ASPECt

Assessing Students' Progress on the Energy Concept

Stacked Bounce: AP14-6 (MC) & AP54-4 (CR)

Middle School – Energy Transfer by Forces

TASK OVERVIEW

Students observe a person dropping a tennis ball stacked on top of a basketball. The task first simplifies the scenario by having the students consider the balls being dropped separately. They analyze data and a graph to identify patterns about how high the balls bounce. Then they select bar graphs that represent the gravitational potential energy and the kinetic energy of the balls at two time points. Next, they construct an explanation for why the balls don't bounce as high as the initial height and describe additional data that could be collected to serve as evidence for why the ball doesn't bounce as high. Finally, they return to the stacked bounce and construct an explanation for why the balls bounce differently when dropped stacked one on top of the other. (Video from: https://www.youtube.com/watch?v=2UHS883_P60)

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.

Science & engineering practices

- SEP4-M.1: Construct, analyze, and/or interpret graphical displays of data and/or large data sets to identify linear and nonlinear relationships.
- SEP4-M.4: Analyze and interpret data to provide evidence for phenomena.
- 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.
- 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

Crosscutting concepts

- CCC5-M.3: Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion).
- CCC5-M.4: The transfer of energy can be tracked as energy flows through a designed or natural system.
- CC1-M.4 Graphs, charts, and images can be used to identify patterns in data.

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

Analyze data and graphical displays to gather evidence about the heights balls bounce. Use energy transfer ideas *and evidence to construct explanations* for why a tennis ball bounces to a lower height when bounced alone and a higher height when bounced on top of a basketball.

LINK TO ONLINE VERSION

http://assess.bscs.org/i/test/590

Task

An athlete has a tennis ball and a basketball. She stacks the tennis ball on top of the basketball and drops them together. Watch the video of what happens:

http://assess.bscs.org/items/media/uploads/image/ASPECt_3D/Stacked_bounce_slow.mp4

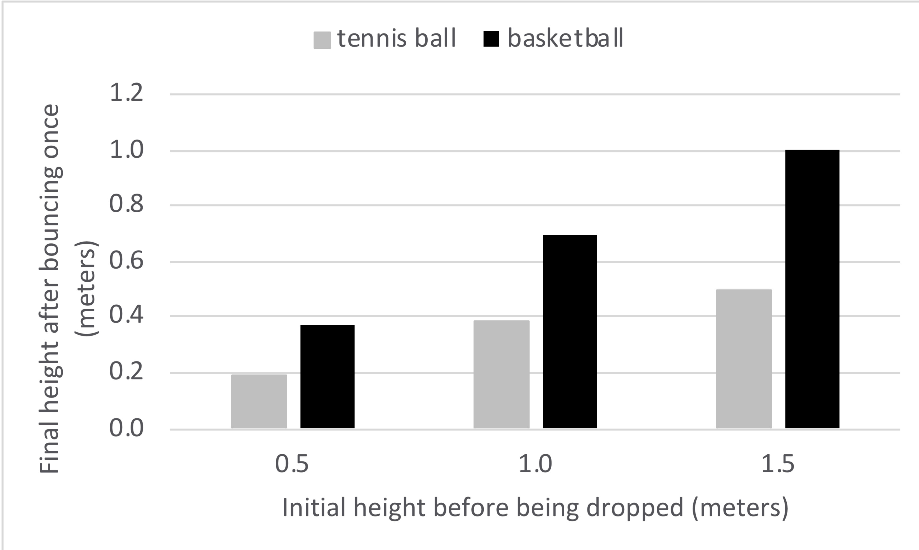
Video from Physics Girl on YouTube

The results surprise the athlete. She decides to bounce each ball separately and observe how high the balls bounce compared to when the balls are stacked. Watch the video below to see what happens when the balls are dropped separately:

http://assess.bscs.org/items/media/uploads/image/ASPECt_3D/separate_bounce.mp4

The athlete drops the tennis ball and the basketball separately multiple times using different initial heights. She records the final height of the ball for each trial. She then plots bar graphs and looks for patterns in the data.

Ball	Trial	Initial height before being dropped (meters)	Final height after bouncing once (meters)
Tennis ball	1	0.500	0.187
	2	1.000	0.383
	3	1.500	0.493
Basketball	1	0.500	0.370
	2	1.000	0.693
	3	1.500	1.005



--Multiple-choice version of #1--------------------------------------

1. For each trial, compare the final height of the tennis ball to the final height of the basketball after each has bounced to its maximum height. What pattern do you observe?

