2024 MCAS Sample Student Work and Scoring Guide

High School Introductory Physics
Question 17: Constructed-Response

Reporting Category: Energy
Practice Category: Evidence, Reasoning, and Modeling
Standard: HS.PHY.3.2 - Develop and use a model to illustrate that energy at the macroscopic scale can be accounted for as either motions of particles and objects or energy stored in fields.
Item Description: Interpret a graph of the gravitational potential energy (GPE) and kinetic energy (KE) of a falling object to identify the object's height and explain the reasoning, create a graph of the object's GPE and KE, and describe how the object's GPE and KE would have been affected by air resistance acting on the object.

View item in MCAS Digital Item Library

Scoring Guide
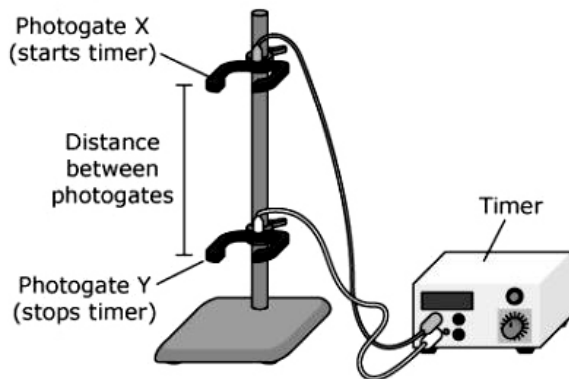*Select a score point in the table below to view the sample student response.*

Score*	Description
3A	The response demonstrates a thorough understanding of gravitational potential energy and kinetic energy. The response correctly identifies the position of the marble in Graph 2 and clearly explains the reasoning. The response correctly graphs the gravitational potential energy and kinetic energy of the marble. The response also clearly describes how the gravitational potential energy and kinetic energy of the marble would have been affected if air resistance acted on the marble.
3B	
2	The response demonstrates a partial understanding of gravitational potential energy and kinetic energy.
1	The response demonstrates a minimal understanding of gravitational potential energy and kinetic energy.
0	The response is incorrect or contains some correct work that is irrelevant to the skill or concept being measured.

*Letters are used to distinguish between sample student responses that earned the same score (e.g., 3A and 3B).

Score Point 3A

This question is part of a module with an introduction. The full introduction is available via the link to the Digital Item Library on the first page of this document. The first part of the introduction is shown.
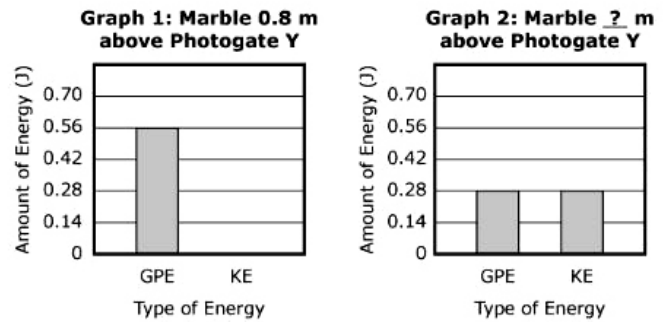
Students in a physics class investigated the amount of time it took a metal marble to fall different distances. The students used two photogates, X and Y, to measure the times. Photogates are devices that start or stop a timer when an object passes through them. The setup for the investigation is shown.

Photogate X
(starts timer)

Distance
between
photogates

Timer

Photogate Y
(stops timer)

The marble had a mass of 0.07 kg. In each trial, the marble was dropped from photogate X with an initial

This question has three parts.

The students made bar graphs to represent the marble's gravitational potential energy (GPE) and kinetic energy (KE) at different positions as it fell during trial 1, as shown. The students forgot to identify the position of the marble in the title of Graph 2.

Graph 1: Marble 0.8 m above Photogate Y

Amount of Energy (J): 0.70, 0.56, 0.42, 0.28, 0.14, 0

Type of Energy: GPE, KE

Graph 2: Marble _?_ m above Photogate Y

Amount of Energy (J): 0.70, 0.56, 0.42, 0.28, 0.14, 0

Type of Energy: GPE, KE

Part A

Identify the position of the marble above photogate Y in Graph 2. Explain your reasoning.

The height is .4 meters.
We can use the formula for gravitational potential energy to find the height:
GPE = (mass) (gravity) (height)
We can rearrange this to be:
height = GPE / (mass x gravity)
We can plug in .28J for GPE, .07kg for mass, and 10m/s^2 for gravity.
After solving the eqation, we get a value for height of .4 meters.

Part B

Drag the top of **each** bar to show the amount of GPE **and** the amount of KE the marble had when it was 0.2 m above photogate Y in trial 1.

