ASPECt
Assessing Students' Progress on the Energy Concept

Crash Tests: AP11-6 (MC) & AP51-4 (CR)

Elementary School – Energy Transfer by Forces

TASK OVERVIEW

Students are presented with the scenario of designing a new car, and they read about an engineer that is evaluating the safety features of the car by doing crash tests. Students begin by analyzing data and using the findings to determine what the engineer can conclude about relationships between the mass and speed of the car and the amount of damage done. Finally, the students are asked to provide evidence for the claim that the car has less energy after the crash because energy was transferred somewhere else.

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

- SEP4-E.2: Analyze and interpret data to make sense of phenomena using logical reasoning.

- SEP6-E.2: Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation
- SEP3-E.1: Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.

Crosscutting concepts

- CCC1-E.3: Patterns can be used as evidence to support an explanation.
- CCC5-E.3: Energy can be transferred in various ways and between objects.

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

Analyze and interpret data to identify patterns that can be used as evidence to support conclusions about the relationships between the mass and speed of a car and the amount of damage done during a collision. *Make a claim* about the energy change in the car after the collision. *Identify evidence that supports the claim* and indicates that energy was transferred somewhere else.

LINK TO ONLINE VERSION

http://assess.bscs.org/i/test/588

Task

An engineer is designing a new car. Part of her job is to make sure that the safety features of the car protect the driver. She tests the safety features by crashing a remote-controlled car into a wall. An adult-sized dummy sits in the driver's seat of the car. Sensors in the dummy and car measure the amount of damage done to the dummy and car.

During the crash, the car hits the wall producing a loud sound. The car stops moving after the crash.

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The engineer does the crash test three times using three identical cars. For each test, the engineer crashes the car at a different speed. She records the car's mass and speed and the amount of damage in the table below.

Crash Test	Mass of car (kilograms)	Speed (miles per hour)	Amount of damage
#1	1000	20	Small
#2	1000	40	Medium
#3	1000	60	Large

1. Based on the data, what can the engineer conclude about the relationship between the speed of the car and the amount of damage done to the car and the dummy?

   A. The faster the car is moving, the larger the amount of damage.

   B. The faster the car is moving, the smaller the amount of damage.

   C. The speed of the car is not related to the amount of damage.

D. She cannot conclude anything about the relationship between the speed of the car and the amount of damage.

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2. Based on the data, what can the engineer conclude about the relationship between the mass of the car and the amount of damage done to the car and the dummy?

   A. The heavier the car is, the larger the amount of damage.

   B. The heavier the car is, the smaller the amount of damage.

   C. She cannot conclude anything about the relationship between the mass and the amount of damage because the mass does not vary in the data she collected.

3a. Does the car have more, less, or the same amount of energy after crashing than when moving toward the wall?

   A. The car has more energy after crashing than when moving toward the wall.

   B. The car has less energy after crashing than when moving toward the wall.

   C. The car has the same amount of energy after crashing and when moving toward the wall.

----------Constructed-response Version of #3b----------

3b. What evidence do you have to support your answer about the energy the car has after crashing? List at least two pieces of evidence.

----------Multiple-choice Version of #3b----------

3b. What evidence do you have to support your answer about the energy the car has after crashing?

   A. The fact that the car stopped moving is the only evidence to support my answer.

   B. The fact that sound was produced during the crash is the only evidence to support my answer.

   C. The fact that the car stopped, and the fact that sound was produced are both evidence to support my answer.

   D. I have no evidence to support whether the car has more, less, or the same amount of energy after the crash.

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

QUESTION 1

Based on the data, what can the engineer conclude about the relationship between the speed of the car and the amount of damage done to the car and the dummy?

A. The faster the car is moving, the larger the amount of damage.

B. The faster the car is moving, the smaller the amount of damage.

C. The speed of the car is not related to the amount of damage.

D. She cannot conclude anything about the relationship between the speed of the car and the amount of damage.

LEARNING GOAL

Learning Performance

- Analyze the data in the table and use patterns in the data to select the correct conclusion about the relationship between the speed of the car and the amount of damage.