   A. The basketball bounces lower than the tennis ball in each trial.

   B. The basketball bounces higher than the tennis ball in each trial.

   C. The basketball bounces the same amount as the tennis ball in each trial.

   D. There is no pattern.

-----------------------------------Constructed-response version of #1---------------------------------

1. For each trial, compare the final height of the tennis ball to the final height of the basketball after each has bounced to its maximum height. What pattern do you observe?

--Multiple-choice version of #2--------------------------------------

2. For each trial, compare the difference in the initial height of the tennis ball and the final height of the tennis ball after bouncing. What pattern do you observe?

   A. The final height of the tennis ball is lower than its initial height.

   B. The final height of the tennis ball is higher than its initial height.

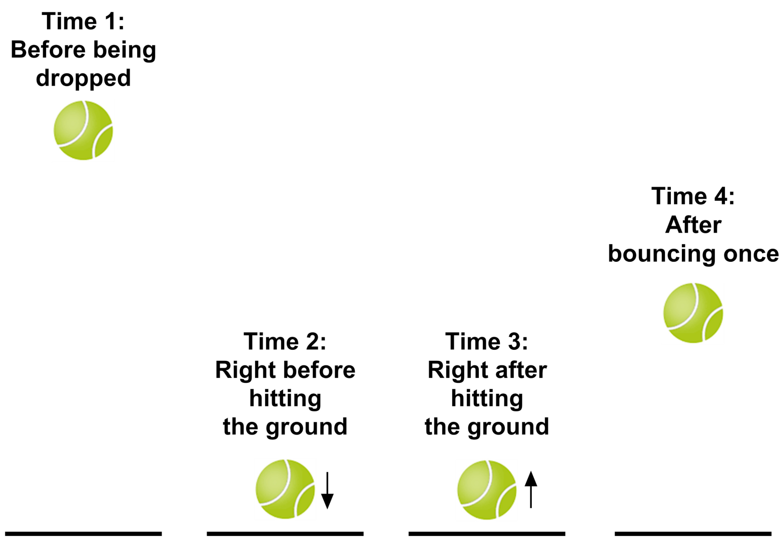
   C. The final height of the tennis ball is the same as its initial height.

   D. There is no pattern.

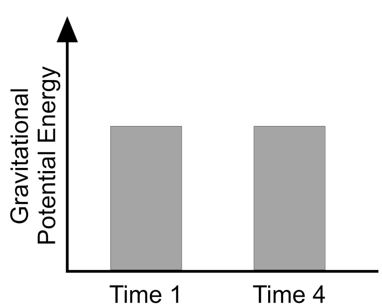
----------------------------------Constructed-response version of #2--------------------------------

2. For each trial, compare the difference in the initial height of the tennis ball and the final height of the tennis ball after bouncing. What pattern do you observe?

The diagram below shows just the tennis ball at four time points during the bounce. Time 1 is the initial height of the ball before being dropped. Time 4 is the final height the ball reaches after bouncing once.



3. To make sense of the patterns she sees in the data, the athlete graphs the gravitational potential energy at the initial height (Time 1) and the final height (Time 4) for the first trial with the tennis ball. Which bar graph represents the amount of gravitational potential energy in the tennis ball-Earth system at Time 1 and Time 4?

A.


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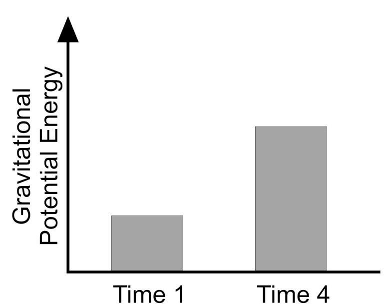
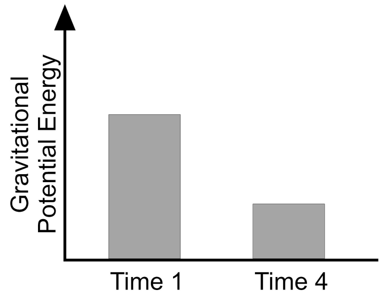
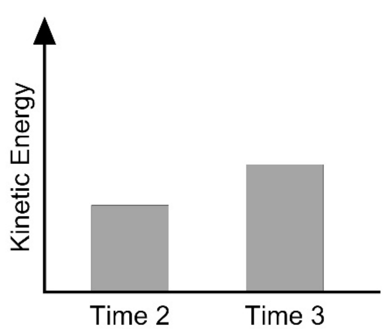


