ASPECt
Assessing Students' Progress on the Energy Concept

Pool Task: AP09-5 (MC) & AP35-6 (CR)

Elementary School – Energy Transfer by Forces

TASK OVERVIEW

In the context of a pool game, students watch videos of two trials and make observations to gather information about the relationship between how fast a white ball is rolling before a collision and how fast a green ball rolls after the collision. They summarize their observations in a table and then answer a series of multiple-choice questions that help them think about the differences between two trials and the role energy plays in the phenomenon. Next, they use the patterns they observed to suggest the strength of the hit in a third trial and predict how the energy of the white ball will change during the third trial. They construct (or select) an explanation using evidence from the previous questions and ideas about energy to support their prediction.

TARGETED DCIs, SEPs, AND CCCs

Disciplinary core ideas

- PS3.A-4.1: The faster a given object is moving, the more energy it possesses.
- 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

- SEP1-E.3: Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships.
- SEP3-E.3: Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation
- SEP6-E.2: Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation

Crosscutting concepts

- CCC5-E.3: Energy can be transferred in various ways and between objects.
- CCC1-E.2: Patterns of change can be used to make predictions.

Related Performance Expectations

- 4-PS3-1: Use evidence to construct an explanation relating the speed of an object to the energy of that object. [*Assessment Boundary*: Assessment does not include quantitative measures of changes in the speed of an object or on any precise or quantitative definition of energy.]
- 4-PS3-3: Ask questions and predict outcomes about the changes in energy that occur when objects collide. [*Clarification Statement*: Emphasis is on the change in the energy due to the change in speed, not on the forces, as objects interact.] [*Assessment Boundary*: Assessment does not include quantitative measurements of energy.]

TASK PERFORMANCE EXPECTATION

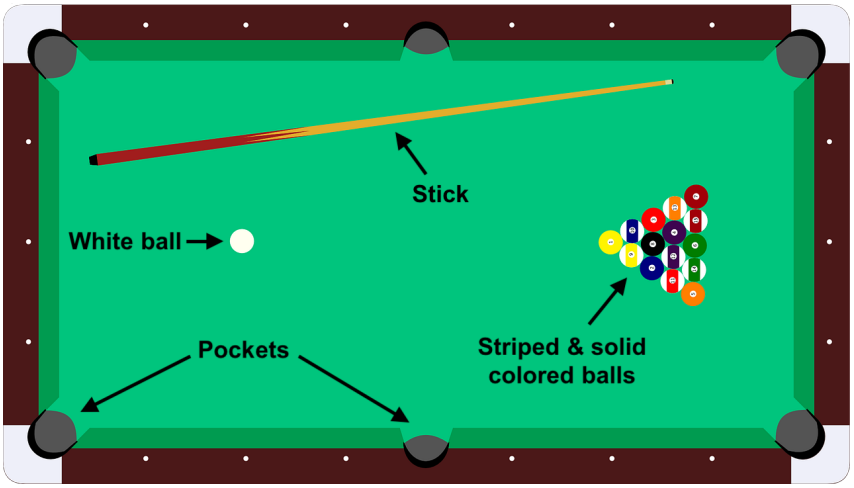
Make observations to produce data that can be used to predict which ball(s) will fall into the pocket when a white ball is hit. Use evidence (e.g., observations and patterns) to *construct an explanation* that supports the prediction and relates the speed of the white ball to the amount of energy the white ball can transfer when it hits the green ball.

LINK TO ONLINE VERSION

http://assess.bscs.org/i/test/587

Task

In the game of pool, players use a stick to hit a white ball into a colored ball so that the colored ball will fall into a pocket on the sides and corners of the pool table. Players lose their turn if the white ball goes into the pocket.



A new pool player wants to do an investigation that will help him learn how hard to hit the white ball into a colored ball so that only the colored ball goes into a pocket. He decides to hit the white ball into the solid green ball a couple of times and make observations. He made a video of each time he hit the ball. Watch the videos and then complete the data table below.

Try 1
https://assess.bscs.org/items/media/uploads/image/ASPECt_3D/Neither_green_nor_cue_ball.mp4

Try 2
https://assess.bscs.org/items/media/uploads/image/ASPECt_3D/Both_green_and_cue_balls.mp4

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1. Summarize your observations by completing the data table below.

