Short Performance Assessment: **MS-PS3-2**

Grade Level: **Middle School**

Adapted from SNAP[1]

Title	**Changes in Energy on a Bicycle**		
Designed by	**Alastair, Matt and Greg: Hong Kong International School**	Course(s)	**Grade 6 Integrated NGSS**

Performance Expectation	**MS-PS3-2**: Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system. **Clarification Statement**: Emphasis is on relative amounts of potential energy, not on calculations of potential energy. Examples of objects within systems interacting at varying distances could include: the Earth and either a roller coaster cart at varying positions on a hill or objects at varying heights on shelves, changing the direction/orientation of a magnet, and a balloon with static electrical charge being brought closer to a classmate's hair. Examples of models could include representations, diagrams, pictures, and written descriptions of systems. **Assessment Boundary**: Assessment is limited to two objects and electric, magnetic, and gravitational interactions.
Science and Engineering Practice	**Developing and Using Models** • Develop a model to describe unobservable mechanisms.
Disciplinary Core Ideas	**PS3.A: Definitions of Energy** • A system of objects may also contain stored (potential) energy, depending on their relative positions. **PS3.C: Relationship Between Energy and Forces** • When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object.
Crosscutting Concept	**Systems and System Models** • Models can be used to represent systems and their interactions – such as inputs, processes, and outputs – and energy and matter flows within systems.
Student Performance	1. Components of the model 2. Relationships 3. Connections

[1] The Short Performance Assessment (SPA) and the Assessment Rubric adapted from the Stanford NGSS Assessment Project http://snapgse.stanford.edu/

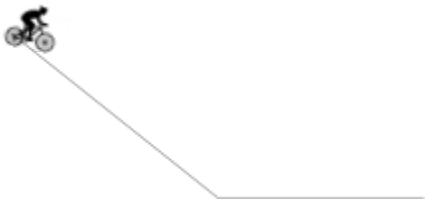
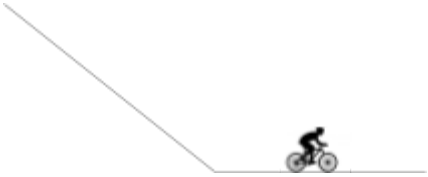
Name:_____ #:_____ Date:_____

Summative Assessment: Change in Energy (MS-PS3-2&5)

Paul exits his house, halfway up a large hill, and hops on his bike to ride down to a friend's house. As he approaches the bottom of the hill, Paul notices his shoelace is untied and he quickly applies the brakes to come to a loud, squealing stop. As he gets off his bike to tie his shoe, his arm brushes against the center of the bike wheel where the disc brake is. "Oww!" he exclaims, "It's hot!"

Part 1. Modeling the Situation

1. Use graphical representations to show how the type of energy experienced by the cyclist and the amount of each type of energy changes at each of the following points in his ride.

(A) Stopped at the starting point on the hill	(B) As he travels down the hill and first starts to apply the brakes	(C) At the bottom of the hill when he has stopped
		
Directions: Show the energy transfer (flow) that occurs in the system using pie charts or bar graphs that takes into account *how you show the total amount of energy in the system.*		

2. How would **increasing the mass** of the cyclist affect the **amount** of total energy in the system?

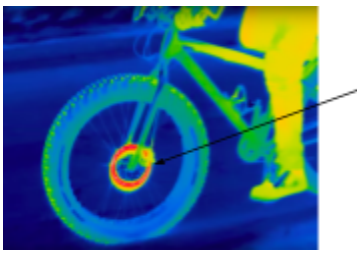
3. Identify which **force(s)** cause an increase or decrease to the speed of the cyclist?

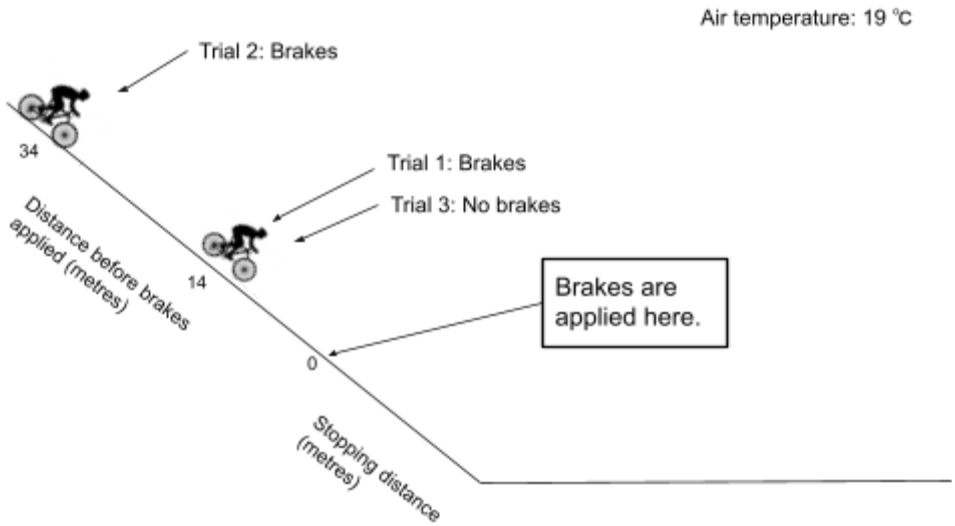
Type of Force (**Cause)**	**Effect** on Speed
	Speed of the cyclist increases.
	Speed of the cyclist decreases.