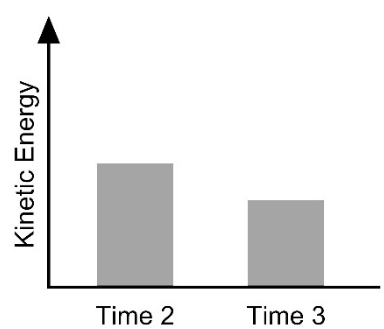
C. 

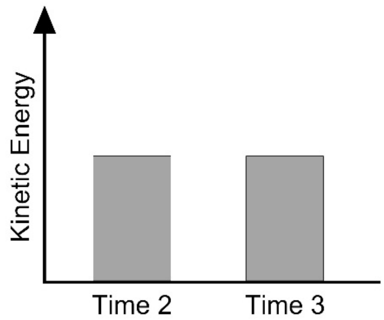
4. Now the athlete thinks about the kinetic energy of the tennis ball. She looks at the speed of each ball right before it hits the ground (Time 2) and right after it hits the ground (Time 3). She measures the speeds when the ball is at the same height before and after it hits the ground. She drops the tennis ball three times and records the data in the table below. She also notices that there is a sound produced each time the tennis ball hits the ground.

Trial	Speed at Time 2: Right before hitting the ground (meters/sec)	Speed at Time 3: Right after hitting the ground (meters/sec)
1	4.07 m/s	3.32 m/s
2	4.05 m/s	3.30 m/s
3	4.08 m/s	3.33 m/s

Which bar graph represents the amount of kinetic energy the tennis ball has at Time 2 (right before hitting the ground) and at Time 3 (right after hitting the ground)? (The graphs show the data averaged over the three trials.)

A. 

B. 

C. 

---------------------------------------Multiple-choice version of #5-------------------------------------

5. What other data besides speed, height, and mass could the athlete collect that would help to explain why the balls reached a lower height after bouncing, and how would this additional data support the explanation? Choose all that apply.
    A. The athlete could measure the size of the ball because the amount of energy an object has depends on its size.
    B. The athlete could measure the force of gravity on the ball, because the force of gravity is changed into energy when the ball hits the ground.
    C. The athlete could measure the loudness of the sound made when the ball hits the ground because sound is an indicator that energy was transferred to the air.
    D. The athlete could measure the temperature of the ground where the ball hit before and after the ball bounces because an increase in temperature is an indicator that energy is transferred from the ball to the ground.

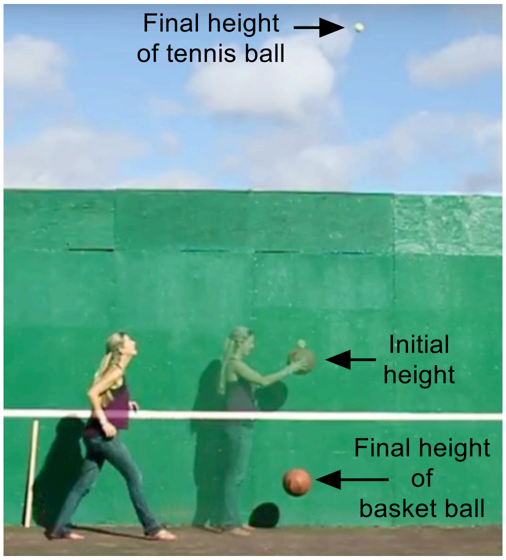
----------------------------------Constructed-response version of #5--------------------------------

5a. What other data besides speed, height, and mass could the athletes collect that would help to explain why the balls reached a lower height after bouncing? Choose all that apply.
    A. Measure the size of the ball
    B. Measure the force of gravity on the ball
    C. Measure the loudness of the sound made when the ball hits the ground
    D. Measure the temperature of the ground where the ball hit before and after the bounce

5b. How would this additional data help to explain why the balls reached a lower height after bouncing?

