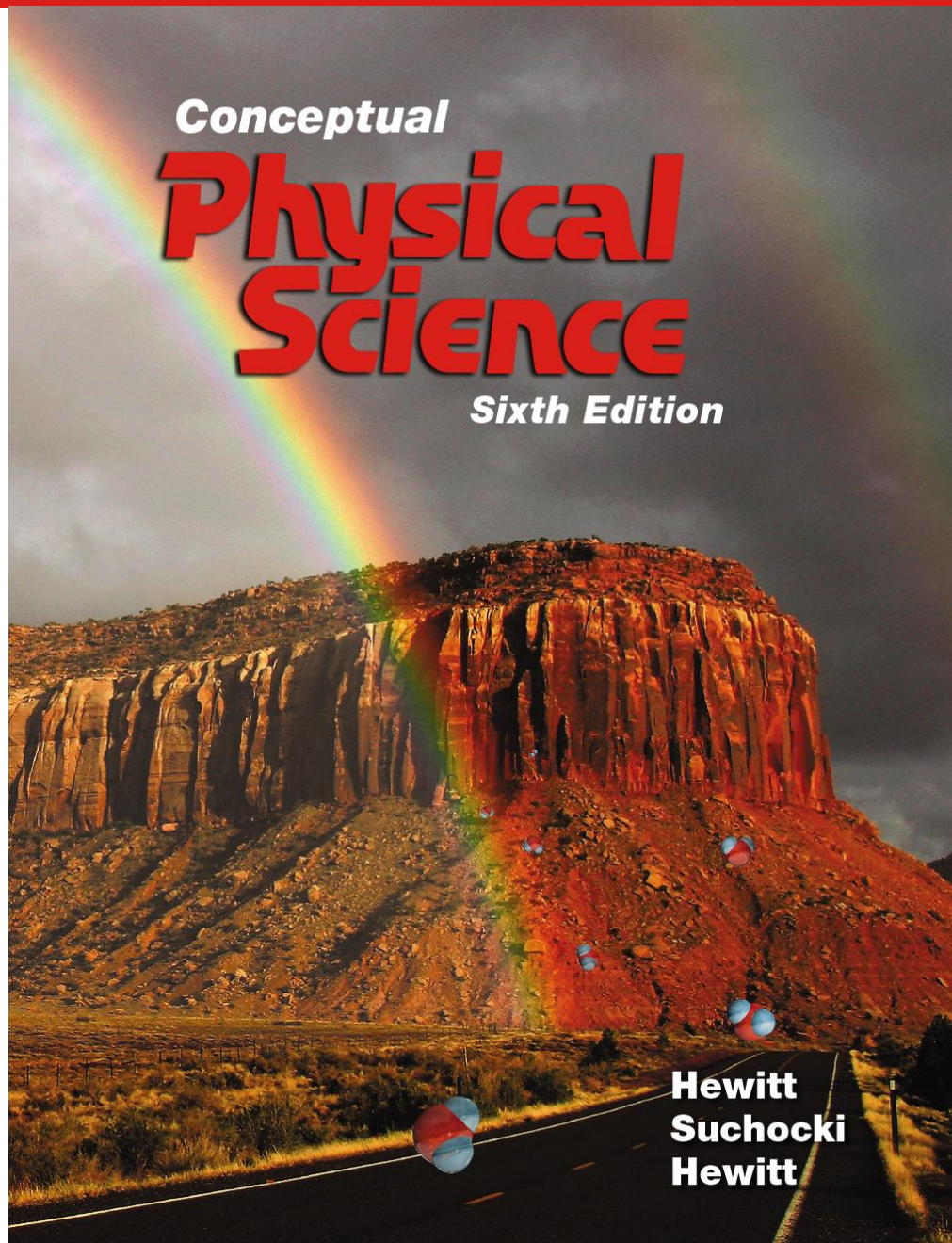
Chapter 10: Magnetism and Electromagnetic Induction



This lecture will help you understand:

- Magnetic Poles
- Magnetic Fields
- Magnetic Domains
- Electric Currents and Magnetic Fields

What Is Magnetism?

