

ASPECT

Assessing Students' Progress on the Energy Concept

Newton's cradle: AP13-5

Middle School – Energy Transfer by Forces

TASK OVERVIEW

Students study a Newton's cradle to determine why the balls eventually stop swinging. First, they make observations about how high the balls swing and describe what happens to the energy of the balls as they swing. Using their observations and what they know about energy transfer, students write an argument for why the balls stop swinging.

TARGETED DCIs, SEPs, AND CCCs

Disciplinary core ideas

- PS3.A-M.1: Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed.
- PS3.A-M.2: A system of objects may also contain stored (potential) energy, depending on their relative positions.
- PS3.B-M.1: When the motion energy of an object changes, there is inevitably some other change in energy at the same time.
- PS3.C-M.1: When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object.
- PS3.B-4.1: Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to

another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced.

Science & engineering practices

- SEP7-M.3: Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem
- SEP6-M.4: Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real-world phenomena, examples, or events.
- SEP3-E.3: Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution.

Crosscutting concepts

- CCC5-M.4: The transfer of energy can be tracked as energy flows through a designed or natural system.
- CCC2-E.1: Cause and effect relationships are routinely identified, tested, and used to explain change.

Related Performance Expectations

- MS-PS3-5. Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object. [*Clarification Statement*: Examples of empirical evidence used in arguments could include an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of object.] [*Assessment Boundary*: Assessment does not include calculations of energy.]

TASK PERFORMANCE EXPECTATION

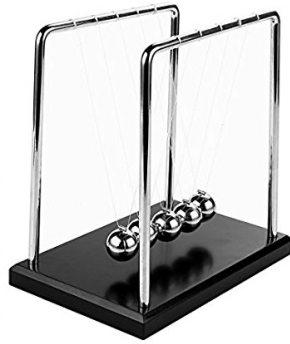
Ask questions to seek additional information and make observations to produce data to serve as evidence of energy transfer and *write an explanation* for why balls in a Newton's cradle eventually stop moving.

LINK TO ONLINE VERSION

<http://assess.bsos.org/i/test/589>

Task

A teacher shows his class a toy called a Newton's cradle. The toy is made up of a series of identical steel balls suspended on a frame as shown in the picture below.



The teacher pulls the ball on the left side toward the left and then releases it. Watch the video below to see what happens.

https://assess.bscs.org/items/media/uploads/image/ASPECT_3D/Newtons_Cradle.mp4

The students notice that the balls slow down and eventually stop swinging. The teacher asks the students to watch the video again and look for evidence that would help them explain why the balls stopped swinging.

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1. Watch the video again and pay close attention to the heights of the balls as they swing. How do the heights of the balls change from the moment the teacher let go of the first ball to the end of the video?
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2. Watch the video again and pay close attention to the sound produced during the video. What causes the sound to be produced?
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3. How did the amount of energy that the balls have change from the moment the teacher let go of the first ball to the end of the video?
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4. Write an argument for why the balls stop swinging. Your argument should begin with a claim. Then support your claim with evidence. Your evidence should be based on observations about the height of the balls and sound that you hear.

Your argument should end with reasoning that links the evidence to your claim using ideas about energy transfer.

Claim:

Evidence:

Reasoning:

Alignment to Targeted DCIs, SEPs, and CCCs and Scoring Rubrics

QUESTION 1

Watch the video again and pay close attention to the heights of the balls as they swing. How do the heights of the balls change from the moment the person let go of the first ball to the end of the video?

LEARNING GOAL

Learning Performance

- Make observations about the relative heights of the first and last ball after several swings.

Targeted DCIs, SEP, and CCC

- SEP3-E.3: Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution.
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SCORING RUBRIC

Ideal Response

The balls swing to a lower and lower height until they stop swinging.

Elements of a Correct Response

Categories	Elements
Student described the observation	<ul style="list-style-type: none">The heights the ball swing decreases over time.