6. The athlete now thinks she knows enough to make sense of the observations she made when the balls are bounced separately. Write your own explanation for why the balls don't bounce as high as the initial height when bounced separately. Be sure to include in your explanation:
    - the speed data that the athlete collected,
    - the athlete's observations about sound,
    - the bar graphs that she drew, and
    - ideas about energy transfer.

7. Now the athlete returns to the question of why the stacked balls bounce as they do. She tries to use what she learned from the bounce of the individual tennis ball and basketball to explain what happened when she dropped the two balls stacked on top of each other. The athlete makes the following observations about the stacked bounce.
    - The basketball with the tennis ball on top of it hits the ground and bounces up.
    - The basketball exerts a force on the tennis ball as it bounces back up.
    - The basketball doesn't bounce as high during the stacked bounce as it did when it was dropped by itself.
    - The tennis ball bounces higher during the stacked bounce than it did when it was dropped by itself.



Using ideas about energy transfer, explain why the tennis ball bounces higher during the stacked bounce than when it was dropped by itself and why the basketball doesn't bounce as high during the stacked bounce as it did when it was dropped by itself.

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

QUESTION 1

For each trial, compare the final height of the tennis ball after bouncing to the final height of the basketball after each has bounced to its maximum height. What pattern do you observe?

LEARNING GOAL

Learning Performance

- Use data in a table and graph to identify a pattern in the maximum height two balls reach after bouncing once.

Targeted DCIs, SEP, and CCCs

- CC1-M.4: Graphs, charts, and images can be used to identify patterns in data.

SCORING RUBRIC

Ideal Response

In each trial, the maximum height of the basketball after bouncing is higher than the maximum height of the tennis ball after bouncing even though they started at the same initial height.

Elements of a Correct Response

Categories	Elements
Student identifies the relevant pattern	• The basketball bounces higher than the tennis ball in each trial.
OR	
Student selects the correct pattern for the multiple-choice version	B. The basketball bounces higher than the tennis ball in each trial.

Sample Student Responses

Student response	Scoring description
"the final high of the tennis ball was 0.5 and the final high on the basketball was 1.0"	Score = 0 This response cited data from the table but did not identify a pattern.
"The basketball always has a higher final height after bouncing once than the tennis ball."	Score = 1 This response includes a description of the correct pattern.

QUESTION 2

For each trial, compare the initial height of the tennis ball to the final height of the tennis ball after bouncing. What pattern do you observe?

LEARNING GOAL

Learning Performance

- Use data in a table and graph to identify a pattern between the initial height of a ball and the height of the ball after bouncing once.

Targeted DCIs, SEP, and CCCs

- CC1-M.4 Graphs, charts, and images can be used to identify patterns in data.

SCORING RUBRIC

Ideal Response

In each trial, the maximum height of the tennis ball after the bounce is lower than the initial height before being dropped.

Elements of a Correct Response

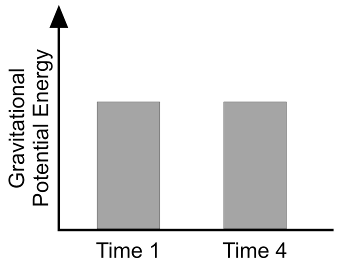
Categories	Elements
Student identifies the relevant pattern	• The height of the tennis ball after bouncing once is lower than the initial height in each trial.
OR	
Student selects the correct pattern for the multiple-choice version	A. The final height of the tennis ball is lower than its initial height.

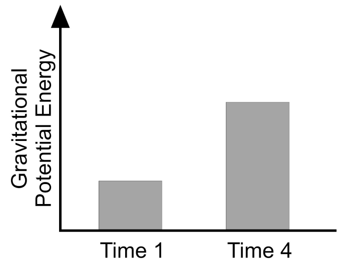
Sample Student Responses

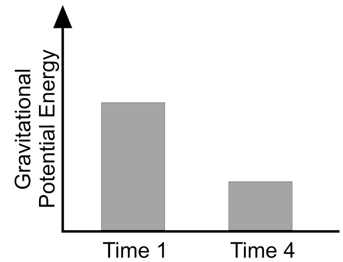
Student response	Scoring description
"The tennis ball went higher than it did before"	Score = 0 This response describes an incorrect pattern.
"I observe that the ball was always lower than the initial height."	Score = 1 This response includes a description of the correct pattern.

