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Unit 4 Energy Transformations

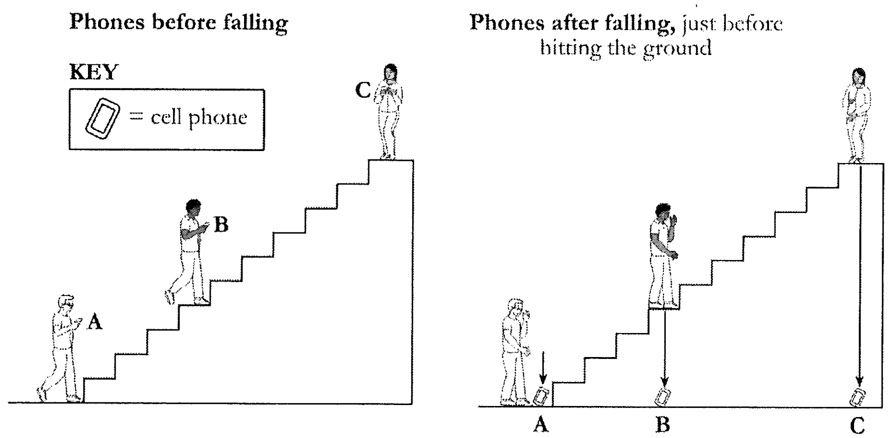
Using Models to Analyze Energy Transformations

Why?

We know that energy comes in many forms – kinetic energy, potential energy, thermal energy, chemical energy, electrical energy, mechanical energy, and more. In this activity we will explore three common situations that result in energy changing from one type to another.

As you work through the following questions, be sure to follow your team role(s).

Model 1 – How does changing the motion and position of an object change its energy?



Total Energy of each cell phone

Phone		Height (m)	Potential Energy (J)	Kinetic Energy (J)	Total Energy (J)
A	Before	1.3	2	0	
	During	0.7	1	1	
	After	≈ 0	≈ 0	2	

Phone		Height (m)	Potential Energy (J)	Kinetic Energy (J)	Total Energy (J)
B	Before	2.6	4	0	
	During	1.3	2	2	
	After	≈ 0	≈ 0	4	

Phone		Height (m)	Potential Energy (J)	Kinetic Energy (J)	Total Energy (J)
C	Before	3.9	6	0	
	During	2	3	3	
	After	≈ 0	≈ 0	6	

Use the information in Model 1 to answer questions 1 – 7.
Reach agreement with your team before writing down your consensus answers.

1. What does the symbol  represent in Model 1?

2. How many cell phones would you need to conduct the experiment shown in Model 1?

   1 2 3 4 6

3. Describe what is happening in Model 1. Be complete and specific.

Read This!

We recall that when two variables are **directly related**, the value of one increases as the value of the other increases. When two variables are **inversely related**, the value of one increases as the value of the other decreases.

4. Look closely at the column labeled **Height** in Model 1.

   a. Circle the variable that is **directly related** to the height of the phone.

   Potential energy Kinetic energy Total Energy

   b. Circle the variable that is **inversely related** to the height of the phone.

   Potential energy Kinetic energy Total Energy

5. Look closely at the diagram and the data table in Model 1.

   a. **Highlight** the word "before" each of the five times it appears in Model 1.

   b. Choose a different color to **highlight** the word "after" each of the four times it appears.

6. Focus on the information about cell phone **A**.

   a. Describe the pattern of **potential energy** (PE) values before → during → after falling.

   b. Describe the pattern of **kinetic energy** (KE) values before → during → after falling.

   c. As the potential energy of the phone decreases, what happens to the kinetic energy of the phone? Include evidence from Model 1 to support your claim.

   d. Is the **relationship** between the potential energy and the kinetic energy of the cell phone **direct** or **inverse**? Include information from your answer in question 6.c. to explain your reasoning.

Read This!

We recall that gravitational **Potential Energy** is related to the height of an object above the ground level. **Kinetic Energy** is related to the speed of an object. We will assume that these are the only two types of energy present in the cell phone.

7. Discuss with your team.

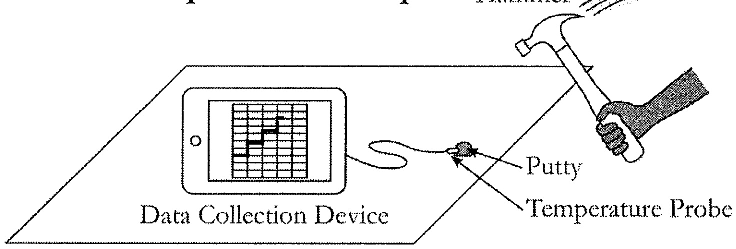
   a. Fill in the correct values in the right column of Model 1.

   b. Write one or two sentences to describe how the **total energy** of the phone is related to its position and to its movement.

