Transformation of Energy
Summative Assessment Rubrics

Question 1: Two mountain bike riders are at different locations on a section of the race course that contains a hill. The two riders have the same mass.

A. Which rider has more Gravitational Potential Energy (GPE)? Explain how you arrive at your answer.

This item measures the student's ability to relate Gravitational Potential Energy (GPE) with height.

Criteria for a complete response:

1. The student states that Rider A has the greater GPE.
2. The student explains that as height increases, so does the object's GPE—or a comparable explanation that communicates the direct relationship between GPE and height above the ground.

Code	Response
	Complete Response
10	Meets the criteria for a complete response.
19	Any other completely correct response.
	Incorrect Response
70	Student only states that Rider A has the most GPE.
71	Student states that Rider A has the most GPE but provides an inadequate explanation of how GPE and height are related.
76	Repeats the stem of the question.
79	Any other incorrect response.
	Non-Response
90	Crossed out/erased, illegible, or impossible to interpret.
99	Blank.

Question 1: Two mountain bike riders are at different locations on a section of the race course that contains a hill. The two riders have the same mass.

B. If both riders are moving at the same speed, how would their kinetic energies (KE) compare? Explain your answer.

This item measures the student's ability to relate mass and speed to kinetic energy (KE).

Criteria for a complete response:

1. The student states that both riders will have the same KE.
2. The student explains that KE depends upon mass and speed, so if the riders both have the same mass and the same speed, they must therefore have the same KE—or a comparable explanation that communicates the relationship between KE, mass, and speed.

Code	Response
	Complete Response
10	Meets the criteria for a complete response.
19	Any other completely correct response.
	Incorrect Response
70	Student only states that both riders have the same KE.
71	Student states that both riders have the same KE, but provides an inadequate explanation of how GPE and height are related.
72	Student states that Rider B will have the greater KE because the rider is moving downhill.
76	Repeats the stem of the question.
79	Any other incorrect response.
	Non-Response
90	Crossed out/erased, illegible, or impossible to interpret.
99	Blank.

Question 2: When the physically disabled or very small children participate in bowling, they often use a ramp so that they do not have to roll the ball down the bowling alley themselves. The person can rest the ball on top of the ramp and give it a gentle push so that it rolls down the ramp and onto the alley. The ramp equipment is illustrated above.

A. In the space below, list the forms of energy that are present in this version of the sport. Start with the energy of the ball when it is released from rest on top of the ramp. End with the ball hitting the pins and everything coming to rest.

This item measures the student's ability to identify the forms of energy in a real-life example.

Criteria for a complete response:

1. Response acknowledges all the following energy forms: gravitational potential energy (or GPE) of the ball, kinetic energy (KE) of the ball, KE of the pins (after the collision with the ball), sound energy (SE) as the ball strikes the pins and creates vibrations (mechanical waves/sound), and heat energy (HE).

Code	Response
	Complete Response
20	Meets the criteria for a complete response. Identifies GPE, KE, SE, and HE as the forms of energy.
29	Any other completely correct response.
	Partially Complete Response
10	Student identifies GPE, KE, and HE only.
19	Student identifies a combination of any other three out of the four forms of energy.
	Incorrect Response
70	Student only identifies GPE and KE.
71	Student only identifies KE and HE.
76	Repeats the stem of the question.
79	Any other combination of two out of the four forms of energy.
	Non-Response
90	Crossed out/erased, illegible, or impossible to interpret.
99	Blank.

Question 2: When the physically disabled or very small children participate in bowling, they often use a ramp so that they do not have to roll the ball down the bowling alley themselves. The person can rest the ball on top of the ramp and give it a gentle push so that it rolls down the ramp and onto the alley. The ramp equipment is illustrated above.

B. Use your response from Part A to draw an energy chain that describes where the energy was transferred and where it was transformed. Start with the energy of the ball when it is released from rest at the top of the ramp. End with the ball hitting the pins and everything coming to rest.