Graph 3: Marble 0.2 m above Photogate Y
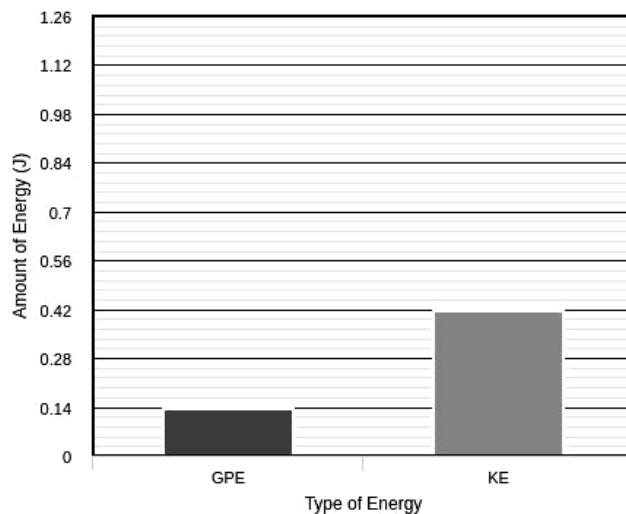
Part C

In Graph 2, the students ignored the effect of air resistance.

Describe how the marble's GPE **and** the marble's KE would have been affected if there had been a large amount of air resistance acting on the marble.
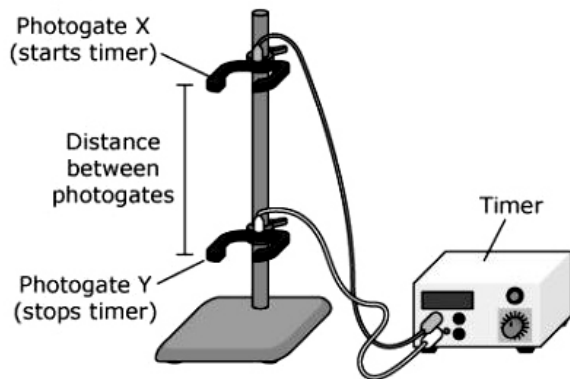
> The GPE would remain the same since air resistance doesn't affect that. However, the KE would decrease since the air resistance would act as a force against the marble causing it to slow down.

Score Point 3B

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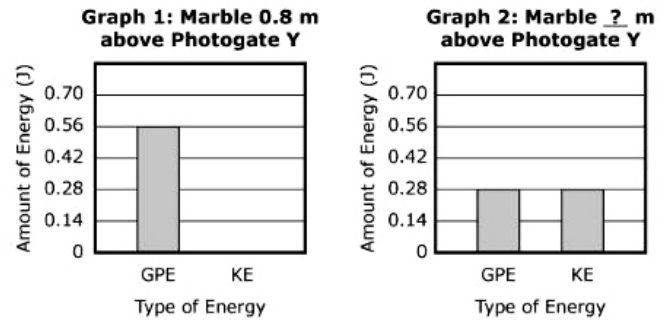
Students in a physics class investigated the amount of time it took a metal marble to fall different distances. The students used two photogates, X and Y, to measure the times. Photogates are devices that start or stop a timer when an object passes through them. The setup for the investigation is shown.

Photogate X
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Timer

Photogate Y
(stops timer)

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This question has three parts.

The students made bar graphs to represent the marble's gravitational potential energy (GPE) and kinetic energy (KE) at different positions as it fell during trial 1, as shown. The students forgot to identify the position of the marble in the title of Graph 2.

Graph 1: Marble 0.8 m above Photogate Y

Amount of Energy (J): 0.70, 0.56, 0.42, 0.28, 0.14, 0

Type of Energy: GPE, KE

Graph 2: Marble _?_ m above Photogate Y

Amount of Energy (J): 0.70, 0.56, 0.42, 0.28, 0.14, 0

Type of Energy: GPE, KE

Part A

Identify the position of the marble above photogate Y in Graph 2. Explain your reasoning.

The marble is halfway through the photogates (0.4m above photogate Y) because half of its potential energy has been converted to kinetic energy.

Part B

Drag the top of **each** bar to show the amount of GPE **and** the amount of KE the marble had when it was 0.2 m above photogate Y in trial 1.

Graph 3: Marble 0.2 m above Photogate Y
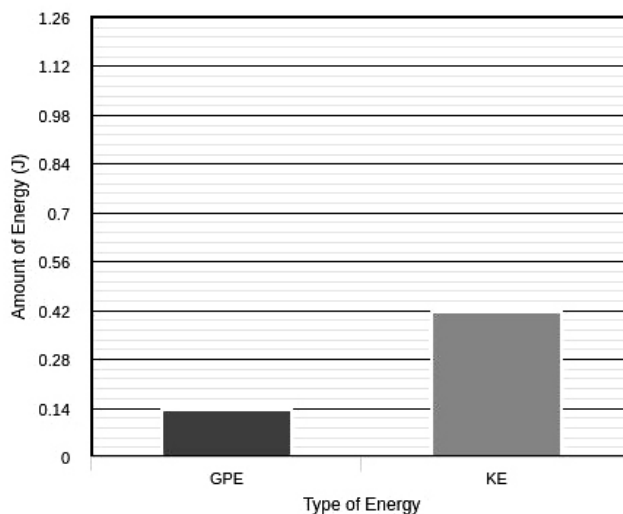
Part C

In Graph 2, the students ignored the effect of air resistance.

