WELCOME TO PERIOD 4: TRANSFER OF THERMAL ENERGY

Homework #3 is due today at the beginning of class.
What is the difference between temperature and thermal energy?

How can thermal energy be transferred?
What’s ahead in Physics 1104?

Period 1 introduced math tools used in Physics 1104.

Period 2 defined types of energy and energy conversions.

Period 3 explained electricity generation and transmission.

Now, we’re ready to discuss energy use!

We begin with thermal energy.
Forms of energy: motion

Three forms of energy are related to energy of motion:

- **Kinetic Energy:** All moving objects exhibit kinetic energy.

- **Thermal Energy:** The unorganized kinetic energy of vibrating molecules and atoms within an object.

  The higher the temperature of an object, the faster its atoms and molecules vibrate.

- **Sound Energy:** When atoms and molecules vibrate in an organized way, their vibrations may travel as a sound wave.
**Temperature vs. 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.
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.
## Thermal conductivities

<table>
<thead>
<tr>
<th>Material</th>
<th>Thermal Conductivity (Joules/sec meter °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>
# Thermal conductivity of common materials

<table>
<thead>
<tr>
<th>Metals</th>
<th>Thermal Conductivity (J/s m °C)</th>
<th>Non-metals</th>
<th>Thermal Conductivity (J/s m °C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silver</td>
<td>430</td>
<td>Brick</td>
<td>0.84</td>
</tr>
<tr>
<td>Copper</td>
<td>398</td>
<td>Glass</td>
<td>0.84</td>
</tr>
<tr>
<td>Aluminum</td>
<td>237</td>
<td>Water</td>
<td>0.56</td>
</tr>
<tr>
<td>Brass</td>
<td>120</td>
<td>Cork</td>
<td>0.042</td>
</tr>
<tr>
<td>Iron</td>
<td>80</td>
<td>Wood</td>
<td>0.04</td>
</tr>
<tr>
<td>Nickel</td>
<td>&lt;80</td>
<td>Air</td>
<td>0.023</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).
- This energy transfer is called convection.
- 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.
Methods of thermal energy transfer

We’ve discussed thermal energy transfer via…

- Conduction
- Convection
- Radiation

What is the **one necessary condition** for thermal energy transfer via any of these three methods?
Thermal energy transfer

What is the one necessary condition for thermal energy transfer between objects via any of these three methods?

The objects must be at different temperatures!
BEFORE THE NEXT CLASS…

✓ Read textbook chapter 5.
✓ Complete Homework Exercise 4.
✓ Print out Activity Sheet 5.