Try	Strength of hit		Speed of white ball before hitting green ball	Speed of green ball after being hit		Did the green ball fall into the pocket?	Did the white ball fall into the pocket?		Change in speed of white ball after hitting green ball
1	Soft		Slow/Fast	Slow/Fast		Yes/No	Yes/No		Increases/ Decreases/ Stays the same
2	Hard		Slow/Fast	Slow/Fast		Yes/No	Yes/No		Increases/ Decreases/ Stays the same

2. How does the speed of the green ball in Try 1 compare to the speed of the green ball in Try 2?

   A. The green ball rolls faster in Try 1 than it did in Try 2.

   B. The green ball rolls slower in Try 1 than it did in Try 2.

   C. The green ball's speed was the same in both tries.

3. What pattern do you see in the change in the speed of the white ball after it hits the green ball?

   A. The white ball's speed decreases after it hits the green ball in both tries.

   B. The white ball's speed increases after it hits the green ball in both tries.

   C. There is no pattern in the change in speed of the white ball.

4. Now that the player has made some observations, he wants to use what he knows about energy to think about what he has seen. How does the amount of energy the green ball has while rolling in Try 1 compare to the amount of energy it has while rolling in Try 2?

   A. The green ball has more energy while rolling in Try 1 than in Try 2.

   B. The green ball has less energy while rolling in Try 1 than in Try 2.

   C. The green ball has the same amount of energy while rolling in Try 1 and Try 2.

5a. Where did the energy the green ball has while rolling come from?

A. The energy the green ball has while rolling came from inside the green ball.

B. The energy the green ball has while rolling was made when the white ball hit the green ball. The energy did not exist before that.

C. When the white ball hit the green ball, energy moved from the white ball to the green ball.

D. When the white ball hit the green ball, the white ball used a force to push the green ball. That force turned into energy that was given to the green ball.

5b. What evidence do you have to support your answer to where the green's ball energy came from?

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6. The player wants to do a third try to see if he can get just the green ball to fall into the pocket and not the white ball. Using the patterns he observed during Tries 1 and 2, how hard should he hit the white ball in Try 3?

A. He should hit the white ball softer than Try 1.

B. He should hit the white ball the same as in Try 1.

C. He should hit the white ball harder than Try 1 but not as hard as Try 2.

D. He should hit the white ball the same as in Try 2.

E. He should hit the white ball harder than Try 2.

----------Multiple-choice Version of #7----------

7. How much energy will the white ball have after hitting the green ball in Try 3, and why? Use the patterns in your table and ideas about energy to explain your prediction.

A. The white ball will have more energy after hitting the green ball because as an object slows down it stores more energy and I saw the white ball slow down.

B. The white ball will have less energy after hitting the green ball because energy was transferred from the white ball to the green ball. I know this because the white ball slows down and the green ball speeds up.

C. The white ball will have less energy after hitting the green ball because energy was destroyed. I know this because a sound was heard.

D. The white ball will have the same amount of energy after hitting the green ball because the amount of energy an object has cannot change.

----------Constructed-response Version of #7----------

7a. How much energy will the white ball have after hitting the green ball in Try 3?

A. The white ball will have less energy after hitting the green ball than before hitting the green ball.

B. The white ball will have more energy after hitting the green ball than before hitting the green ball.

C. The white ball will have the same amount of energy before and after hitting the green ball.

7b. Use the patterns in your table and ideas about energy to explain the prediction you made about the amount of energy the white ball will have after hitting the green ball in Try 3.

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

QUESTION 1

Summarize your observations by completing the data table below.

Try	Strength of hit	Speed of white ball before the collision	Speed of green ball after collision	Did the green ball fall into the pocket?	Did the white ball fall into the pocket?		Change in speed of white ball after collision
1	Soft	Slow/Fast	Slow/Fast	Yes/No	Yes/No		Increases/Decreases/ Stays the same

2	Hard	Slow/Fast	Slow/Fast	Yes/No	Yes/No		Increases/Decreases/ Stays the same

LEARNING GOAL

Learning Performance

- Make and record observations about the white ball and green ball during each trial that will serve as evidence for how hard the player will need to hit the white ball on the third trial so that only the green ball goes into a pocket and not the white ball.

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

SCORING RUBRIC

Elements of a Correct Response

Categories	Elements
Student makes the correct observations about the speeds of the white ball before the collision and the green ball after the collision	• Try 1: Slow, Slow AND • Try 2: Fast, Fast
Students makes the correct observations about which balls fall into the pocket	• Try 1: No, No AND • Try 2: Yes, Yes
Student makes the correct observations about the change in the speed of the white ball after the collision	• Try 1: Decreases AND • Try 2: Decreases

QUESTION 2

How does the speed of the green ball in Try 1 compare to the speed of the green ball in Try 2?

