Chapter 18 The Electromagnetic Spectrum and Light

Summary

18.1 Electromagnetic Waves

Electromagnetic waves are produced when an electric charge vibrates or accelerates.

- **Electromagnetic waves** are transverse waves consisting of changing electric fields and changing magnetic fields.
- An **electric field** in a region of space exerts electric forces on charged particles.
- A magnetic field in a region of space produces magnetic forces.

Electromagnetic waves can travel through a vacuum, or empty space, as well as through matter.

- The transfer of energy by electromagnetic waves traveling through matter or across space is called **electromagnetic radiation**.
- The speed of light in a vacuum, *c*, is 3.00 imes 10⁸ meters per second.
- Electromagnetic waves vary in wavelength and frequency.

Electromagnetic radiation behaves sometimes like a wave and sometimes like a stream of particles.

- **The photoelectric effect** is the emission of electrons from a metal caused by light striking the metal.
- **Photons** are packets of electromagnetic energy. Each photon's energy is proportional to the frequency of the light.

The intensity of light decreases as photons travel farther from the source.

• **Intensity** is the rate at which a wave's energy flows through a given unit of area.

18.2 The Electromagnetic Spectrum

The electromagnetic spectrum includes radio waves, infrared rays, visible light, ultraviolet rays, X-rays, and gamma rays.

• The full range of frequencies of electromagnetic radiation is called the **electromagnetic spectrum.**

Radio waves are used in radio and television technologies, as well as in microwave ovens and radar.

Class

- In **amplitude modulation**, the amplitude of the wave varies. The frequency remains the same.
- In **frequency modulation**, the frequency of the wave varies. The amplitude remains the same.

Infrared rays are used as a source of heat and to discover areas of heat differences.

• **Thermograms** are color-coded pictures that show variations in temperature.

People use visible light to see, to help keep them safe, and to communicate with one another.

Ultraviolet rays have applications in health and medicine, and in agriculture.

• X-rays are used in medicine, industry, and transportation to make pictures of the inside of solid objects.

Gamma rays are used in the medical field to kill cancer cells and make pictures of the brain, and in industrial situations as an inspection tool.

18.3 Behavior of Light

Materials can be transparent, translucent, or opaque.

- A **transparent** material transmits light, which means it allows most of the light that strikes it to pass through it. Clear glass is transparent.
- A translucent material scatters light. Frosted glass is translucent.
- An **opaque** material either absorbs or reflects all of the light that strikes it. Wood is opaque.

When light strikes a new medium, the light can be reflected, absorbed, or transmitted. When light is transmitted, it can be refracted, polarized, or scattered.

- An **image** is a copy of an object formed by reflected (or refracted) waves of light.
- **Regular reflection** occurs when parallel light waves strike a surface and reflect all in the same direction. A regular image is sharp.
- **Diffuse reflection** occurs when parallel light waves strike a rough, uneven surface, and reflect in many different directions. A diffuse image is blurry.

- A light wave can refract, or bend, when it passes at an angle from one medium into another.
- Refraction sometimes causes mirages. A **mirage** is a false or distorted image.
- Light with waves that vibrate in only one plane is **polarized light**.
- Scattering means that light is redirected as it passes through a medium.

18.4 Color

As white light passes through a prism, shorter wavelengths refract more than longer wavelengths, and the colors separate.

- The process in which white light separates into colors is called **dispersion**.
- A rainbow forms when droplets of water in the air act like prisms. The droplets separate sunlight into the spectrum.

The color of any object depends on what the object is made of and on the color of light that strikes the object.

The primary colors of light are red, green, and blue.

- **Primary colors** are three specific colors that can be combined in varying amounts to create all possible colors.
- The secondary colors of light are cyan, yellow, and magenta. Each **secondary color** of light is a combination of two primary colors.
- Any two colors of light that combine to form white light are **complementary colors of light.**

The primary colors of pigments are cyan, yellow, and magenta.

- A **pigment** is a material that absorbs some colors of light and reflects other colors.
- Any two colors of pigments that combine to make black pigment are **complementary colors of pigments.**

18.5 Sources of Light

Common light sources include incandescent, fluorescent, laser, neon, tungsten-halogen, and sodium-vapor bulbs.

• Objects that give off their own light are **luminous**.

When electrons flow through the filament of an incandescent bulb, the filament gets hot and emits light.

• The light produced when an object gets hot enough to glow is **incandescent**.

Fluorescent light bulbs emit light by causing a phosphor to steadily emit photons.

- In a process called **fluorescence**, a material absorbs light at one wavelength and then emits light at a longer wavelength.
- A **phosphor** is a solid material that can emit light by fluorescence.

Laser light is emitted when excited atoms of a solid, liquid, or gas emit photons.

- A **laser** is a device that generates a beam of coherent light.
- Light in which waves have the same wavelength, and the crests and troughs are lined up, is **coherent light**.

Seon lights emit light when electrons move through a gas or a mixture of gases inside glass tubing.

As electric current passes through a sodium-vapor bulb, it ionizes the gas mixture. The mixture warms up and the heat causes the sodium to change from a solid into a gas.

Inside a tungsten-halogen bulb, electrons flow through a tungsten filament. The filament gets hot and emits light.