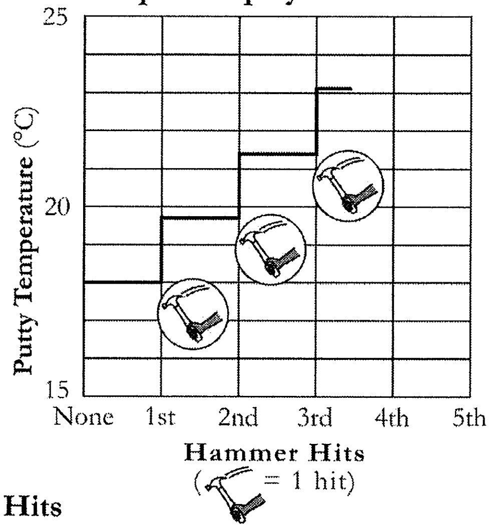
STOP Check your answer to question 7 with your teacher before you continue.

Model 2 – How does changing the motion of one object change the motion of particles in another object?

Experimental Setup



Close-up of display on tablet screen



Temperature vs. Hammer Hits

Hammer Hit	Hammer's KE just **before** the hit (J)	Hammer's KE just **after** the hit (J)	Putty's Internal TE just **after** the hit (J)	Temperature of putty (°C)	Movement (jiggle) of putty molecules
None	No Hammer	No Hammer	No Hits 4,250	Room temp. 18	slow jiggle
1st	25	0	4,275	19.7	
2nd	25	0	4,300	21.4	
3rd	25	0	4,325	23.1	

KEY

= slow jiggle

= fast jiggle

Use the information in Model 2 to answer questions 8 – 18.
Reach agreement with your team before writing down your consensus answers.

8. What does the symbol represent in Model 2?

9. What does the symbol represent in Model 2? Be specific.

10. How many times did the person hit the putty with a hammer during the experiment in Model 2?

0 1 2 3 4 6

11. Describe the experimental setup shown in Model 2. Be complete and specific.

12. Focus on the **top two rows** of the data table in Model 2. Let's look at the energy in the **hammer** before and after the first hammer hit. Assume the hammer does not bounce after each hit.

a. Fill in the data table below to organize your information. Think about the meaning of kinetic energy as it relates to movement.

Energy in the Hammer

Time	Hammer's Kinetic Energy (J)	Is the hammer moving or not moving?
Before 1st hammer hit		
Just after 1st hammer hit		

b. Discuss with your team. Does the **KE of the hammer** increase or decrease after the hammer hit? How much change is there?

STOP Check your answers to question 12 with your teacher before you continue.

13. Focus again on the **top two rows** of the data table in Model 2. Now let's look at the energy in the **putty** before and after the first hammer hit.

a. Fill in the data table below to organize your information. Think about the meaning of internal thermal energy as it relates to the movement of particles in the putty.

Energy in the Putty

Time	**Putty's Internal Thermal Energy (J)**	**Temperature of putty (°C)**	**Movement (jiggle) of putty molecules**
Just before 1st hammer hit			
Just after 1st hammer hit			

b. Does the **temperature** of the putty increase or decrease after the hammer hit? How much change is there?

c. Discuss with your team. Does the **movement** of putty molecules increase or decrease after the hammer hit?

14. Where do you think the hammer's Kinetic Energy went during the hit?
Explain your reasoning. Include specific data from Model 2 to support your claim.

15. Does your answer in question 14 work for the second and third hammer hits? Explain your reasoning.

STOP Check your answers to questions 14 and 15 with your teacher before you continue.

16. Predict what will happen to the system if you hit the putty with a hammer one more time.

a. Your team's calculations:

b. Fill in the data table below to record your numerical and particle motion predictions.

Hammer Hit	Hammer's KE just **before** the hit (J)	Hammer's KE just **after** the hit (J)	Putty's Internal TE just **after** the hit (J)	Temperature of putty (°C)	Movement (jiggle) of putty molecules
3rd	25	0	4,325	23.1	
4th					

c. **Add** your team's predicted next portion of the curve to the graph in Model 2.

17. A student states, "When you hit putty with a hammer, the motion of the whole hammer is transformed into the motion of putty particles."

a. Does your team agree with the student's claim?

b. Provide evidence from Model 2 to support your answer.

18. A carpenter is building a new wall. The carpenter hits a nail multiple times to drive it into the wood. When the carpenter touches the nail head to make sure it is flat against the surface of the wood, what is the carpenter most likely to say?
Explain your choice. Include ideas from Model 2 in your explanation.

a. "Wow, that nail is really bumpy."

b. "Wow, that nail is really shiny."