A. The green ball rolls faster in Try 1 than it did in Try 2.

B. The green ball rolls slower in Try 1 than it did in Try 2.

C. The green ball's speed was the same in both tries.

LEARNING GOAL

Learning Performance

- Select the correct pattern in the data about the green ball's speed.

Targeted DCIs, SEP, and CCC

- CCC1-E.2: Patterns of change can be used to make predictions.

SCORING RUBRIC

Elements of a Correct Response

Categories	Elements
Student selects the correct pattern	B. The green ball rolls slower in Try 1 than it did in Try 2.

QUESTION 3

What pattern do you see in the change in the speed of the white ball after it hits the green ball?

A. The white ball's speed decreases after it hits the green ball in both tries.

B. The white ball's speed increases after it hits the green ball in both tries.

C. There is no pattern in the change in speed of the white ball.

LEARNING GOAL

Learning Performance

- Select the correct pattern in the data about the white ball's speed.

Targeted DCIs, SEP, and CCC

- CCC1-E.2: Patterns of change can be used to make predictions.

SCORING RUBRIC

Elements of a Correct Response

Categories	Elements
Student selects the correct pattern	A. The white ball's speed decreases after it hits the green ball in both tries.

QUESTION 4

Now that the player has made some observations, he wants to use what he knows about energy to think about what he has seen. How does the amount of energy the green ball has while rolling in Try 1 compare to the amount of energy it has while rolling in Try 2?

A. The green ball has more energy while rolling in Try 1 than in Try 2.

B. The green ball has less energy while rolling in Try 1 than in Try 2.

C. The green ball has the same amount of energy while rolling in Try 1 and Try 2.

LEARNING GOAL

Learning Performance

- Identify that the green ball has less energy while rolling slower in Try 1.

Targeted DCIs, SEP, and CCC

- PS3.A-4.1: The faster a given object is moving, the more energy it possesses.

SCORING RUBRIC

Elements of a Correct Response

Categories	Elements
Student selects the correct answer	B. The green ball has less energy while rolling in Try 1 than in Try 2.

QUESTION 5

Where did the energy the green ball has while rolling come from?

A. The energy the green ball has while rolling came from inside the green ball.

B. The energy the green ball has while rolling was made when the white ball hit the green ball. The energy did not exist before that.

C. When the white ball hit the green ball, energy moved from the white ball to the green ball.

D. When the white ball hit the green ball, the white ball used a force to push the green ball. That force turned into energy that was given to the green ball.

What evidence do you have to support your answer to where the green ball's energy came from?

LEARNING GOAL

Learning Performance

- Select the correct claim for where the energy the green ball has while rolling came from, identify evidence that support the claim, and use reasoning to describe how this evidence supports the claim using ideas about energy.

Targeted DCIs, SEP, and CCC

- PS3.A-4.1: The faster a given object is moving, the more energy it possesses.
- 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.

- CCC5-E.3: Energy can be transferred in various ways and between objects.
- SEP6-E.2: Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation

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SCORING RUBRIC

Ideal Response

The evidence that supports my answer is that after the collision, the white ball slowed down, and the green ball sped up.

Elements of a Correct Response

Categories	Elements
Student selects the correct claim	C. When the white ball hit the green ball, energy moved from the white ball to the green ball.
Student lists evidence	• After the collision, the white ball slows down. • After the collision, the green ball speeds up or started to move. • The white ball hits/pushes the green ball. (Note: mentioning the hit or collision is not enough to receive this point. The hit/push should be written in such a way that it is being cited as evidence. For example, "When the white ball hit the green ball it transferred energy") <u>Note</u>: Students who selected the wrong answer to Question #5a should not earn points for Question #5b. Even if they provide evidence listed above, they are saying that it is evidence for the wrong claim. Unless it is clear from the response that the student miskeyed Question #5a.

Sample Student Responses

Student response	Scoring description
Student selects D and writes "it came from the force of the white ball hitting it."	Score = 0 The student selects the claim that the force is turned into energy instead of the claim that the energy is transferred.
Student selects C and writes "The green ball's energy changed when the white ball hit it."	Score = 1 The student selects the correct claim but does not cite evidence to support the claim.
Student selects C and writes "When the white ball hit the green ball the white ball slowed down while the green ball sped up."	Score = 2 The student selects the correct claim and provides evidence about the change in speed observed to support the claim.