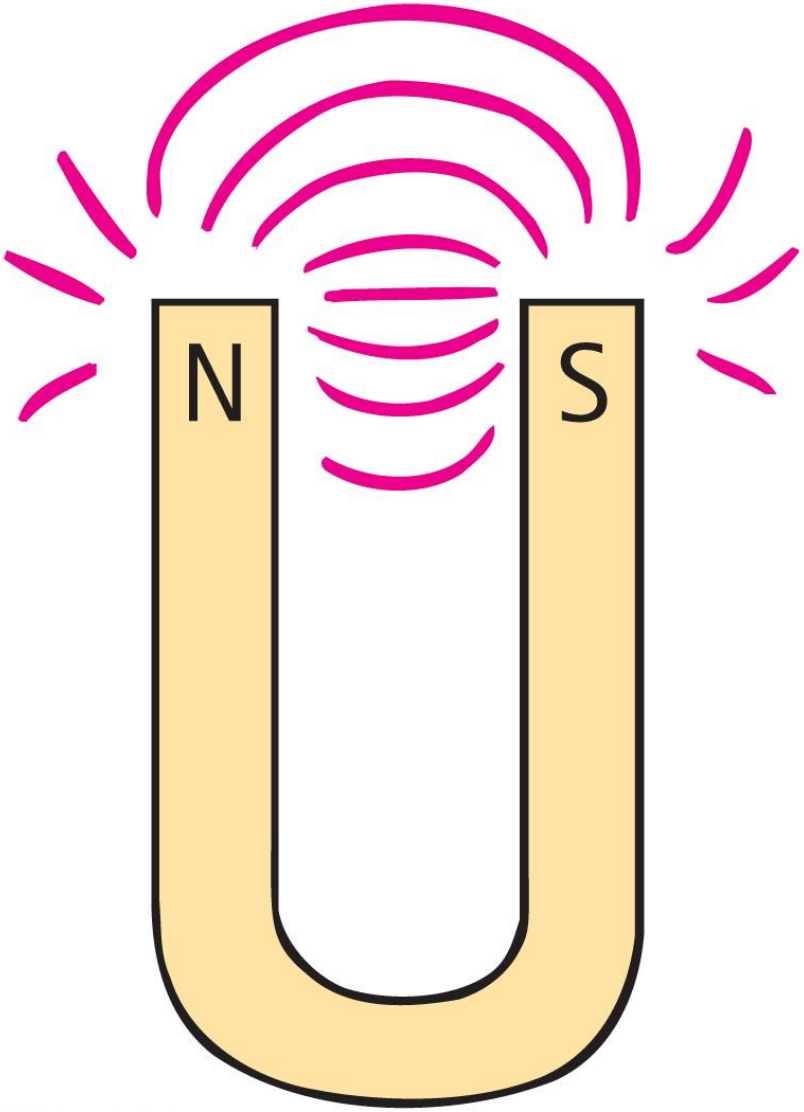
A magnet produces a force that can attract or repel other magnets and can attract certain other substances. You can feel this by holding two magnets near each other. Depending on how you hold the magnets, you can feel them push or pull on each other. The physical properties and interactions of magnets are referred to as **magnetism.**

Magnetic Fields

Magnetism is produced by moving electrons. In addition to moving in their energy levels, electrons also spin. As an electron moves in these two ways, it creates a tiny magnetic field. A **magnetic field** consists of the forces of a magnet exerted in a region surrounding the magnet. A magnetic field is strongest close to the magnet, and it gets weaker farther away from it.

Magnetic Poles

- Magnetic poles are in all magnets:
  - you can't have one pole without the other
  - no single pole known to exist
  - Example:
    - simple bar magnet—poles at the two ends
    - horseshoe magnet: bent U shape—poles at ends