QUESTION 3

To make sense of the patterns she sees in the data, the athlete graphs the gravitational potential energy at the initial height (Time 1) and the final height (Time 4) for the first trial with the tennis ball. Which bar graph represents the amount of gravitational potential energy in the tennis ball-Earth system at Time 1 and Time 4?

A.


B.


C.


LEARNING GOAL

Learning Performance

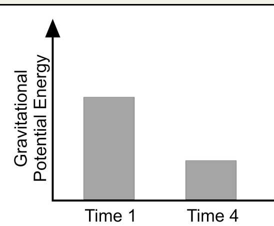
- Identify a bar graph that represents the relative amounts of gravitational potential energy a ball has before being dropped and after bouncing once.

Targeted DCIs, SEP, and CCCs

- PS3.A-M.2: A system of objects may also contain stored (potential) energy, depending on their relative positions.
- SEP4-M.1: Construct, analyze, and/or interpret graphical displays of data and/or large data sets to identify linear and nonlinear relationships.

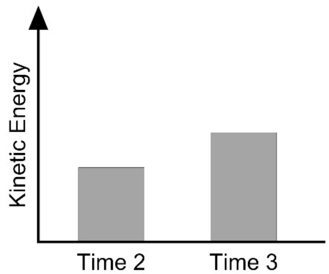
SCORING RUBRIC

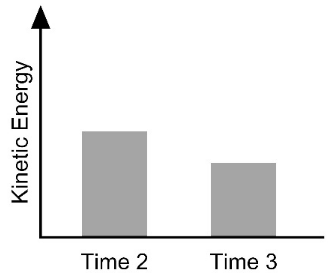
Elements of a Correct Response

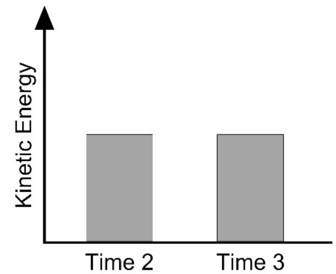
Categories	Elements
Student selects the correct graph	C. 

QUESTION 4

Which bar graph represents the amount of kinetic energy the tennis ball has at Time 2 (right before hitting the ground) and at Time 3 (right after hitting the ground)? (The graphs show the data averaged over the three trials.)

A. 

B. 

C. 

LEARNING GOAL

Learning Performance

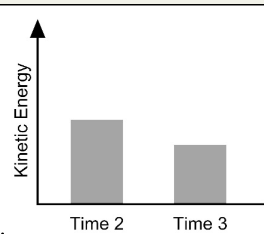
- Identify a bar graph that represents the relative amounts of kinetic energy a ball has right before and after hitting the floor.

Targeted DCIs, SEP, and CCCs

- 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.
- SEP4-M.1: Construct, analyze, and/or interpret graphical displays of data and/or large data sets to identify linear and nonlinear relationships.

SCORING RUBRIC

Elements of a Correct Response

Categories	Elements
Student selects the correct graph	B. 

QUESTION 5

What other data besides speed, height, and mass could the athletes collect that would help to explain why the balls reached a lower height after bouncing? Choose all that apply.

A. Measure the size of the ball
B. Measure the force of gravity on the ball
C. Measure the loudness of the sound made when the ball hits the ground
D. Measure the temperature of the ground where the ball hit before and after the bounce

How would this additional data help to explain why the balls reached a lower height after bouncing?

LEARNING GOAL

Learning Performance

- Cite additional data that would serve as evidence to support the explanation for why balls reach a lower height after bouncing on the ground and describe how that data would support the claim.

Targeted DCIs, SEP, and CCCs

- 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.A-4.2: Energy can be moved from place to place by moving objects or through sound, light, or electric currents.
- SEP4-M.4: Analyze and interpret data to provide evidence for phenomena.
- 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
- CCC5-M.3: Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion).
- CCC5-M.4: The transfer of energy can be tracked as energy flows through a designed or natural system.

SCORING RUBRIC

Ideal Response

An increase in temperature indicates that the ground has more thermal energy after the bounce. Energy can be tracked through a system. If there is an increase in energy in the ground, there must be a corresponding decrease in energy somewhere else (i.e., the ball slows down). Therefore, an increase in temperature of the ground after the ball bounces would support the idea that the ball transferred energy to the ground and would have less energy on the rebound and not be able to reach the initial height.

