

## Chapter 36 Magnetism

## Summary

**THE BIG IDEA** : A moving electric charge is surrounded by a magnetic field.

### 36.1 Magnetic Poles

✓ Like poles repel; opposite poles attract.

- Magnets can both attract and repel without touching. The strength of the interaction between two magnets depends on the distance between them.
- Regions called **magnetic poles** produce magnetic forces.
- If you suspend a bar magnet from its center by a piece of string, it will act as a compass. The end that points northward is called the *north pole*. The end that points south is called the *south pole*. All magnets have a north and a south pole.
- If the north pole of one magnet is brought near the north pole of another magnet, they repel. The same is true of a south pole near a south pole. If opposite poles are brought together, however, attraction occurs.
- A north magnetic pole never exists without the presence of a south pole, and vice versa. If you break a bar magnet, each piece still behaves as a complete magnet.

### 36.2 Magnetic Fields

✓ The direction of the magnetic field outside a magnet is from the north to the south pole.

- The space around a magnet, in which a magnetic force is exerted, is filled with a **magnetic field**. The shape of the field is revealed by *magnetic field lines* that spread out from the north pole, curve around the magnet, and return to the south pole.
- Where the magnetic field lines are closer together, the field strength is greater than where the lines are farther apart.

### 36.3 The Nature of a Magnetic Field

✓ A magnetic field is produced by the motion of electric charge.

- Just as an electric charge is surrounded by an electric field, a moving electric charge is surrounded by a magnetic field.
- Both the orbital motion and the spinning motion of every electron in an atom produce magnetic fields.
- Every spinning electron is a tiny magnet. Multiple electrons spinning in the same direction make a stronger magnet, but electrons spinning in opposite directions work against one another. Their magnetic fields cancel. This is why most substances are not magnets.

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**36.4 Magnetic Domains**

- ✓ Permanent magnets are made by simply placing pieces of iron or certain iron alloys in strong magnetic fields.
- The magnetic fields of individual atoms are sometimes so strong that interactions among adjacent atoms cause large clusters of them to line up. These clusters of aligned atoms are called **magnetic domains**.
- The difference between ordinary iron and an iron magnet is the alignment of domains.
- Iron can be magnetized by placing it in a strong magnetic field or by stroking it with a magnet.

**36.5 Electric Currents and Magnetic Fields**

- ✓ An electric current produces a magnetic field.
- If you arrange magnetic compasses around a current-carrying wire, the compasses will align with the magnetic field around the wire.
- A current-carrying coil of wire with many loops is an **electromagnet**. A piece of iron inside the coil increases the magnetic field intensity.

**36.6 Magnetic Forces on Moving Charged Particles**

- ✓ A moving charge is deflected when it crosses magnetic field lines but not when it travels parallel to the field lines.
- A charged particle at rest will not interact with a static magnetic field. However, if the charged particle *moves* in a magnetic field, the particle experiences a deflecting force. The direction of the deflecting force is always perpendicular to both the magnetic field lines and the velocity of the charged particle.
- Examples of magnetic forces acting on moving charged particles include the deflection of electrons in TV tubes and the deflection of cosmic radiation by Earth's magnetic field.

**36.7 Magnetic Forces on Current-Carrying Wires**

- ✓ Since a charged particle moving through a magnetic field experiences a deflecting force, a current of charged particles moving through a magnetic field also experiences a deflecting force.
- A current-carrying wire experiences a force in a magnetic field. If the direction of current in the wire is reversed, the deflecting force acts in the opposite direction. The force is maximum when the current is perpendicular to the magnetic field lines.

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**36.8 Meters to Motors**

- ✓ The principal difference between a galvanometer and an electric motor is that in an electric motor the current is made to change direction every time the coil makes a half revolution.
- A sensitive current-indicating instrument is called a *galvanometer*. A galvanometer calibrated to measure current (amperes) is called an *ammeter*. A galvanometer calibrated to measure electric potential (volts) is called a *voltmeter*.
- If the design of the galvanometer is slightly modified, you have an electric motor. Unlike a galvanometer, the current in an electric motor is reversed during each half revolution by means of stationary contacts on the shaft.

**36.9 Earth's Magnetic Field**

- ✓ A compass points northward because Earth itself is a huge magnet.
- A compass aligns with the magnetic field of Earth. The discrepancy between the orientation of a compass and true north is known as the *magnetic declination*.
- Convection currents in the molten parts of Earth's interior may produce Earth's magnetic field.
- The magnetic field of Earth is not stable; it has flip-flopped throughout geologic time. These changes are recorded in Earth's rocks.