Chapter 14 Learning Goals

- Describe the properties of light.
- Explain the relationship between energy and the colors of light.
- Describe waves included in the electromagnetic spectrum in terms of energy, frequency, and wavelength.
Properties of light

- You see book pages because light in the room reflects from the page to your eyes.

- Your eyes and brain use the information carried by the light to make a mental picture.
Properties of light

- Light is fast moving energy.
- The speed at which light travels through air is about 300 million meters per second.
- The *speed of light* is so important in physics that it is given its own symbol, a lower case “c”.

![Reflection of sound](1 second, 170 meters)  
**Speed of sound**  
340 m/s

![Reflection of light](0.000001 second, 170 meters)  
**Speed of light**  
300,000,000 m/s
Properties of light

- **Light:**
  - travels extremely fast and over long distances;
  - carries energy and information;
  - has color;
  - varies in intensity, which means it can be bright or dim;
  - travels in straight lines; and
  - bounces and bends when it comes in contact with objects.
The electromagnetic spectrum

- Light, like sound and heat, is a form of electromagnetic energy.
- The *visible light* we see is part of the *electromagnetic spectrum*. 
Light is produced by atoms

- Most light is produced by atoms.
- Atoms release light when they have extra energy.
- In order to get light out of an atom you must put some energy into the atom first.
- Adding heat is one way to give atoms extra energy.
Incandescent light

- Making light with heat is called *incandescence*.

- Atoms in the filament convert electrical energy to heat and then to light.

- Incandescent bulbs are inefficient, but their waste heat can be useful.
Fluorescent light

- To make light, fluorescent bulbs use high-voltage electricity to energize atoms of gas in the bulb.
- These atoms release the electrical energy directly as light (not heat), in a process called fluorescence.
Color and energy

- **Color** is how we perceive the energy of light.
- When all the colors of the rainbow are combined, we see light without *any* color.
- We call the combination of all colors *white light.*
Color and energy

- Compare the hot, blue flame from a gas stove to the orange flame of a match.

- The light from a gas flame is blue (high energy) and the light from a match is red-orange (low energy).
Photons and light

- Light energy comes in tiny wave bundles called *photons*.
- Each photon has its own energy.
- The energy of photons is seen as color.
# Wavelength and Frequency of Light

<table>
<thead>
<tr>
<th>Energy</th>
<th>Color</th>
<th>1 x 10^{-6} m</th>
<th>Wavelength (nanometers)</th>
<th>Frequency (THz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Red</td>
<td></td>
<td>650</td>
<td>462</td>
</tr>
<tr>
<td></td>
<td>Orange</td>
<td></td>
<td>600</td>
<td>500</td>
</tr>
<tr>
<td></td>
<td>Yellow</td>
<td></td>
<td>580</td>
<td>517</td>
</tr>
<tr>
<td></td>
<td>Green</td>
<td></td>
<td>530</td>
<td>566</td>
</tr>
<tr>
<td></td>
<td>Blue</td>
<td></td>
<td>470</td>
<td>638</td>
</tr>
<tr>
<td></td>
<td>Violet</td>
<td></td>
<td>400</td>
<td>750</td>
</tr>
<tr>
<td>High</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
What kind of wave is light?

- A sound wave is an oscillation of air.
- A water wave is an oscillation of the surface of water.
- An oscillation of electricity or magnetism creates electromagnetic waves.
Electromagnetic waves

- When you move a magnet in your hand back and forth, you make a change in the magnetic field.
- The changing magnetic field causes the other magnet to move.
Electromagnetic waves

- In a similar way, the force between two electric charges is carried by an electric field.

Moving this charge...

... creates a changing electrical field that moves the other charge.
Electromagnetic waves

- If you could shake the magnet up and down 100 million times per second, you would make FM radio waves at 100 million Hz (100 MHz).
Electromagnetic spectrum

- The entire range of electromagnetic waves, including all possible frequencies, is called the *electromagnetic spectrum*.

- This spectrum includes *visible light* and invisible waves:
  - radio wave
  - microwaves
  - infrared light
  - ultraviolet light
  - X-rays
  - gamma rays
# Electromagnetic Spectrum

<table>
<thead>
<tr>
<th>Radio and television</th>
<th>Microwaves</th>
<th>Infrared light</th>
<th>Visible light</th>
<th>Ultraviolet light</th>
<th>X rays</th>
<th>Gamma rays</th>
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<tbody>
<tr>
<td>Radar</td>
<td>Cooking</td>
<td>Heat lamps</td>
<td>Sterilizers</td>
<td>Medicine</td>
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<td>Radio</td>
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<td>TV remote controls</td>
<td>Black lights</td>
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<td>Research</td>
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<td>Research</td>
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<td>Nuclear energy</td>
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<td>Wireless networking</td>
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</tr>
</tbody>
</table>

- **Low energy** - High energy
- **Low frequency** - High frequency
- **Long wavelength** - Short wavelength