Additionally, measuring of the loudness of the sound would support the explanation for why the ball doesn't bounce as high by indicating how much energy was transferred to the surroundings.

Elements of a Correct Response

Categories	Elements
Student selects the correct data to collect	C. Measure the temperature of the ground before and after the bounce D. Measure the loudness of the sound made when the ball hits the ground
Student either states or uses a general science idea	• When the motion energy of an object changes, there is inevitably some other change in energy (e.g., thermal energy) at the same time (i.e., the ball is moving slower after the bounce so there must be an increase in energy somewhere else). [*links change in motion energy and other energy change*] • The warmer an object is the more thermal energy it has (i.e., an increase in temperature of the ground indicates it has more energy). [*links temperature and energy*] • Sound is an indicator of energy transfer (i.e., the loudness of the sound made when the ball hits the ground indicates how much energy is transferred to the surroundings). [*links sound and energy*]

Student states or uses a crosscutting concept	• The transfer of energy can be tracked through a system (i.e., if the ball has less energy, we need to look for where else in the system the energy went). [*energy can be tracked*] • Energy may take different forms (i.e., the athletes should look for evidence of different forms of energy). [*forms of energy*]
OR	
Student selects the correct responses to the multiple-choice version	C. The athlete could measure the loudness of the sound made when the ball hits the ground because sound is an indicator that energy was transferred to the air. D. The athlete could measure the temperature of the ground where the ball hit before and after the ball bounces because an increase in temperature is an indicator that energy is transferred from the ball to the ground.

Sample Student Responses

Student response	Scoring description
Student selects A and B. "The size would be important because it will increase the kinetic energy."	Score = 0 This student selected the incorrect data to collect, and their response does not describe how the data would help explain why the balls reached a lower height after bouncing.
Student selects D. "Because the balls were bounced more than once."	Score = 1 This student selected the correct data to collect, but their response does not describe how the data would help explain why the balls reached a lower height after bouncing.

Student selects C. “This additional data would help to explain why the balls reached a lower height after bouncing because these key points would give data to explain the difference in the balls' heights from the initial starting point based on gravity. They would also explain the release of energy when the ball hits the ground, based on energy transfer.”	Score = 2 This student selected the correct data to collect, and their response includes the crosscutting concept about how energy can be tracked through a system. However, their response does not include the science idea that a sound indicates a change in energy.
Student selects C and D. “Sound and temperature are evidence of the transformation of energy. If the ground temperature changes and a sound is made, then energy is being lost and transformed into sound energy and thermal energy. That lost energy is why the ball reaches a lower height, as it has less energy.”	Score = 3 This student selects the correct data to collect, and their response uses science ideas and crosscutting concepts about forms of energy to describe how the data would help explain why the balls reached a lower height after bouncing.

QUESTION 6

The athlete now thinks she knows enough to make sense of the observations she made when the balls are bounced separately. Write your own explanation for why the balls don’t bounce as high as the initial height when bounced separately. Be sure to include in your explanation:

- the speed data that the athlete collected,
- the athlete’s observations about sound,
- the bar graphs that she drew, and
- ideas about energy transfer.

LEARNING GOAL

Learning Performance

- Use evidence and science ideas to write an explanation for why balls reach a lower height after bouncing on the ground.

Targeted DCIs, SEP, and CCCs

- 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.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.
- PS3.A-4.2: Energy can be moved from place to place by moving objects or through sound, light, or electric currents. (secondary)
- SEP4-M.4: Analyze and interpret data to provide evidence for phenomena.
- 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 balls reached a lower height after bouncing on the ground because some of their energy was transferred to the environment. Data on the speed of the ball before and after the bounce indicate that the ball has less energy after the bounce because the slower an object moves the less energy it has. Additionally, the sound the athletes heard when the ball hit the ground is evidence that energy was transferred to the surroundings. Because the balls have less energy after they hit the ground, they will not have enough energy to reach the height from which they were dropped.

