Preview of Period 4: Transfer of Thermal Energy

4.1 Temperature and Thermal Energy

How is temperature measured?

What temperature scales are used?

4.2 How is Thermal Energy Transferred?

How do conduction, convection, and radiation energy transfer differ?

4.3 How Can Thermal Energy Transfer be Minimized?

What determines the amount of heat flow through a surface?
Summary of Forms of Energy

Mechanical Energy of Motion: The energy exhibited by objects in motion.

Thermal Energy: The unorganized energy of motion of vibrating atoms and molecules.

Sound Energy: The organized energy of motion of vibrating atoms and molecules.

Electrical Energy: The energy resulting from forces between charged particles.

Magnetic Energy: The energy resulting from the forces between magnets.

Radiant Energy: The energy resulting from vibrations of charges, such as radio waves, microwaves, or visible light.

Gravitational Potential Energy: The energy stored in raised objects, which could fall.

Strain Potential Energy: The energy stored in a stretched or compressed spring.

Chemical Potential Energy: The energy available in the chemical bonds binding atoms together.

Electrical Potential Energy: The energy stored by static electric charges.

Nuclear Energy: Energy available in the nuclei of radioactive atoms.
Temperature and Thermal Energy

♦ Temperature: a measure of the AVERAGE kinetic energy of the atoms and molecules of a substance.

♦ Thermal Energy: a measure of the TOTAL internal energy of the atoms and molecules of a substance.

If you put two identical materials at the same temperature in contact, their temperatures are the same, but the total thermal energy doubles.
Measuring Temperature

Three temperature scales are commonly used

Fahrenheit, Celsius, or Kelvin

<table>
<thead>
<tr>
<th>°Fahrenheit</th>
<th>°Celsius</th>
<th>Kelvin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water boils</td>
<td>212</td>
<td>100</td>
</tr>
<tr>
<td>Water freezes</td>
<td>32</td>
<td>0</td>
</tr>
<tr>
<td>Nitrogen boils</td>
<td>-320</td>
<td>-196</td>
</tr>
<tr>
<td>Absolute zero</td>
<td>-460</td>
<td>-273</td>
</tr>
</tbody>
</table>
Transfer of Thermal Energy: Conduction

- During conduction, energy is transferred by collisions between adjacent molecules.
- No matter is transported.
- The materials must be touching.
- Different materials conduct thermal energy at different rates. This property is called thermal conductivity.

<table>
<thead>
<tr>
<th>Material</th>
<th>K = Thermal Conductivity (J/s m °C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silver</td>
<td>430</td>
</tr>
<tr>
<td>Aluminum</td>
<td>237</td>
</tr>
<tr>
<td>Brass</td>
<td>120</td>
</tr>
<tr>
<td>Copper</td>
<td>398</td>
</tr>
<tr>
<td>Iron</td>
<td>80</td>
</tr>
<tr>
<td>Nickel</td>
<td>&lt;80</td>
</tr>
</tbody>
</table>
Transfer of Thermal Energy: **Convection**

- Thermal energy is transferred due to the motion of the substance containing thermal energy (examples: water or air)
- Warmer matter rises because it is less dense.
- This motion can set up convection currents.
- Convection has more effect in gasses and liquid than in solids.

Transfer of Thermal Energy: **Radiation**

- Electromagnetic radiation can transfer thermal energy - usually as infrared radiation.
- No medium such as air or water is required.
- Radiation can be reflected to reduce energy transfer.

What one condition must exist for the transfer of thermal energy by any of these methods?
Reducing Thermal Energy (Heat) Flow

Which variables affect the rate of heat flow through the window?
Using Insulation to Reduce Heat Flow

The effectiveness of insulation is called its R-value.

The R-value is based on the insulation thickness and its thermal conductivity.

\[
R = \frac{L}{K}
\]

- \( R \) = the R-value of the material
- \( L \) = thickness (meters or inches)
- \( K \) = the thermal conductivity (J/s m °C or BTU inch/ hour ft² °F)

<table>
<thead>
<tr>
<th>Material</th>
<th>( K = \text{Thermal Conductivity (J/s m °C)} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick</td>
<td>0.84</td>
</tr>
<tr>
<td>Glass</td>
<td>0.84</td>
</tr>
<tr>
<td>Water</td>
<td>0.56</td>
</tr>
<tr>
<td>Cork</td>
<td>0.042</td>
</tr>
<tr>
<td>Wood</td>
<td>0.04</td>
</tr>
<tr>
<td>Air</td>
<td>0.023</td>
</tr>
</tbody>
</table>