Part 2. Planning and Carrying Out an Investigation

Paul set up the following experiment to investigate further. He collected data for himself on the bike and his father, who is exactly double his mass. After each trial, he used a thermal imaging camera to determine the hottest parts of the bike.

- The video https://youtu.be/z2hfVV7odEw shows the investigation.
- The image shows a thermal image of his bike after applying his brakes.





Trial 1 (control).

- Paul starts from outside his house, halfway up the hill.
- He carefully measures the distance before he applies the brakes and the distance it took to stop once the brakes were applied.

Trial 2.

- Paul starts at a *higher* point on the hill.
- He applies the brakes at exactly the same point in his ride as in trial 1 and measures the distance it took to stop once the brakes were applied.

Trial 3.

- Paul repeats the original situation in trial 1 but without ever applying his brakes.
- He measures the distance it took him to coast to a stop without using his breaks.

Mass of Cyclist 1: 40kg (Paul)

Trials	Distance before brakes applied (meters)	Stopping distance (meters)	Temperature of the disc brakes **before each ride** in ºC	Temperature of the disc brakes **after stopping** in ºC	Maximum Speed (kilometers per hour)
1. Halfway up hill, with brakes	14m	2m	19ºC	37ºC	20 km/h
2. Higher point on the hill with brakes	34m	6m	19ºC	42ºC	25 km/h
3. Halfway up hill, without brakes	--	100m	19ºC	20ºC	20 km/h

Mass of Cyclist 2: 80kg (Paul's father)

Trials	Distance before brakes applied (meters)	Stopping distance (meters)	Temperature of the disc brakes **before each ride** in ºC	Temperature of the disc brakes **after stopping** in ºC	Maximum Speed (kilometers per hour)
1. Halfway up hill, with brakes	14m	5m	19ºC	39ºC	20 km/h
2. Higher point on the hill with brakes	34m	15m	19ºC	47ºC	25 km/h
3. Halfway up hill, without brakes	--	250m	19ºC	20ºC	20 km/h

4. Analyze the information in the video, pictures and data in the tables above and describe what is happening to **cause his disc brake to get so hot**.

What patterns do you see in the information (video, pictures and data)?	**Ranking based on usefulness to answer the question (Least, somewhat, most useful)**

Part 3. Constructing and Supporting a Claim

5. Use your knowledge of energy and the evidence above to answer Paul's question: "**What causes his disc brake to get so hot?"**

Claim:_____

_____

Select *at least* 2 pieces of evidence that support your claim. List them as bullet points below.

Evidence:

1.
2.
Optional:

Reasoning:

MS-PS3-2 Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.				
Criteria	Developing Towards Expectations	Approaches Expectation	**Meets Expectations**	Exceeding Expectations
Explains Phenomena: Does my model explain or predict the phenomenon?	Model includes major misconceptions and/ or is missing key parts of the system.	Model includes misconceptions or is missing some parts of the system. .	Model accurately explains what is happening by connecting: ❏ transformation of energy ❏ position of object ❏ forces acting on the object	All ME requirements met accurately. The model also connects: ❏ conservation conservation and flow of energy within the rollercoaster system and the boundary of the system is clearly defined.
Builds on Science Ideas: Does my model incorporate established scientific ideas and fit with evidence?	Model includes irrelevant information and/ or no supporting evidence.	Model includes inaccurate information or lacks supporting evidence.	Model accurately shows how as **height** changes: ❏ the amount of **Potential Energy** in the object changes ❏ energy is **transformed** into other forms of energy Model is supported by appropriate evidence.	All ME requirements met accurately. The model also shows how as **height** changes: ❏ the **types** of **energy** within the system change ❏ energy distribution throughout the system changes ❏ the total energy of the object changes
Clarity of Communication: Would someone else be able to understand my model?	Model cannot be understood.	Model is difficult to understand without further clarification	Model is clearly explained and easy to understand. Visuals and text include clear representations.	All ME requirements met. It includes a description of the models **simplifications** and **limitations**, compared to the phenomena from the real world.
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.				
Explains Phenomena: Does my argument explain the phenomenon?	Model does not or inaccurately supports the claim that as **KE changes**, energy is **transferred** to or from the object.	Model is used to partially support the claim that as **KE changes**, energy is **transferred** to or from the object. The argument excludes one or more main point.	Model is used to support the claim that as **KE changes**, energy is **transferred** to or from the object. Argument successfully explains: ❏ The cause(s) of Energy transfer **to** the object ❏ The cause(s) of Energy transfer **from** the object ❏ How **motion** changes as a result of changes in KE	All ME requirements met accurately. The model also connects: ❏ conservation and flow of energy within the rollercoaster system and the boundary of the system is clearly defined
Fits with Evidence: Does my model and explanation fit with the evidence collected? Can I use the evidence to support my argument?	Model and explanations are not supported with evidence.	Model and explanations are supported by limited evidence or irrelevant evidence.	Model and explanations are supported by evidence which might include observations based on sound, motion and/or other measurements.	All ME requirements met accurately. The evidence collected is evaluated based on its reliability.