Magnetic Poles

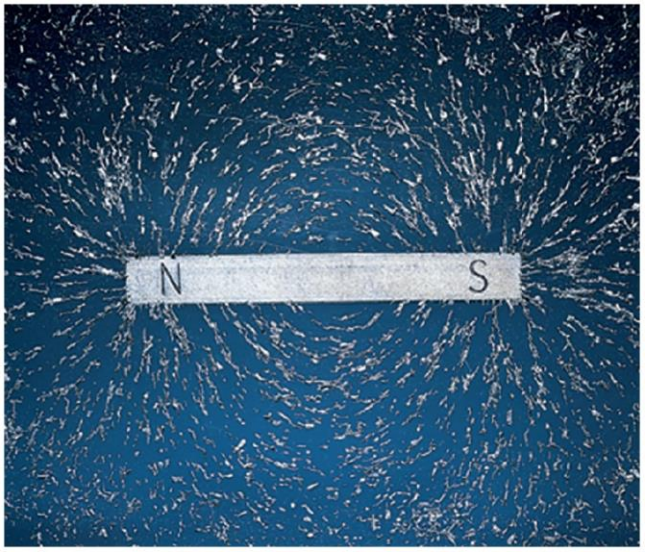
- Magnetic force
  - force of attraction or repulsion between a pair of magnets depends on which end of the magnet is held near the other
  - behavior similar to electrical forces
  - strength of interaction depends on the distance between the two magnets

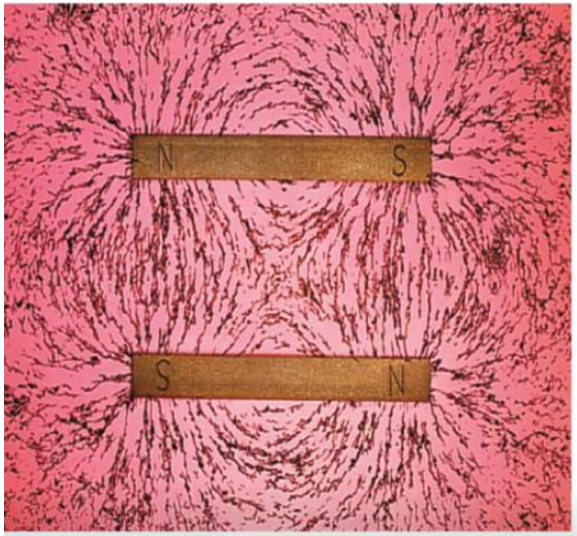
Magnetic Poles

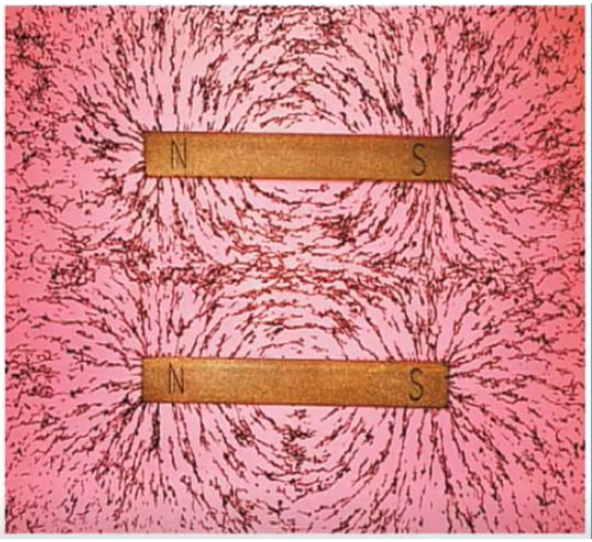
- Magnetic poles
  - give rise to magnetic force
  - two types interacting with each other
    - north pole (north-seeking pole)
    - south pole (south-seeking pole)
- Rule for magnetic forces between magnetic poles:
  - Like poles repel; opposite poles attract

Magnetic Fields

- Magnetic fields:
  - occupy the space around a magnet
  - produced by moving electric charges
- Field shape revealed by magnetic field lines that spread from one pole, curve around magnet, and return to other pole
  - Lines closer together ⇒ field strength is greater







Magnetic Fields

- Magnetic fields
  - produced by two kinds of electron motion
    - electron spin
      - main contributor to magnetism
      - pair of electrons spinning in same direction creates a stronger magnet
      - pair of electrons spinning in opposite direction cancels magnetic field of the other
    - electron revolution

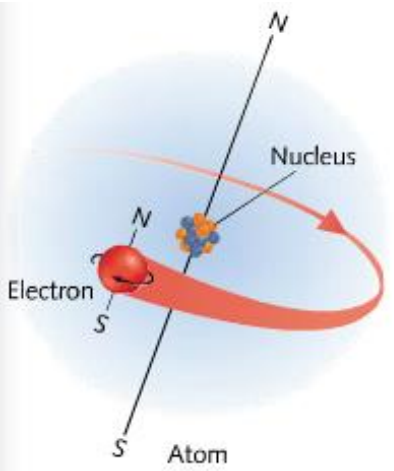


Figure 24.2
Moving electrons produce magnetic fields.