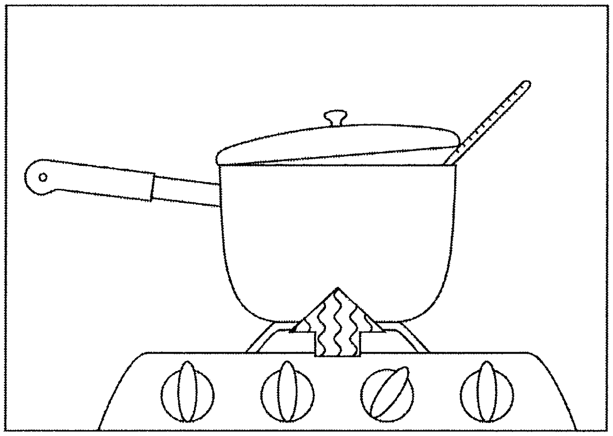
c. "Wow, that nail is really hot."

d. Wow, that nail is really cold."

Explanation:

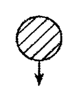
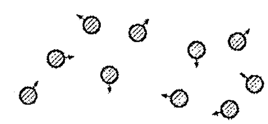
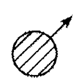
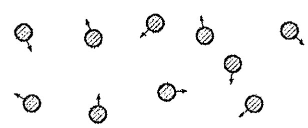
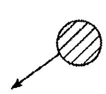
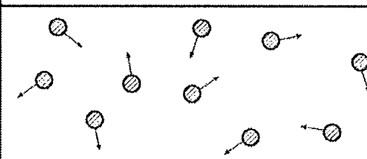
STOP Send spies to check your answers to questions 17 and 18 with two other teams before you continue.

Model 3 – How does changing the energy in a liquid change the motion and relative position of particles in the liquid?



Volume of water = 1 L
Mass of water = 1 kg

Key

Temperature of liquid water (° C)	Internal Thermal Energy (kJ)	Speed of water molecules	Spacing of water molecules
25	573		
50	678		
75	783		
100	888		

Note: The water molecules in the diagram are simplified to make it easier to analyze the speed and spacing of the particles. Each molecule is drawn as a single particle, rather than showing all the atoms that make up each molecule.

Use the information in Model 3 to answer questions 19 – 26.
Reach agreement with your team before writing down your consensus answers.

19. Read all the words in Model 3.

a. What is the mass of 1 L of water?

b. What property of molecules is represented by the length of arrows?
(Hint: Look at the details in the boxes)

c. Circle the state of matter for the water shown in Model 3.

Solid | Liquid | Gas | Can't tell from the Model

20. How much **thermal energy** is contained in **1 kg** of water when it has a temperature of **50˚C**? Include the correct unit.

21. Focus on the data table columns labeled **Temperature of liquid water** and **Internal Thermal Energy**. Complete the sentence below to describe how these two properties are related.

*As the **temperature** of liquid water increases, the **internal thermal energy** contained in the water...*

22. Focus on the data table columns labeled **Internal Thermal Energy** and **Speed of water molecules.** Complete the sentence below to describe how these two properties are related.

*As the **internal thermal energy** contained in liquid water increases, the **speed of the water molecules...***

23. Focus on the data table columns labeled **Speed of water molecules** and **Spacing of water molecules.** Circle the statement that best describes how these two properties are related.

a. As the speed of the water molecules increases, the molecules move **closer together**.

b. As the speed of the water molecules increases, the molecules move slightly **farther apart**.

c. As the speed of the water molecules increases, the molecules remain the **same distance apart**.

24. As **thermal energy is added** to liquid water, what happens to the **spacing** of water molecules?

STOP Check your answers to questions 23 and 24 with your teacher before you continue.

25. Use the information in Model 3 to answer the following questions.

    a. Add particle diagrams to complete the data table in Model 3.

    b. A student states, "Adding thermal energy can overcome the attraction that water molecules have for each other."
    Explain the evidence in Model 3 that supports this claim.

26. We use temperature to represent the amount of internal thermal energy in a substance. The **internal thermal energy** in water can be accounted for as a combination of the **energy** associated with the **motion** of water particles and the **energy** associated with the **relative positions** of those particles. Draw two diagrams to illustrate this idea. Use details from Model 3. Include six particles in each drawing.

Low temperature water	**High temperature** water

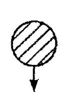
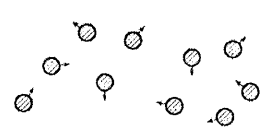
What I Still Wonder…

27. Write one additional question you have about how energy in a system can be accounted for by movement and position of objects and/or movement and relative position of particles.

Extension Questions

28. When a phone hits the ground, its KE is converted to thermal energy and mechanical energy (like bending). Explain why falling from a greater height may cause more damage to a cell phone. Include ideas about total energy and changes in types of energy in your explanation.

29. Look closely at the patterns of data in Model 3. Complete the data table below to show a reasonable estimate of the internal thermal energy, the speed of water molecules, and the spacing of water molecules when the water is cooled.

Temperature of liquid water (° C)	**Internal Thermal Energy** (kJ)	**Speed of water molecules**	**Spacing of water molecules**
25	573		
10			