a strong electromagnet with fields 100x - 1000x the applied fields (also, can turn fields on and off).

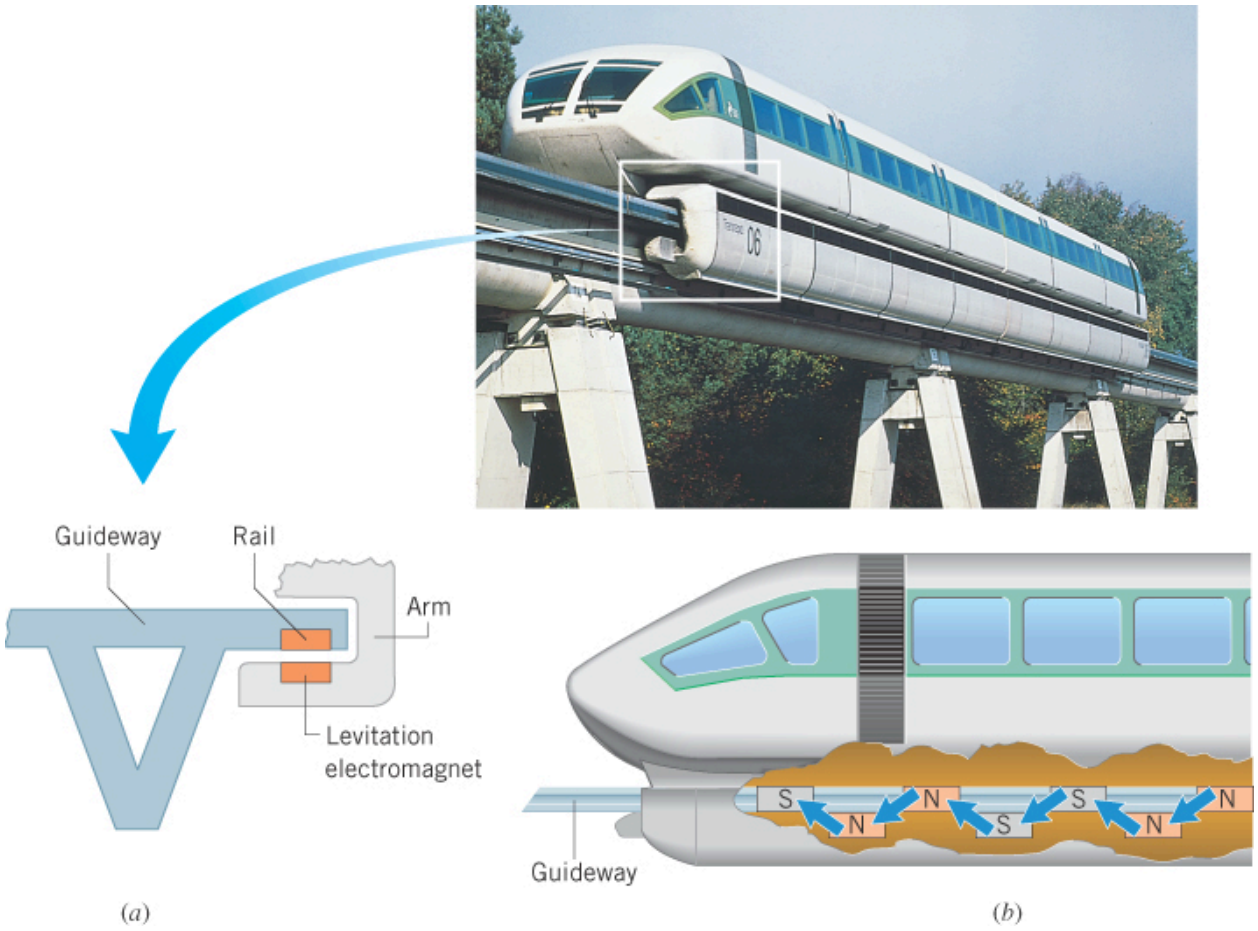
Applications: Magnetic tape recording.

The induced magnetization patterns on the magnetic coating become permanent so the recording can be played back later.



Applications: Magnetically levitated trains

Turn on electromagnets to levitate the train over the tracks. Use a different set of electromagnets to propel the train forward or backward.



References:

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2) Cutnell, J. D. & Johnson, K. W. (1998). *Cutnell & Johnson Physics, Fourth Edition*. New York: John Wiley & Sons, Inc.

The edition was dedicated to the memory of Stella Kupferberg, Director of the Photo Department: "We miss you, Stella, and shall always remember that a well-chosen photograph should speak for itself, without the need for a lengthy explanation"

3) Martindale, D. G. & Heath, R. W. & Konrad, W. W. & Macnaughton, R. R. & Carle, M. A. (1992). *Heath Physics*. Lexington: D.C. Heath and Company

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