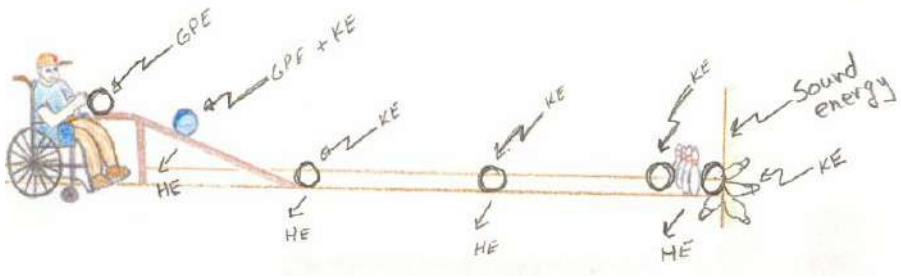
This item measures the student's ability to trace the flow of energy, using an energy chain, in a real-life example.

Criteria for a complete response:

1. Response includes all the following: Ball at top of ramp has GPE, as it rolls down the ramp the GPE is transformed into KE. When the ball reaches the bottom of the ramp and as it rolls down the alley, it only has KE (as it rolls along the floor some of its KE is transformed to heat energy). When the ball strikes the pins it transfers some of its KE to the pins. This KE is then transferred away from the pins and the ball when they collide with the lane and gutters. This KE is ultimately transformed into mechanical waves (sound energy) and heat energy.
2. Student response may be in a graphical form.

Code	Response
	Complete Response
20	Meets the criteria for a complete response. Identifies GPE, KE, SE, and HE as the forms of energy and includes the correct energy transfers and transformations in the energy chain.
29	Any other completely correct response.
	Partially Complete Response
10	Student identifies the four energy forms only.
11	Student identifies most of the forms of energy and most of the energy transfers and transformations.
19	Any other partially correct energy chain response.
	Incorrect Response
70	Student only identifies only some of the energy forms (no attempt to acknowledge energy transfer or transformation).
71	Student only illustrates the example—little to no detail about energy forms or the flow of energy in the example.
76	Repeats the stem of the question.
79	Any other combination of two out of the four forms of energy.
	Non-Response
90	Crossed out/erased, illegible, or impossible to interpret.
99	Blank.

Example Responses



Ramp ball has GPE → Rolling down ramp ball's GPE is transformed to kinetic energy

Bottom of ramp kinetic energy → Kinetic energy of the ball transferred to pins and a transformation of some kinetic energy to sound and heat energy → Pin's kinetic energy to floor/wall as heat energy

Question 3: A beaker of water rests on a hot plate that serves as a source of heat energy. The starting temperature of the water is 22°C. After 5 minutes, the temperature of the water is 55°C and after another 5 minutes the temperature increases to 80°C. The temperature of the room is 28°C.

A. Use the Particle Model to explain heat energy.

This item measures the student's ability to use the Particle Model to describe heat energy as the random kinetic energy (motion energy) of particles.

Criteria for a complete response:

1. The student explains that all matter consists of tiny particles too small to be seen.
2. The student communicates that "heat energy" is really the random, disorganized kinetic energy of these particles. This may be accomplished with the use of words and/or graphics. The student must relate random motion to heat energy to receive full credit for the response.

Code	Response
	Complete Response
10	Meets the criteria for a complete response.
19	Any other completely correct response.
	Incorrect Response
70	Student only states that matter consists of particles that are too small to be seen and are in motion.
71	Student states that that matter consists of particles that are too small to be seen and provides an inadequate or incomplete description of how the random motion of the particles is related to heat energy.
76	Repeats the stem of the question.
79	Any other incorrect response.
	Non-Response
90	Crossed out/erased, illegible, or impossible to interpret.
99	Blank.

Question 3: A beaker of water rests on a hot plate that serves as a source of heat energy. The starting temperature of the water is 22°C. After 5 minutes, the temperature of the water is 55°C and after another 5 minutes the temperature increases to 80°C. The temperature of the room is 28°C.

B. Use the Particle Model to describe the difference between the water particles when the temperature of the water is 80°C and when the temperature of the water is 55°C.

This item measures the student's ability to relate temperature to the particles' motion and kinetic energy.

Criteria for a complete response:

1. The student explains that the water particles are moving faster (they have more kinetic energy/motion energy) at 80°C than at 55°C.
2. The student must establish a link between the motion of the water particles and the temperature of the water.