Magnetic Domains

- Magnetic domains
  - clustered regions of aligned atoms
  - oriented in random fashion—magnetic fields produced by each can cancel the fields of other.
  - When oriented in one direction, then the substance containing them is a magnet
  - Magnet strength depends on number of magnetic domains that are aligned.

Magnetic Induction

When all of the magnetic domains point in the same direction, the material develops a magnetic field of its own. The process by which a magnetic field is created in a material as a result of aligning the material's magnetic domains is called **magnetic induction.**

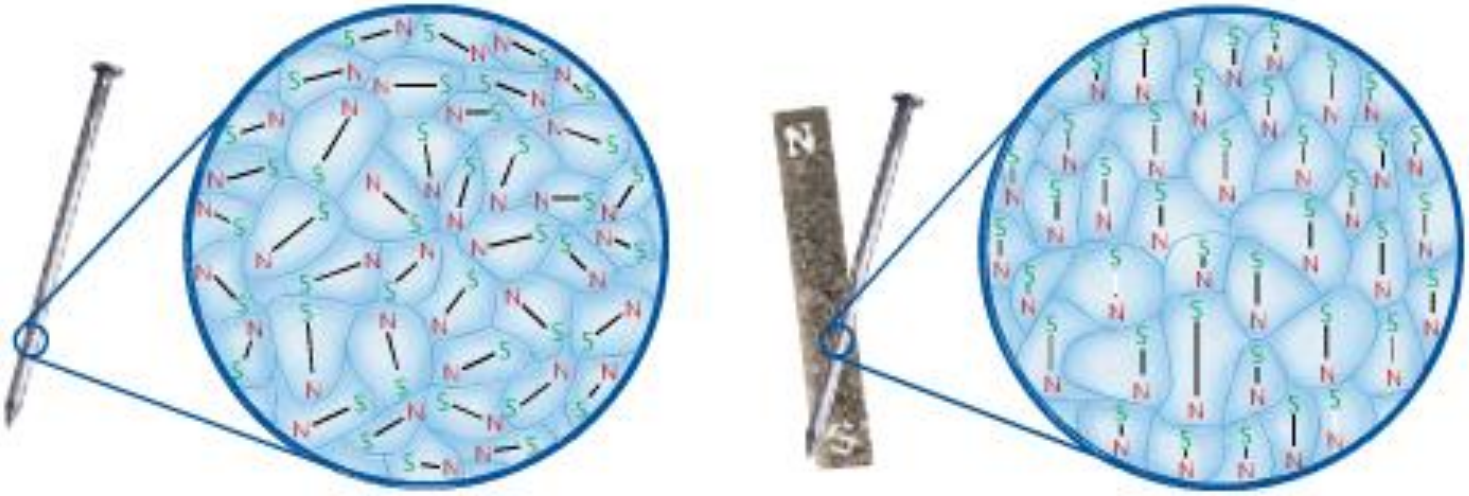
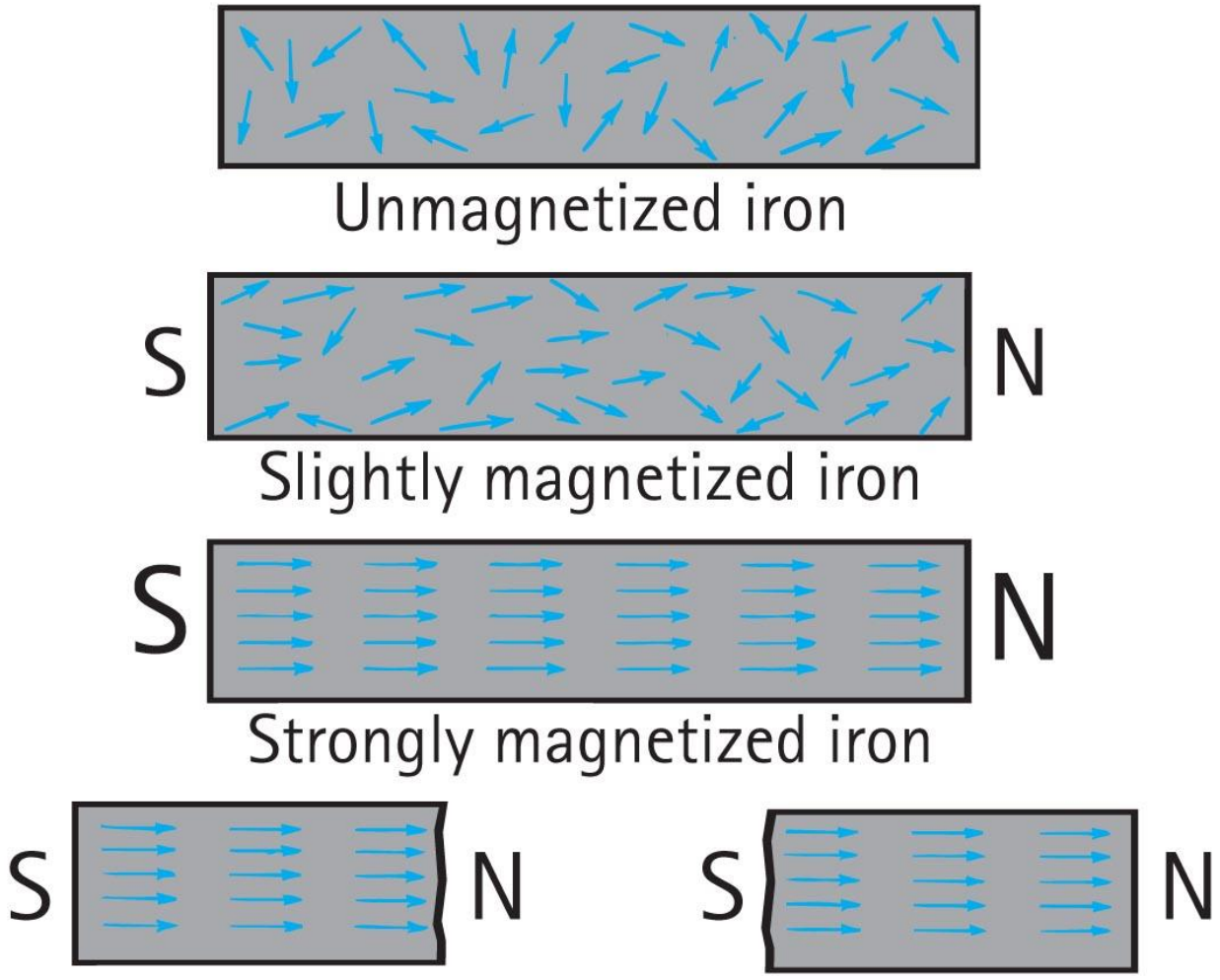


