



ASPECT

Assessing Students' Progress on the Energy Concept

Spinning Fan: AP15-5 (MC) & AP55-5 (CR)

Middle School – Energy Transfer by Forces

TASK OVERVIEW

Students observe a demonstration of a fan that spins over a lit candle. They analyze the data from three investigations to identify evidence that can be used to explain what causes the fan to spin. Then they use the evidence and ideas about energy transfer to write an explanation for the phenomenon.

TARGETED DCIs, SEPs, AND CCCs

Disciplinary core ideas

- 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.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.

Crosscutting concepts

- CC1-M.3: Patterns can be used to identify cause and effect relationships.

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 and interpret data from investigations to identify patterns and use energy transfer ideas to *explain* the cause for the phenomenon of a fan spinning over a lit candle.

LINK TO ONLINE VERSION

<http://assess.bscs.org/i/test/591>

Task

A teacher shows her class a demonstration of a fan that spins over a lit candle. The students notice that the fan only spins while the candle is burning.



Watch the video to see the demonstration.

<http://test.p2061.org/items/media/uploads/image/ASPECT 3D/spinning fan-mute.mp4>

The students want to figure out whether the light from the candle, the air rising from the candle, or both of them are causing the fan to spin. They also want to know if energy plays a role. They conduct a series of investigations by placing a fan over different objects. The table below summarizes their findings.

Investigation #	Description	Was light observed?	Did air move toward the fan?	Did the fan start to spin?
1	The fan is placed over a burning candle.	Yes	Yes	Yes
2	The fan is placed over a hot plate that is turned on.	No	Yes	Yes
3	The fan is placed over an LED light bulb that is turned on.	Yes	No	No

1. Based on the observations in the table, which of the following explains what caused the fan to spin?
 - A. The fan spins because of the light.
 - B. The fan spins because air is moving toward the fan.
 - C. Both the light and the moving air cause the fan to spin.
 - D. Neither the light nor the moving air causes the fan to spin.
2. What patterns in the data helped you decide whether light caused the fan to spin?
3. What patterns in the data helped you decide whether moving air caused the fan to spin?

-----Multiple-choice Version of #4-----

4. Light, heat, and motion are all related to energy. Use ideas about light, heat, motion, and energy to explain why the fan spins during Investigations 1 and 2.
- A. When the candle was lit, light transferred energy to the fan, causing the fan to start spinning.
 - B. When the hot plate was turned on, heat moved upward, causing the fan to start spinning.
 - C. When the candle was lit and the hot plate was turned on, the air started moving upward and collided with the fan. This collision transferred energy that caused the fan to start spinning.
 - D. When the candle was lit and the hot plate was turned on, the potential energy of the fan was turned into kinetic energy. This energy transformation caused the fan to start spinning.

-----Constructed-response Version of #4-----

4. One way to relate light, heat, and motion is through energy and forces. Use ideas about energy and forces to explain why the fan moves during Investigations 1 and 2. Be sure to include evidence from the investigations in your explanation.

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

QUESTION 1

Based on the observations in the table, which of the following explains what caused the fan to spin?

- A. The fan spins because it absorbed light.
- B. The fan spins because air is moving toward the fan.
- C. Both the light and the moving air cause the fan to spin.
- D. Neither the light nor the moving air causes the fan to spin.

LEARNING GOAL

Learning Performance

- Based on the data from the investigations, select the correct explanation for what caused the fan to spin.

Targeted DCIs, SEP, and CCC

- SEP4-M.4: Analyze and interpret data to provide evidence for phenomena.
- CC1-M.3: Patterns can be used to identify cause and effect relationships.

SCORING RUBRIC

Elements of a Correct Response

Categories	Elements
Student selects the correct explanation	B. The fan spins because air is moving toward the fan.

QUESTION 2

What patterns in the data helped you decided whether light caused the fan to spin?

LEARNING GOAL

Learning Performance

- Describe the patterns in the data that provide evidence that can be used to identify what caused the fan to spin.

Targeted DCIs, SEP, and CCC

- SEP4-M.4: Analyze and interpret data to provide evidence for phenomena.
- CC1-M.3: Patterns can be used to identify cause and effect relationships.

SCORING RUBRIC

Ideal Response

When the fan was placed over the hot plate, it started to spin even though there was no light. When the fan was placed over the LED light bulb, there was light, but the fan did not spin.

Elements of a Correct Response

Categories	Elements
Student described relevant patterns	<ul style="list-style-type: none">• In investigation 2, there was no light, but the fan started to spin.• In investigation 3, there was light, and the fan did not spin. <p><u>Note:</u> Must reference more than one investigation [either explicitly or implicitly (e.g., using “only”)]. They should not receive credit for just writing that the air moved or that “Light did not cause the fan to spin.” They can reference an investigation by describing it (e.g., when there is an LED the fan does not spin).</p>

Sample Student Responses

Student response	Scoring description
“It began spinning once the fire was lit.”	Score = 0 The response does not describe the relevant patterns.
“when the fan was over a led light bulb it gave of light but the fan didn't spin”	Score = 1 The response describes the pattern from investigation 3 but not the pattern from investigation 2.
“Because in an experiment where light was used the fan didn't spin and in another experiment where light was not used the fan spun.”	Score = 2 The response describes the relevant patterns from both investigations.

QUESTION 3

What patterns in the data helped you decide whether moving air caused the fan to spin?

LEARNING GOAL

Learning Performance

- Describe the patterns in the data that provide evidence that can be used to identify what caused the fan to spin.

Targeted DCIs, SEP, and CCC

- SEP4-M.4: Analyze and interpret data to provide evidence for phenomena.
- CC1-M.3: Patterns can be used to identify cause and effect relationships.