Elements of a Correct Response

Categories	Elements
Student makes a valid claim	• The balls reached a lower height after bouncing on the ground because o some of their energy was transferred to the environment. o the balls have less energy after the bounce. o the balls slow down after hitting the ground. o a sound was produced when the ball hit the ground.
Student lists evidence	• The speed of the balls after bouncing is slower than the speed before hitting the ground. • A sound was heard when the ball hit the ground. • The bar graphs show that the kinetic energy and/or potential energy of the ball are less after the bounce.
Student either states or uses a general science idea	• The slower an object moves, the less kinetic energy it has (i.e., the ball has less energy when it is moving slower). [*links speed and energy*] • When two objects interact, each one exerts a force on the other that causes energy to be transferred resulting in a change in motion (i.e., the ball transfers energy to the ground when it hits the ground and bounces upward). [*links force and energy transfer*]. (Note: the word “force” is not required.) • Sound is an indicator of energy transfer (i.e., the sound made when the ball hits the ground transfers energy to the surroundings). [*links sound and energy transfer*] • The closer an object is to the earth, the less gravitational potential energy the system has (i.e., the ball has less energy if it is closer to the ground). [*links distance and energy*] • When the motion energy of an object changes, there is inevitably some other change in energy (e.g., gravitational potential energy) at the same time (i.e., the decrease in kinetic energy of the ball means the gravitational potential

	energy at final height will be less). [*links change in motion energy and other energy change*]
Student uses a crosscutting concept	• The transfer of energy can be tracked through a system (e.g., from the ball to the air and/or the ground). [*energy can be tracked*] Note: The student must explicitly state where the energy is coming from and going to.
Student uses reasoning to link evidence and science ideas to support their claim	• The reason the ball did not bounce as high is because it has less energy. It has less energy because energy was transferred from the ball to the ground when the ball hit the ground [as evidenced by the change in speed]. OR • The reason the ball did not bounce as high is because it has less energy. It has less energy because energy was transferred from the ball to the air as evidenced by the sound heard. OR • The reason the ball did not bounce as high is because it has less energy as illustrated by the graphs that show that the ball has less energy (either kinetic or potential) after the bounce. Note: Student's response must include energy to receive the reasoning point. Students do not need to use both the science idea and evidence to get the reason point. They can provide a "rule-based" explanation or an "evidence-based" explanation. But they must one or the other to make it different than the claim.

Sample Student Responses

Student response	Scoring description
"I think the balls didn't bounce as high separately because when they were bounced together the balls had more power."	Score = 0 This response does not use science ideas and crosscutting concepts about energy to explain why the ball doesn't bounce as high.
"I think the ball loses energy when it hits the ground and gains gravity control."	Score = 1 This response includes a claim that the ball loses energy, the claim is not supported by evidence, science ideas, or crosscutting concepts.
"The balls don't bounce as high as the initial height because there is less kinetic energy after the ball hits the ground. In the diagram, the speed at time 2(before hitting the ground) is 4.07/4.05/4.08 m/s while the speed at time 3(after hitting the ground) is 3.32/3.30/3.33 m/s."	Score = 2 This response includes a claim and evidence, but it does not include reasoning with science ideas and crosscutting concepts to link the evidence with the claim.
"They did not bounce as high as the initial height because they had less potential energy due to being closer to the ground. The balls had less speed at time 2 than time 3 as well, further slowing the balls down from being able to bounce as high as their initial height."	Score = 3 This response includes a claim, evidence, and science ideas about potential energy, but it does not use crosscutting concepts and reasoning.
"The ball loses energy when it makes contact with the ground. This is seen when it loses energy on the way back up compared to just before it hits the ground. The sound produced indicates a loss of energy. The bar graphs support the idea that energy is lost once the ball makes contact with the	Score = 4 This response includes a well-reasoned explanation but does not include the crosscutting concept of tracking energy. Instead, the

ground. Time 2's kinetic energy is greater than time 3's. Overall , there is a transfer of energy when the ball makes contact with the ground, meaning the ball loses Kinetic Energy with that contact.”	response describes energy as being lost.
“It makes sense that the balls don't bounce as high as the initial height because after they bounce, they are moving at a slower speed. At time 3, the ball is moving slower than at time 2, so it doesn't move as far/high. The athlete also observed a sound when the ball hit the ground, and this occurs because there is a transfer of energy from the ball to the ground. The ball then has less energy and moves more slowly back up after the bounce as shown in the athlete's bar graphs.”	Score = 5 This response includes all the elements in the rubric.

QUESTION 7

Using ideas about energy transfer, explain why the tennis ball bounces higher during the stacked bounce than when it was dropped by itself and why the basketball doesn’t bounce as high during the stacked bounce as it did when it was dropped by itself.