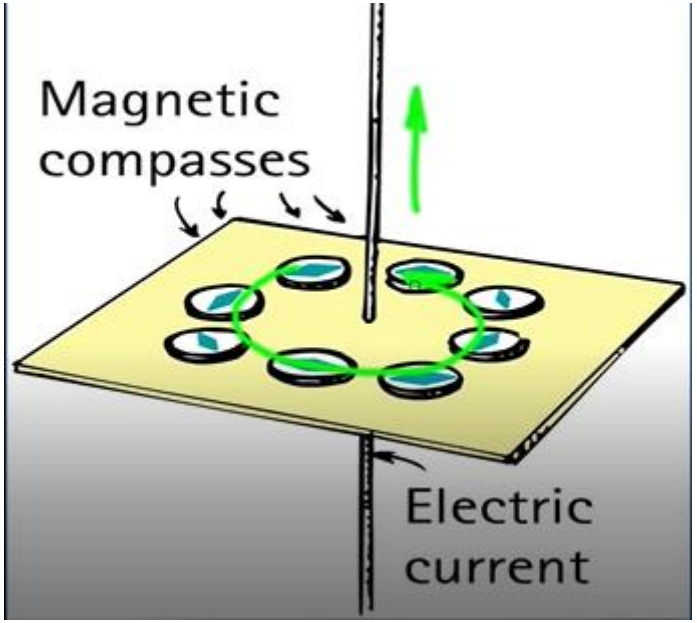
Figure 24.10 The magnetic domains inside the nail normally point in many directions (*left*). The magnetic fields cancel each other, so the nail does not act like a magnet. When a magnet is brought near the nail, the nail's magnetic domains line up with the magnet's magnetic field *(right)*. The nail's magnetic domains do not cancel each other, and the nail becomes a magnet.