SCORING RUBRIC

Ideal Response

When the fan was placed over the hot plate and the candle, it started to spin. In both cases, the surrounding air moved up toward the fan. When the fan was placed over the LED light bulb, it did not spin, and the surrounding air did not move up toward the fan.

Elements of a Correct Response

Categories	Elements
Student described relevant patterns	<ul style="list-style-type: none">• In investigations 1 and 2, air moved up toward the fan, and the fan started to spin.• In investigation 3, no air moved up toward the fan, and the fan did not spin. <p><u>Note:</u> Must reference more than one investigation [either explicitly or implicitly (e.g., using “only”). They should not receive credit for just writing that the air moved or that “The air that comes from the lit candle is moved toward the fan and it causes the fan to spin.”</p> <p><u>Note:</u> No credit is received for only mentioning heat.</p>

Sample Student Responses

Student response	Scoring description
"The fan wasn't spinning before the candle was lit so the heat was what made the fan spin."	Score = 0 The response does not describe the relevant patterns.
"Moving air caused the fan to spin when the fan is placed over a hot plate that is turning on a low setting and the fan is placed over a burning candle."	Score = 1 The response describes the pattern from investigations 1 and 2 but not from investigation 3.
"Both investigation 1 and 2 all use air and they both spin while investigation 3 uses only light and it doesn't spin."	Score = 2 The response describes the relevant patterns from all the investigations.

QUESTION 4

One way to relate light, heat, and motion is through energy and forces. Use ideas about energy and forces to explain why the fan moves during Investigations 1 and 2. Be sure to include evidence from the investigations in your explanation.

LEARNING GOAL

Learning Performance

- Write an explanation for why the fan moves during Investigations 1 and 2 using evidence from the investigations and ideas about energy and forces.

Targeted DCIs, SEP, and CCC

- 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.
- 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.
- CC1-M.3: Patterns can be used to identify cause and effect relationships.

SCORING RUBRIC

Ideal Response

The air rising and hitting the fan causes it to spin. The fan only spins during the investigations with the hot plate and candle. During these two investigations, the surrounding air moved from the plate or candle up toward the fan. When the air reached the fan, energy was transferred from the air to the fan as the air exerted a force on the fan. This transfer of energy caused the fan to spin.

Elements of a Correct Response

Categories	Elements
Student makes a claim that answers the question	<ul style="list-style-type: none"> • The fan spins in investigations 1 and 2 because <ul style="list-style-type: none"> ○ the rising air pushes/hits/exerts a force on the fan. ○ the air transferred energy to the fan. ○ the fan gets energy from the air. ○ convection currents in the air.
Student lists evidence	<ul style="list-style-type: none"> • The fan <i>only</i> spins when air is moving upward or the fan <i>only</i> spins in investigations 1 and 2.
Student either states or uses a general science idea	<ul style="list-style-type: none"> • When two objects collide, energy is transferred from one to another resulting in a change in motion. (i.e., the moving air exerted a force on (hit or collided with) the fan that transferred energy to the fan causing it to start spinning). [links force and energy transfer] <p><u>Note:</u> It may be useful to keep track of students who use term "force" vs. "hit" or "collide." It's not a requirement but it is what differentiates the middle school DCI and elementary school DCI.</p>
Student uses reasoning to link evidence and science ideas to the claim	<ul style="list-style-type: none"> • There is air rising toward the fan. This air exerts a force on the fan in investigations 1 and 2 which transfers energy and causes the fan to start spinning.
OR	
Student selects the correct response to the	C. When the candle was lit and the hot plate was turned on, the air was heated and started moving upward. As the air moved

multiple-choice version	upward, it collided with the fan. Energy was transferred during the collision, causing the fan to start spinning.
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Sample Student Responses

Student response	Scoring description
<p>"the heat rises up through the air, and the fan moves when air passes through it, so the hot air coming form the candle and the plate was moving the fan."</p>	<p>Score = 0</p> <p>The response does not include any elements from the rubric. It explains the phenomenon using the idea that "heat rises."</p>
<p>"Heat or hot air rises. Hot air has molecules that are moving way faster, those molecules are bouncing around and have a higher probability of hitting the fan causing it to turn. Like a stirling engine"</p>	<p>Score = 1</p> <p>The response includes a claim that the fan spins because the molecules of the air hit it, but it doesn't use energy ideas to explain the phenomenon.</p>
<p>"The candle and the hot plate transfer energy to the air. The hot air rises towards towards the fan and causes it to move.</p> <p>The LED releases a very low amount of heat into the air, which means that the air didn't rise, so the fan never moved."</p>	<p>Score = 2</p> <p>The response makes a correct claim and supports it with evidence from the investigations, but it does not reason with science ideas about transferring energy by forces to link the claim and evidence.</p>
<p>"The fan moves when there is air rising towards it, which is a result of the air becoming heated. The heat increases the energy in the air and excites the movement of the atoms, so they rise upwards, causing motion in the fan as they pass through. This is seen in the table, where the fan only spun when placed over sources of heat. Light is not always an indicator of heat, but it can produce similar energy: for example, sunlight being used in photosynthesis of plants, in which they produce carbohydrates. However, in this case, it was not the same: the LED light bulb didn't make the air rise."</p>	<p>Score = 3</p> <p>The response makes a claim and uses reasoning to link the claim and evidence but does not include science ideas about the air transferring energy by exerting a force on the fan.</p>

<p>“Cold air is denser than hot air, so when the hot air and cold air combine, the cold air sinks and pushes the warmer air up. In investigations 1 and 2, the heat from the candle and hot plate and causing the warm air to move up and push the fan, giving it the energy to move.”</p>	<p>Score = 4</p> <p>The response includes all the elements in the rubric.</p>
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