NSTA Web Seminar:
Energy: Stop Faking It!

Wednesday, March 25, 2009
NSTA Web Seminar
Energy: Stop Faking It!

Bill Robertson
March 25, 2009
Temperature and Heat!
Temperature is a measure of...

<table>
<thead>
<tr>
<th>The total amount of energy in an object</th>
<th>The total amount of thermal energy in an object</th>
<th>How much heat something gives off</th>
<th>How fast the molecules in an object are moving</th>
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Heat is...

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<th>Energy given off or absorbed by an object</th>
<th>A measure of the motion of the molecules in an object</th>
<th>The total amount of molecular energy in an object</th>
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How do we measure temperature?

Think about using a thermometer.
How does the thermometer know how hot the substance is?
Before You Begin

This simulation demonstrates the relationship between temperature and speed of gas molecules. As you change the temperature of the gas molecules in the jar, observe how the speed changes as a result of the temperature change.

Use the instructions tab to reveal more specific instructions to operate this interactive simulation.
NSTA SCIENCE SIMULATION: Molecule Speed and Temperature

CONTROL PANEL

START

RESET

Temperature of Molecules

Speed

Molecule

Average Speed of Molecules

1  2  3  4  5  6  7  8  9
The molecules of the substance bump into the thermometer and transfer energy. How often and how hard they bump into the thermometer are directly related to their speed.
Temperature turns out to be related to the *average speed* of the molecules in a substance.
Temperature is *not* a measure of the total amount of energy in an object.

\[
\text{Thermal Energy} = \text{internal energy} = \text{a measure of the total kinetic and potential energy in an object}
\]
Before You Begin

This simulation demonstrates the relationship between thermal energy and temperature. As you transfer the goo from one bucket to the other, pay close attention to how the temperature and thermal energy of the goo in each bucket changes. What do you notice?

Use the instructions tab to reveal more specific instructions to operate this interactive simulation.
NSTA SCIENCE SIMULATION: Thermal Energy and Temperature

Temperature of Substance
30 °C

Thermal Energy of Substance
10000 joules

Temperature of Substance
0 °C

Thermal Energy of Substance
0 joules

Transfer one Scoop

CONTROL PANEL
RESET
Each has half the thermal energy of the original piece.
High temperature, very little thermal energy

Low temperature, lots of thermal energy
50 degrees C

20 degrees C
50 degrees C  

20 degrees C  

Heat
Temperature is a measure of...

| The total amount of energy in an object | The total amount of thermal energy in an object | How much heat something gives off | How fast the molecules in an object are moving |
Heat is...

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Let’s pause for two minutes for questions
Let's explore heat transfer
Before You Begin

Energy Transfer Simulation C demonstrates how energy is transferred from one object to another when one of the objects is not solid. Carefully observe the temperature of the brick and the water as time passes. What is different about this situation when compared to the first two?

Use the instructions tab to reveal the specific instructions to operate this interactive simulation.
"I knew Florida was a bad choice for the company picnic."

Heat transfer by radiation
Heat transfer by conduction and radiation
Hot water, just like hot air, rises. Then the cold water rushes in to fill the void. This creates a convection cell.
Hot liquid pushed up by cool liquid

Cool liquid sinks
Put this bottle with the coin on top in the freezer for a half hour.

What happens when you take it out and put it on a table at room temperature?
What’s the explanation?

• When you heat air molecules, they need more room. Therefore, they push up on the coin to get more room.
• When you heat air molecules, they are farther apart on average, so naturally they push the coin up.
• Heating air molecules causes the air to expand, so the coin has to lift up.
• Heating air molecules makes them move faster and push harder, so the coin moves up.
Kinetic Theory of Gases
The Kinetic Theory of Gases

- Gas molecules move in a straight line at a constant speed until they collide with another molecule or with a wall.
- Molecules bounce off one another or off a wall as if they are billiard balls.
- When you heat gas molecules, they move faster.
- When you cool gas molecules, they move slower.
The Kinetic Theory of Gases

| Gas molecules move in a straight line at a constant speed until they collide with another molecule or with a wall. | Molecules bounce off one another or off a wall as if they are billiard balls. | When you heat gas molecules, they move faster. | When you cool gas molecules, they move slower. |
Just my luck, I'm full of energy and no place to go.

Make way! Heated molecule!

Coming through!

Will you guys keep it down?! I'm trying to think outside the box.

Ouch!

This box ain't big enough for all of us. What we need is a balloon.
Is it hot in here, babe? Or is it just you?

How’d you like to feel the transfer of energy from my fist to your mouth?

Who just goosed me?!  

Fancy bumping into you here!

Watch it, clown!

Blockhead...
<table>
<thead>
<tr>
<th>When the people move slowly, how much of the space do they cover?</th>
<th>Let’s heat the people up. Now how much of the space do they cover?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Some of it</td>
<td>Some of it</td>
</tr>
<tr>
<td>All of it</td>
<td>All of it</td>
</tr>
<tr>
<td>Does this gas of people expand when you heat them?</td>
<td>Does this gas of people contract when you cool them?</td>
</tr>
<tr>
<td>-------------------------------------------------</td>
<td>---------------------------------------------------</td>
</tr>
<tr>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>No</td>
<td>No</td>
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Gases do not necessarily expand when you heat them.

Gases do not necessarily contract when you cool them.
Are these people being hot or cold gas molecules?
Gas molecules do not need any more space when you heat them, nor do they need any less space when you cool them.
Put this bottle with the coin on top in the freezer for a half hour.

What happens when you take it out and put it on a table at room temperature?
What’s the explanation?

| When you heat air molecules, they need more room. Therefore, they push up on the coin to get more room. | When you heat air molecules, they are farther apart on average, so naturally they push the coin up. | Heating air molecules causes the air to expand, so the coin has to lift up. | Heating air molecules makes them move faster and push harder, so the coin moves up. |
• The temperature of an object or substance is directly related to the average kinetic energy (which depends on the square of the speed) of the molecules in the object or substance.
• Thermal, or internal, energy is a measure of the total kinetic and potential energy within an object. Thermal energy and temperature are not the same thing.

• Gases expand when heated if they are allowed to do so by their surroundings and gases contract when cooled if their surroundings are of a nature to contract around them.
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