Code	Response
	Complete Response
10	Meets the criteria for a complete response.
19	Any other completely correct response.
	Incorrect Response
70	Student only states that the 80°C water particles are moving faster.
71	Student only states that the 55°C water particles are moving slower.
76	Repeats the stem of the question.
79	Any other incorrect response.
	Non-Response
90	Crossed out/erased, illegible, or impossible to interpret.
99	Blank.

Question 3: A beaker of water rests on a hot plate that serves as a source of heat energy. The starting temperature of the water is 22°C. After 5 minutes, the temperature of the water is 55°C and after another 5 minutes the temperature increases to 80°C. The temperature of the room is 28°C.

C. Use your understanding of the Particle Model and of heat energy transfer by **conduction** and **convection** to describe how the energy from the hot plate reaches the water particles at the surface of the water. Be sure to include all heat energy transfers that take place between the hotplate and the top surface of the water.

This item measures the student's ability to communicate heat energy transfer by conduction and convection using the particle model.

Criteria for a complete response:

1. The student explains the heat energy transfer by conduction and convection in some combination of the following steps.
   a. The bottom of the hotplate is in contact with the bottom of the beaker. The particles that make up the hotplate surfaces transfer their energy, through collisions, to the particles that make up the bottom of the beaker.
   b. The particles that make up the bottom of the beaker then transfer their energy, through collisions, to the water particles at the bottom of the beaker.
   c. The water particles at the bottom of the beaker now have more motion energy and spread apart, due to collisions between the particles. Since the water particles are more spread out than in other areas of the beaker, this portion of the water is less dense than the other areas in the beaker. This difference in density creates a convective current where the more energetic, less dense water particles move from the bottom of the beaker to the top of the beaker.

Code	Response
	Complete Response
30	Meets the criteria for a complete response.
39	Any other completely correct response.
	Partially Correct Reponses
20	Student correctly explains two of the three steps.
29	Any other explanation of two of the three steps.
	Minimally Correct Response
10	Student correctly explains only one of the three steps.
19	Any other explanation of one of the three steps.
	Incorrect Response
70	Student vaguely discusses heat energy transfer, but makes no specific references to the steps in the process.
76	Repeats the stem of the question.
79	Any other incorrect response.
	Non-Response
90	Crossed out/erased, illegible, or impossible to interpret.
99	Blank.

Question 3: A beaker of water rests on a hot plate that serves as a source of heat energy. The starting temperature of the water is 22°C. After 5 minutes, the temperature of the water is 55°C and after another 5 minutes the temperature increases to 80°C. The temperature of the room is 28°C.

The hot plate is turned off.

D. Explain what will happen to the temperature of the water in the beaker after 5 hours? Use the Particle Model and your knowledge of heat energy transfer to justify your answer.

This item measures the student's ability to communicate heat energy transfer mechanisms that result in thermal equilibrium.

Criteria for a complete response:

Response indicates the following:

a. The hot plate is no longer providing a source of heat energy to the water, but the water particles will continue to collide with the glass of the beaker and the air.
b. These collisions will result in the transfer of the water particles' kinetic energy to the particles in the beaker and the air.
c. The loss of kinetic energy will result in a decrease in temperature of the water in the beaker.
d. This process will continue until the water is at room temperature (28°C).

Code	Response
	Complete Response
30	Meets the criteria for a complete response.
39	Any other completely correct response.
	Partially Correct Reponses
20	Student includes only three of the four criteria in response.
29	Any other explanation of three steps.
	Minimally Correct Response
10	Student includes only two of the four criteria in response.
19	Any other explanation of two steps.
	Incorrect Response
70	Student includes only one of the four criteria in response.
76	Repeats the stem of the question.
79	Any other incorrect response.
	Non-Response
90	Crossed out/erased, illegible, or impossible to interpret.
99	Blank.

Question 4: A band of outlaws in the Old West plans to rob the train that comes through Sagebrush Canyon. One of the cowboys keeps his ear to the train rail while the others attempt to block the track so that the train has to stop.