Sample Student Responses

Student response	Scoring description
"they get higher as the video progresses."	Score = 0 The response does not correctly describe what happens in the video.
"The balls height decreases gradually."	Score = 1 The response correctly describes what happens in the video.

QUESTION 2

Watch the video again and pay close attention to the sound produced during the video. What causes the sound to be produced?

LEARNING GOAL

Learning Performance

- Make observations about the sound as they swing and hit one another.

Targeted DCIs, SEP, and CCC

- PS3.B-4.1: Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced.

- SEP3-E.3: Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution.
- CC2-E.1: Cause and effect relationships are routinely identified, tested, and used to explain change.

SCORING RUBRIC

Ideal Response

Sound is produced when the balls collide with one another.

Elements of a Correct Response

Categories	Elements
Student described the cause of an effect	<ul style="list-style-type: none"> • The sound is caused by collisions between the balls.

Sample Student Responses

Student response	Scoring description
"it make nose when it moves"	Score = 0 The response does not correctly describe the cause of the sound.
"The sound is caused because the metal balls are hitting together and it cause those clinking sounds."	Score = 1 The response correctly describes the cause of the sound.

QUESTION 3

How did the amount of energy the balls have change from the moment the person let go of the first ball to the end of the video?

LEARNING GOAL

Learning Performance

- Describe how the energy of the balls change over time.

Targeted DCIs, SEP, and CCC

- PS3.B-4.1: Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced.
- PS3.A-M.1: Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed.
- PS3.A-M.2: A system of objects may also contain stored (potential) energy, depending on their relative positions.
- SEP6-M.4: Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real-world phenomena, examples, or events.
- CCC5-M.4: The transfer of energy can be tracked as energy flows through a designed or natural system.

SCORING RUBRIC

Ideal Response

The amount of energy the balls has decreases over time.

Elements of a Correct Response

Categories	Elements
Student describes energy changes	<ul style="list-style-type: none">• The amount of energy the balls has decreases over time.

Sample Student Responses

Student response	Scoring description
"they slowed down."	Score = 0 The response does not describe how the energy of the balls changes.
"The amount of energy the balls had decreased. This is shown because the height of the balls slowly decrease."	Score = 1 The response correctly describes how the energy of the balls changes.

QUESTION 4

Write an argument for why the balls stop swinging. Your argument should begin with a claim. Then support your claim with evidence. Your evidence should be based on observations about the height of the balls and sound that you hear. Your argument should end with reasoning that links the evidence to your claim using ideas about energy transfer.

LEARNING GOAL

Learning Performance

- Write an argument using evidence and reasoning to support a claim for why the balls stop swinging.

Targeted DCIs, SEP, and CCC

- PS3.A-M.1: Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed.
- PS3.A-M.2: A system of objects may also contain stored (potential) energy, depending on their relative positions.
- PS3.A-4.2: Energy can be moved from place to place by moving objects or through sound, light, or electric currents.
- PS3.C-M.1: When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object.

- PS3.B-M.1: When the motion energy of an object changes, there is inevitably some other change in energy at the same time.
- SEP7-M.3: Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem
- CC5-M.4: The transfer of energy can be tracked as energy flows through a designed or natural system.
- CC2-E.1: Cause and effect relationships are routinely identified, tested, and used to explain change.

SCORING RUBRIC

Ideal Response

Claim: The balls stop swinging because energy is transferred away from the Newton's cradle system resulting in the balls having less and less energy to swing.

Evidence: I saw in the video that the last balls swing to a lower and lower height each time. The video also showed that the balls collided with one another, and a sound was produced each time the balls collided.

Reasoning: The fact that the height the balls swing decreases over time means that the gravitational potential energy of the balls is decreasing. The sound is evidence that energy is transferred to the surrounding air. Both of these pieces of evidence mean that the balls have less energy over time. As energy is transferred away from the balls, they will move slower until they eventually stop.