Targeted DCIs, SEP, and CCC

- SEP4-E.2: Analyze and interpret data to make sense of phenomena using logical reasoning.

SCORING RUBRIC

Elements of a Correct Response

Categories	Elements
Student selects the correct conclusion	A. The faster the car is moving, the larger the amount of damage.

QUESTION 2

Based on the data, what can the engineer conclude about the relationship between the mass of the car and the amount of damage done to the car and the dummy?

A. The heavier the car is, the larger the amount of damage.

B. The heavier the car is, the smaller the amount of damage.

C. She cannot conclude anything about the relationship between the mass and the amount of damage because the mass does not vary in the data she collected.

LEARNING GOAL

Learning Performance

- Analyze the data in the table and use patterns in the data to determine that no conclusion about the relationship between the mass of the car and the amount of damage can be drawn if the mass does not vary in the investigations.

Targeted DCIs, SEP, and CCC

- SEP3-E.1: Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.
- CCC1-E.3: Patterns can be used as evidence to support an explanation.

SCORING RUBRIC

Elements of a Correct Response

Categories	Elements
Student selects the correct conclusion	C. She cannot conclude anything about the relationship between the mass and the amount of damage because the mass does not vary in the data she collected.

QUESTION 3a & 3b

Does the car have more, less, or the same amount of energy after crashing than when moving toward the wall?

A. The car has more energy after crashing than when moving toward the wall.

B. The car has less energy after crashing than when moving toward the wall.

C. The car has the same amount of energy after crashing than when moving toward the wall.

What evidence do you have to support your answer about the energy the car has after crashing? List at least two pieces of evidence.

LEARNING GOAL

Learning Performance

- Use patterns in the data and ideas about energy transfer to make a claim about the change in energy of the car. Cite (CR) or identify (MC) evidence that supports the claim about the energy change in the car.

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

SCORING RUBRIC

Ideal Response

After the car hits the wall, it is no longer moving. Therefore, it has less energy than it did before it hit the wall. The sound that is heard during the crash, the damage done during the crash, and the increase in motion of the dummy are evidence that some of the car's energy was transferred somewhere else.

Elements of a Correct Response

Categories	Elements
Student selects the correct claim	B. The car has less energy after crashing than when moving toward the wall.
Student lists at least **two** pieces of evidence	• The car stopped moving or slowed down. • A sound was heard during the crash. • There was damage that occurs during the collision. Note: Students who selected the wrong answer to Question #3a should not earn points for Question #3b. Even if they provide evidence listed above, they are saying that it is evidence for the wrong claim.
OR	
Student selects the correct claim	B. The car has less energy after crashing than when moving toward the wall.
Student selects a partially correct response to the multiple-choice version of 3b	A. The fact that the car stopped moving is the only evidence to support my answer. B. The fact that sound was produced during the crash is the only evidence to support my answer. Note: Student receives one point for selecting either of these options.
Student selects the correct response to the multiple-choice version of 3b	C. The fact that the car stopped, and the fact that sound was produced are both evidence to support my answer. Note: Student receives two points for selecting C.

Sample Student Responses

Student response	Scoring description
Student selects A and writes "The car wouldn't lose energy after crashing into the wall. When you stop moving you don't lose or gain energy. Also, a wall doesn't obtain that energy that the car loses (if the car lost any energy) so that energy would just float away, which it doesn't"	Score = 0 The student does not select the correct claim.
Student selects B and writes "The faster the car is moving the more damage it has, cause when she made one go 20, 40, and 60, miles per hour. There damage 1-3 is small, medium, and large."	Score = 1 The student selects the correct claim but does not cite the correct evidence to support the claim.
Student selects B and writes "The car has less energy because it has come to a complete stop after hitting the wall."	Score = 2 The student selects the correct claim but cites only one piece of evidence about the change in speed of the car to support the claim.
Student selects B and writes "The car has less energy after it hits the wall. It stops after it hits the wall and doesn't move. The loud sound the car made after the crash shows the the car hit the wall with a lot of force, and release some energy."	Score = 3 The student selects the correct claim and cites two pieces of evidence to support it.

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