The cowboy knows that some of the train's energy moves through the rail in the form of mechanical waves. Use your knowledge of energy and the Particle Model to explain why the cowboy has decided to put his ear to the metal rail to hear the approaching train instead of just listening for it in the air.

This item measures the student's ability to describe energy transfer by mechanical waves through different media.

Criteria for a complete response:

1. Response describes that the particles are closer together and/or more closely connected to one another in a solid (the metal rail) than in a gas (the air).
2. Response explains that energy is transferred by way of organized vibrations of particles (called a mechanical wave) and that it is easier to transfer energy through a solid because the connections between particles are stronger.

Code	Response
	Complete Response
20	Meets the criteria for a complete response.
29	Any other completely correct response.
	Partially Complete Response
10	Student describes the difference between the air and the metal rail using the Particle Model only.
11	Student discusses energy transfer through the rail in terms of vibrations or mechanical waves using the Particle Model but does not contrast it to energy transfer through the air.
19	Any other partially correct energy chain response.
	Incorrect Response
70	Student only discusses the difference between air particles and the particles making up the metal rail.
71	Student responds that sound energy travels faster through solids and through gases but provides no explanation.
76	Repeats the stem of the question.
79	Any other combination of two out of the four forms of energy.
	Non-Response
90	Crossed out/erased, illegible, or impossible to interpret.
99	Blank.

Question 5: Sarah and her mother go to the beach during the summer. Sarah notices that the sand is very hot on a bright, sunny day. Her mother explains that the Sun heats the sand.

Describe how the Sun can heat the sand even though there is no heat energy coming from the Sun?

This item measures the student's ability to discuss energy transfer by electromagnetic waves and the energy transformation to heat energy that usually results at the end of this simple energy chain.

Criteria for a complete response:

1. The student explains that only electromagnetic (EM) waves come from the Sun.
2. The student explains that when the EM waves interact with the sand, the electromagnetic energy is transformed into heat energy.

   The student may also explain that there is nothing between the Sun and the Earth, so there are no particles for which conduction or convection to occur between. This additional information is desirable, but not necessary, for a complete response.

Code	Response
	Complete Response
10	Meets the criteria for a complete response.
19	Any other completely correct response.
	Incorrect Response
70	Student only states that the sunlight is transformed into heat energy.
71	Student states that heat energy does come from the Sun or attempts to describe infrared EM wave energy as "heat energy."
76	Repeats the stem of the question.
79	Any other incorrect response.
	Non-Response
90	Crossed out/erased, illegible, or impossible to interpret.
99	Blank.

Question 6: On a sunny, summer day, Bob mows the grass at his house. He wore a shirt but no sunscreen. When he takes off his shirt later, he notices that he is burned (red) in all of the areas that were not covered by the shirt.

Sunburn is caused by ultraviolet (UV) waves interacting with skin. Use your knowledge of how energy is transferred by waves to explain why Bob got sunburn only in the uncovered areas of his body.

This item measures the student's ability to discuss energy transfer by electromagnetic waves and selective absorption of waves.

Criteria for a complete response:

1. The student explains that only ultraviolet (UV) electromagnetic waves come from the Sun and interact with the person's skin.
2. The student explains that the person's skin absorbed the UV waves, causing the sunburn in the areas that were not protected by the person's shirt.
3. The student explains that the person's shirt prevented the UV waves from reaching the person's skin in the areas that were protected by the person's shirt. The response should either take the stance that the UV waves were reflected by the shirt or that they were absorbed by the shirt; in either case it prevented the UV waves from being transmitted through the shirt to the person's skin.

Code	Response
	Complete Response
30	Meets the criteria for a complete response.
39	Any other completely correct response.
	Partially Correct Reponses
20	Student includes only two of the three criteria in response.
29	Any other explanation of two of the three steps.
	Minimally Correct Response
10	Student includes only one of the three criteria in response.
19	Any other explanation of one of the three steps.
	Incorrect Response
70	Student discusses how waves transfer energy but does not address the question being asked.
71	Student discusses the sunburn in terms of heat energy transfer from the Sun.
76	Repeats the stem of the question.
79	Any other incorrect response.
	Non-Response
90	Crossed out/erased, illegible, or impossible to interpret.
99	Blank.