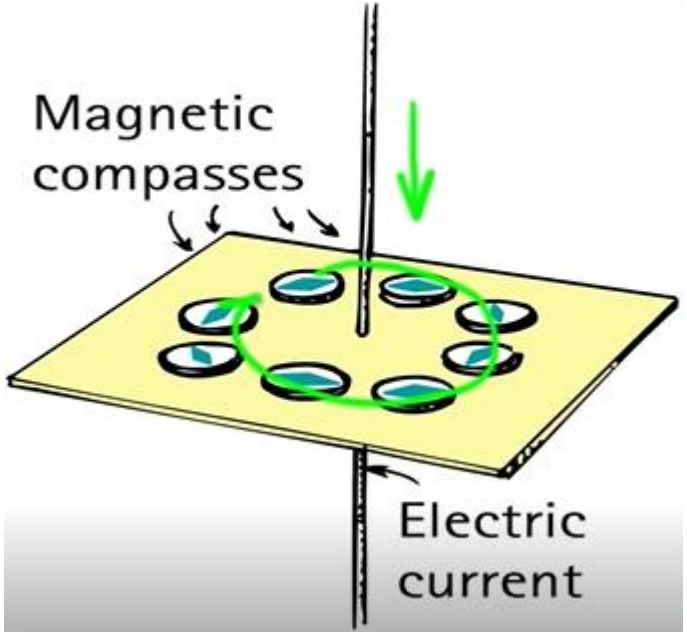
Magnetic Domains



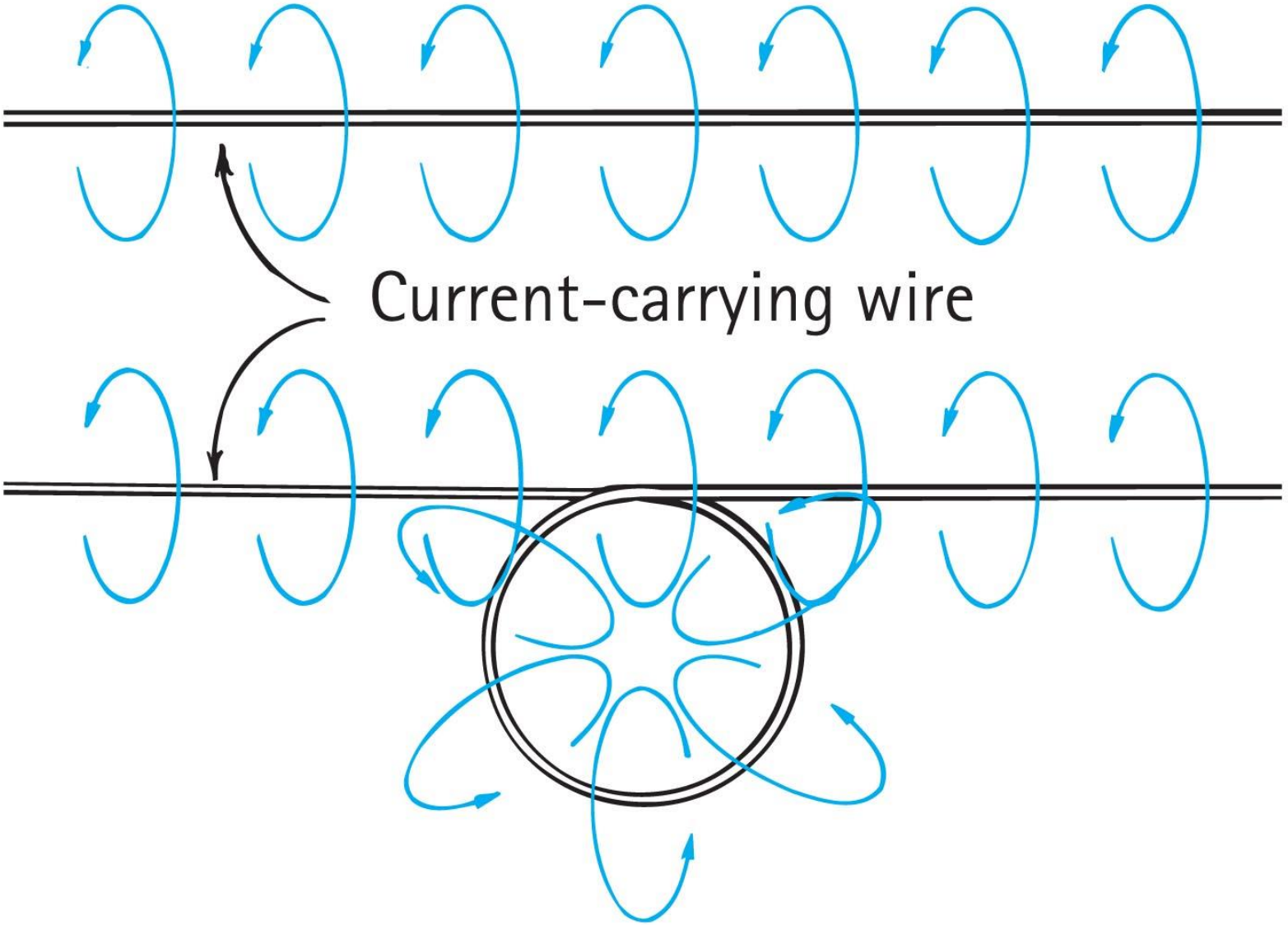
Electric Currents and Magnetic Fields

- Connection between electricity and magnetism
- Magnetic field forms a pattern of concentric circles around a current-carrying wire
  - when current reverses direction, the direction of the field lines reverse