LEARNING GOAL

Learning Performance

- Write an explanation for why a tennis ball bounces higher during a stacked bounce than when it is dropped by itself and why a basketball doesn’t bounce as high during a stacked bounce as it does when it is dropped by itself.

Targeted DCIs, SEP, and CCCs

- 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.
- SEP4-M.4: Analyze and interpret data to provide evidence for phenomena.
- 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.3: Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion).
- CCC5-M.4: The transfer of energy can be tracked as energy flows through a designed or natural system.

SCORING RUBRIC

Ideal Response

When the two balls are stacked and dropped together, they each have kinetic energy as they fall toward the ground. The basketball hits the ground first and rebounds into the path of the falling tennis ball. The basketball hits the tennis ball and transfers some of its energy to the tennis ball as the two balls collide. This means that the tennis ball has additional energy as it travels upward, and this allows it to reach a higher height. This also means that the basketball has less energy than during the individual bounce, so it reaches a lower height.

Elements of a Correct Response

Categories	Elements
Student makes a valid claim	• The tennis ball bounces higher because it has more energy on the stacked bounce rebound. The basketball bounces lower because it has less energy on the stacked bounce rebound. OR • The tennis ball bounces higher, and the basketball bounces lower because the basketball transfers energy to the tennis ball. OR • The tennis ball bounces higher, and the basketball bounces lower because the basketball pushes the tennis ball.
Student lists evidence	• The basketball pushes/collides with the tennis ball when it bounces up or the tennis ball bounces off the basketball.
Student either states or uses a general science idea	• When two objects interact, each one exerts a force on the other that causes energy to be transferred. (i.e., the basketball pushes the tennis ball as it bounces up,

	transferring energy from the basketball to the tennis ball.) [*links force and energy transfer*]
Student uses a crosscutting concept	• The transfer of energy can be tracked through a system (e.g., from the basketball to the tennis ball). [*energy can be tracked*] Note: The student must explicitly state where the energy is coming from and going to.
Student uses reasoning to link evidence and science ideas to support their claim	• The tennis ball bounces higher during the stacked bounce because it has more energy. The tennis ball has more energy because the basketball pushed it upwards transferring energy to the tennis ball. • The basketball bounces lower during the stacked bounce because it has less energy. The basketball has less energy because it pushes the tennis ball transferring energy to the tennis ball. Note: Student's response must include energy to receive the reasoning point. Students do not need to use both the science idea and evidence to get the reason point. They can provide a "rule-based" explanation or an "evidence-based" explanation. But they must one or the other to make it different than the claim.

Sample Student Responses

Student response	Scoring description
"The tennis ball bounced higher when it was stacked because the basketball could have had a larger impact on the ground. The same with the basketball but opposite."	Score = 0 This response does not use ideas about energy transfer to explain the phenomenon.
"because it was bouncing off of the basketball and because the basketball is more dense the tennisball does higher."	Score = 1 This response includes a claim but does not include an explanation using ideas about energy transfer.

“The kinetic energy transfers from the basketball to the tennis ball, so the tennis ball will bounce much higher than it will on its own.”	Score = 2 This response makes a claim and crosscutting concepts about tracking energy, but it does not use reasoning with science ideas.
“The basketball transfers energy over to the tennis ball, so the tennis ball bounces higher while the basketball bounces lower because it lost energy.”	Score = 3 This response makes a claim and uses reasoning with crosscutting concepts about tracking energy through a system, but it does not include evidence and science ideas linking forces and energy transfer.
“I think the tennis ball bounces higher because the basketball gives it extra force/push and transfers its energy to the tennis ball.”	Score = 4 This response includes the claim, evidence, science ideas, and crosscutting concept but the reasoning about the heights of both balls is not present.
“The tennis ball bounces higher in the instance where it is dropped on top of a basketball because the basketball hits the bottom of the tennis ball and hits it up. Because of this contact though, the bouncing height of the basketball is interfered with and its path is obstructed, therefore making it bounce lower than it would if it didn't hit the tennis ball. The energy is transferred from the basketball to the tennis ball when it is hit, thus the tennis ball receives more energy, making it bounce higher, and the basketball loses energy because it is transferred to the tennis ball.”	Score = 5 This response is a well-reasoned explanation that includes all the elements in the rubric.

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