Elements of a Correct Response

Categories	Elements
Student makes a claim	<ul style="list-style-type: none"> • The balls stop swinging because energy is transferred away from the balls/cradle. <p><u>Note</u>: Saying the energy is lost is ok as long as the student does not mention the energy being destroyed.</p>
Student lists evidence	<ul style="list-style-type: none"> • The balls reach a lower height each time they swing. • A sound is heard as the balls hit one another.
Student either states or uses a	<ul style="list-style-type: none"> • Moving slower means less kinetic energy (i.e., the slower moving ball has less kinetic energy). [<i>links speed and energy</i>]

<p>general science idea</p>	<ul style="list-style-type: none"> • A lower height means less gravitational potential energy (i.e., the ball that reaches the lower height has less gravitational potential energy). [<i>links height and energy</i>] • When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object (i.e., as the balls swing, they interact with the air {air resistance or friction} causing energy to transfer from the balls to the air.) [<i>links forces and energy transfer</i>]. <ul style="list-style-type: none"> ○ <u>Note</u>: the use of the word force is not required here. • Sound is an indicator of energy transferred to the surroundings (i.e., the sound the balls make when they hit transfers energy to the surroundings). [<i>links sound and energy transfer</i>]
<p>Student uses reasoning to link evidence and science ideas to the claim</p>	<ul style="list-style-type: none"> • The balls stop swinging because energy was transferred away from the cradle by the sound made when the balls collide resulting in less and less energy to swing. <p style="text-align: center;">OR</p> <ul style="list-style-type: none"> • The balls stop swinging because energy was transferred from the balls to the air as the ball interacts with the air (because of air resistance/forces) resulting in less and less energy to swing.

Sample Student Responses

Student response	Scoring description
<p>“The balls stopped swinging because there are multiple forces acting on the balls.”</p> <p>“The video shows the balls slowing down because of other forces like gravity that pushes down.”</p> <p>“With other forces like gravity in the net force this makes the balls slow down and eventually stop like what we saw in the video.”</p>	<p>Score = 0</p> <p>The response does not use reasoning with energy ideas to explain why the balls stop moving.</p>

<p>"all the energy was being used up"</p> <p>"when all the balls hit the energy moved on to the other ones"</p> <p>"that was only place for the energy to move to"</p>	<p>Score = 1</p> <p>The response states a science idea about energy being transferred during collisions, but it does not cite evidence or use reasoning to support a claim.</p>
<p>"The balls are losing energy because there isn't anything producing any for them"</p> <p>"Throughout the video the balls are starting to not go as high and slowly start to stop going back and forth"</p> <p>"At the end of the video the balls are no longer swinging back and forth"</p>	<p>Score = 2</p> <p>The response includes a claim about the balls losing energy and cites evidence about the height of the balls decreasing, but it does not use reasoning with science ideas.</p>
<p>"It stop swing because it lost the energy it had before."</p> <p>"Like it started going really high and then it kind of comes down."</p> <p>"when the ball was trsferring it was hiting the other ball witch gave more energy."</p>	<p>Score = 3</p> <p>The response includes a claim, evidence about the decreasing height of the balls, and the science idea about energy being transferred during collisions, but it doesn't use reasoning to link the claim, evidence, and science idea.</p>
<p>"I think that the balls stopped swinging because of the transfer of energy from one type to another caused by the swinging of the balls, more specifically, the transfer of kinetic energy into sound energy"</p> <p>"As the balls hit each other in the video, they produced a sound. Sounds use sound energy to be produced. As well, energy can transfer itself into one state to another and typically sound energy is produced from kinetic energy."</p> <p>"If the balls have kinetic energy, and there were also producing sound, then there would have to be a transfer of energy taking place. The balls' kinetic energy was being</p>	<p>Score = 4</p> <p>The response includes all of the elements in the rubric.</p>

transferred into sound energy to create the sound they made as they hit each other, and the balls need kinetic energy to keep moving and swinging. Therefore, the transfer of energy caused the balls to lose kinetic energy and eventually stop swinging altogether”

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