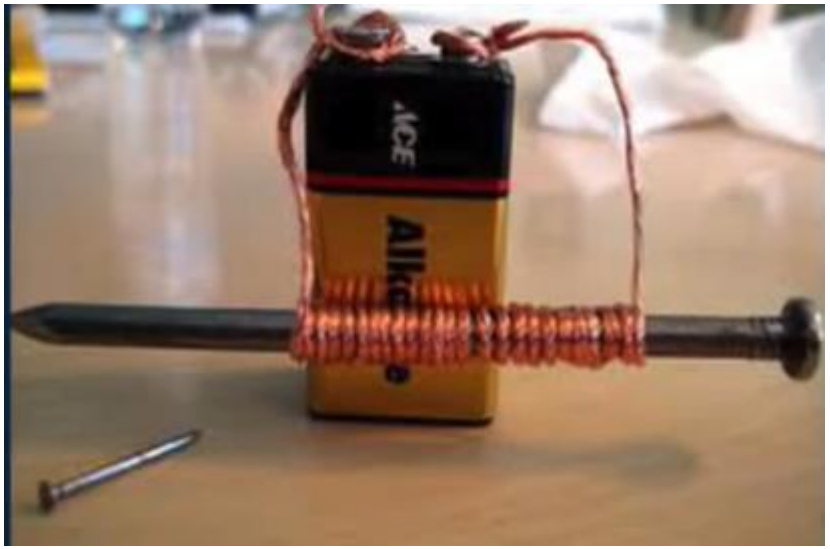




Electric Currents and Magnetic Fields



Magnetic filed lines about a current carrying wires become bunched up when the wire is bent Into a loop.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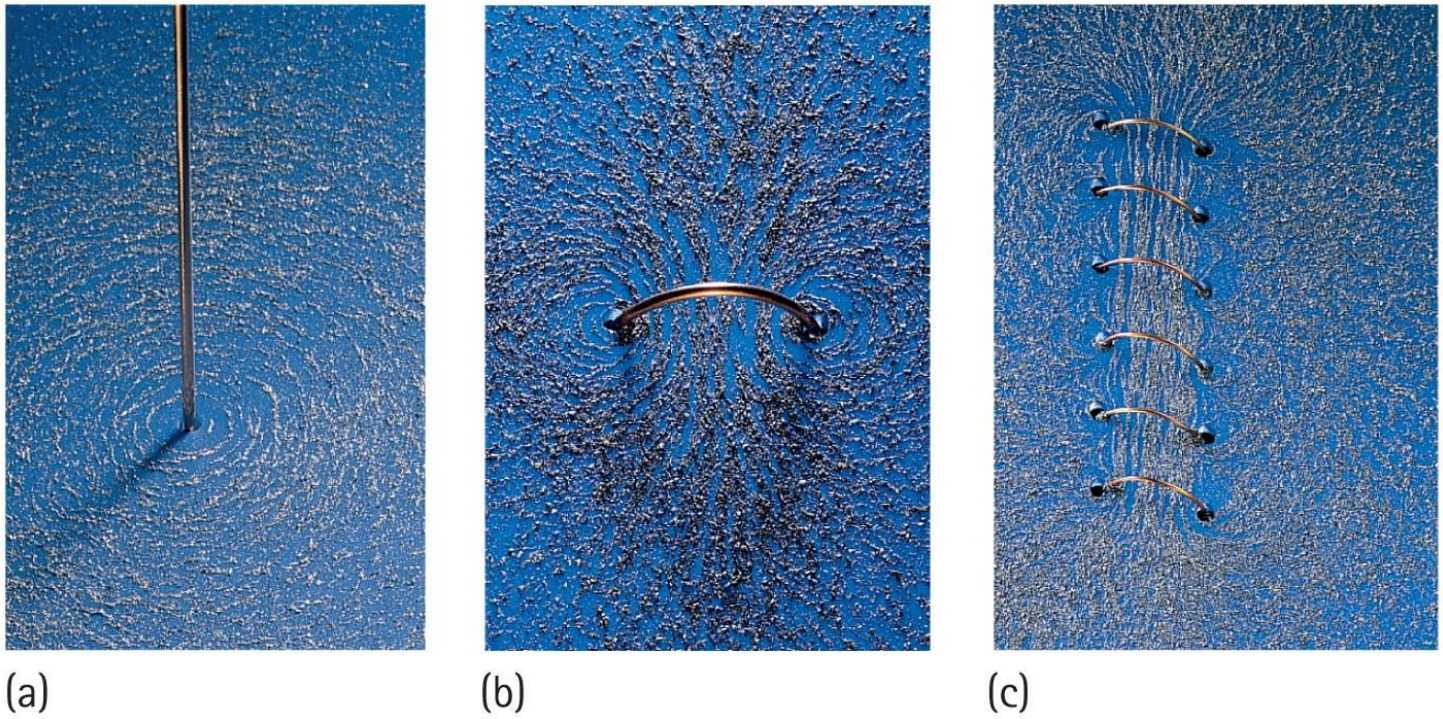
Natural Magnets

Some materials are naturally magnetic. One of these materials is called **magnetite.** It is a form of iron ore that contains two slightly different iron atoms. Some of the iron atoms in magnetite are missing two electrons (Fe^{2+}), and some are missing three electrons (Fe^{3+}). Both types of iron atoms are called ions, or charged atoms. Electrons are constantly passed from one type of iron ion to the other. The moving electrons create aligned magnetic domains, and the magnetic domains give the mineral a strong magnetic field.

Electric Currents and Magnetic Fields

- Magnetic field intensity
  - increases as the number of loops increase in a current-carrying coil



Iron filing sprinkling on paper reveal the magnetic field configurations about (a) A current carrying wire, (b) a current carrying loop, and © a coil of loops

Electric Currents and Magnetic Fields
CHECK YOUR NEIGHBOR

An electromagnet can be made stronger by

A. increasing the number of turns of wire.
B. increasing the current in the coil.
C. Both A and B.
D. None of the above.

Electric Currents and Magnetic Fields
CHECK YOUR ANSWER

An electromagnet can be made stronger by

A. increasing the number of turns of wire.

B. increasing the current in the coil.

C. Both A and B.

D. None of the above.