QUESTION 6

The player wants to do a third try to see if he can get just the green ball to fall into the pocket and not the white ball. Using the patterns he observed during Tries 1 and 2, how hard should he hit the white ball in Try 3?

A. He should hit the white ball softer than Try 1.

B. He should hit the white ball the same as in Try 1.

C. He should hit the white ball harder than Try 1 but not as hard as Try 2.

D. He should hit the white ball the same as in Try 2.

E. He should hit the white ball harder than Try 2.

LEARNING GOAL

Learning Performance

- Based on the patterns observed in the videos, select the correct prediction for how hard the player should hit the white ball so that only the green ball goes into the pocket.

Targeted DCIs, SEP, and CCC

- CCC1-E.2: Patterns of change can be used to make predictions.

SCORING RUBRIC

Elements of a Correct Response

Categories	Elements
Student selects the correct explanation	C. He should hit the white ball harder than Try 1 but not as hard as Try 2.

QUESTION 7

How much energy will the white ball have after hitting the green ball in Try 3?

A. The white ball will have less energy after hitting the green ball than before hitting the green ball.

B. The white ball will have more energy after hitting the green ball than before hitting the green ball.

C. The white ball will have the same amount of energy before and after hitting the green ball.

Use the patterns in your table and ideas about energy to explain the prediction you made about the amount of energy the white ball will have after hitting the green ball in Try 3.

LEARNING GOAL

Learning Performance

- Select the correct prediction for the change in the amount of energy the white ball will have after the collision in Try 3 and write (CR) or select (MC) an explanation for that prediction using the patterns observed and ideas about energy.

Targeted DCIs, SEP, and CCC

- PS3.A-4.1: The faster a given object is moving, the more energy it possesses.
- 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.
- CCC1-E.2: Patterns of change can be used to make predictions.
- SEP1-E.3: Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships.
- SEP6-E.2: Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation

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SCORING RUBRIC

Ideal Response

I think the white ball will have less energy after the collision because whenever the white ball hit the green ball (i.e., tries 1 and 2), the white ball slowed down. Slower speed means less energy. The white ball transferred energy to the green ball when the white ball hit the green ball.

Elements of a Correct Response

Categories	Elements
Student selects the correct prediction	A. The white ball will have less energy after hitting the green ball than before hitting the green ball.
Student lists evidence	In both tries, the speed of the white ball decreases after the collision with the green ball.

Student either states or uses a general science idea	• The faster an object is moving, the more energy it has or the slower an object is moving, the less energy it has (i.e., the faster the ball rolls the more energy it has). [*links speed and energy*] • When objects collide, energy can be transferred from one object to another [resulting in a change in motion] (i.e., the white ball transfers energy to the green ball when they collide). [*links collisions and energy transfer*]
Student links the evidence to their claim using reasoning based on valid science ideas	• The white ball will have less energy after the collision **because** in both tries the speed of the cue ball decreased after the collision **and** a decrease in speed indicates a decrease in energy.
OR	
Student selects the correct response to the multiple-choice version	B. The white ball will have less energy after hitting the green ball because energy was transferred from the white ball to the green ball. I know this because the white ball slows down and the green ball speeds up.

Sample Student Responses

Student response	Scoring description
Student selects B and writes "the gravity can make the ball go faster"	Score = 0 The student does not select the correct prediction.
Student selects A and writes "Try 1 and try 2 after the white ball hit the green ball it had less energy so I think in try 3 the white ball will have less energy after hitting the green ball."	Score = 1 The student selects the correct prediction but does not cite evidence or use reasoning with science ideas.
Student selects A and writes "well when the white ball hits the green ball it loses some energy so it goes slower."	Score = 2 The student selects the correct prediction and uses the science idea about speed and energy, but it does not reason with evidence.

Student selects A and writes "In both try 1 and 2 the white ball immediately slowed down after hitting the green ball."	Score = 3 The student selects the correct prediction, cites evidence, and uses the science idea about speed and energy, but it does not use reasoning to link the evidence and science ideas to the prediction.
Student selects A and writes "in both simulations, even when the ball was hit very hard, the white ball's speed decreased after hitting the green ball. when it hits the green ball it transfers energy so it's speed can't stay the same, and it can't absorb energy if it's giving it away."	Score = 4 The student selects the correct prediction and writes a well-reasoned explanation.

The research reported here was supported by the Institute of Education Sciences, U.S. Department of Education, through Grant R305A180512 to BSCS Science Learning. The opinions expressed are those of the authors and do not represent views of the Institute or the U.S. Department of Education.