Describe how the marble's GPE **and** the marble's KE would have been affected if there had been a large amount of air resistance acting on the marble.
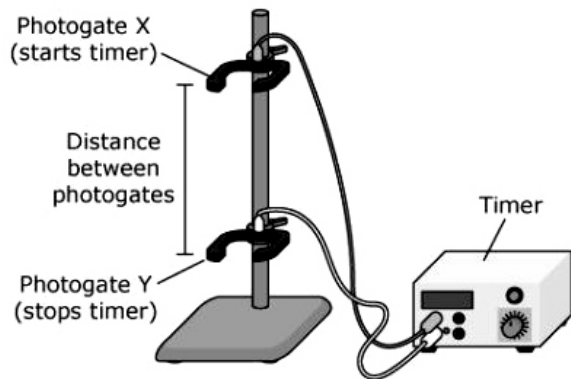
> The marble's GPE wouldn't have changed, but its KE would have been lower.

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Score Point 2

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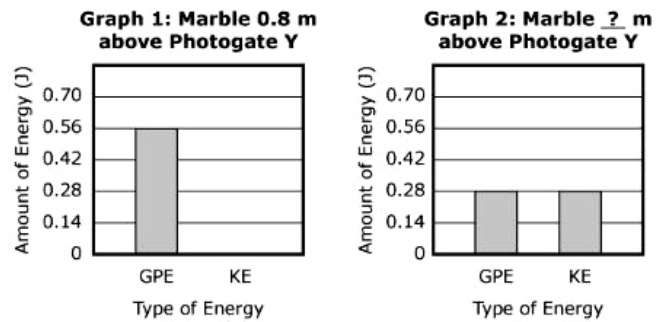
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photogates

Timer

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(stops timer)

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The students made bar graphs to represent the marble's gravitational potential energy (GPE) and kinetic energy (KE) at different positions as it fell during trial 1, as shown. The students forgot to identify the position of the marble in the title of Graph 2.

Graph 1: Marble 0.8 m above Photogate Y

Amount of Energy (J): 0.70, 0.56, 0.42, 0.28, 0.14, 0

Type of Energy: GPE, KE

Graph 2: Marble _?_ m above Photogate Y

Amount of Energy (J): 0.70, 0.56, 0.42, 0.28, 0.14, 0

Type of Energy: GPE, KE

Part A

Identify the position of the marble above photogate Y in Graph 2. Explain your reasoning.

the position of the marble would be 0.4 meters because half of the gravitaitonal potental energy was transfered into kinetic energy so that would mean the marble is about halfway down.

Part B

Drag the top of **each** bar to show the amount of GPE **and** the amount of KE the marble had when it was 0.2 m above photogate Y in trial 1.

Graph 3: Marble 0.2 m above Photogate Y
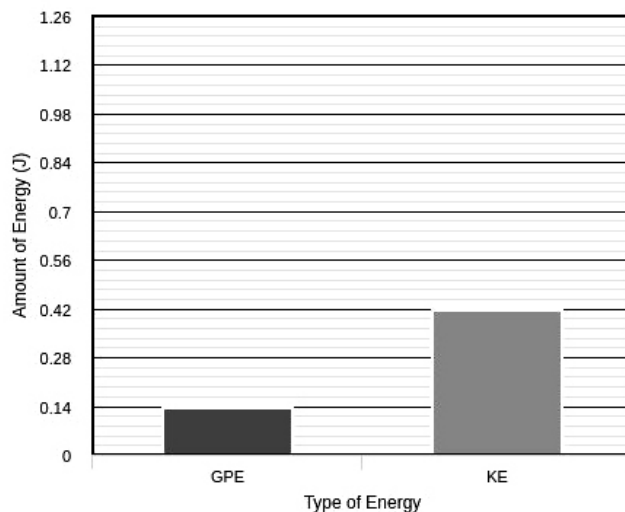
Part C

In Graph 2, the students ignored the effect of air resistance.

Describe how the marble's GPE **and** the marble's KE would have been affected if there had been a large amount of air resistance acting on the marble.
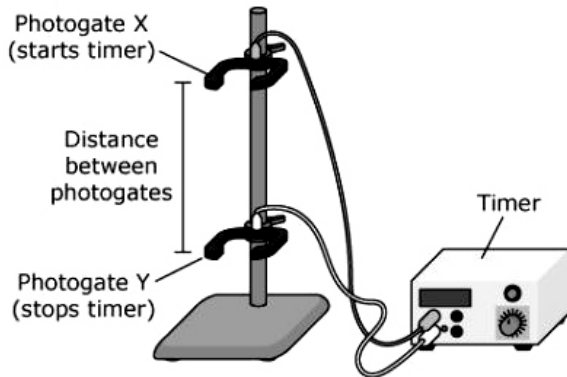
> There would be more GPE if there was more air resistance on the marble. It would take longer for the GPE to convert to KE because the marble woud be falling slower.

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Score Point 1

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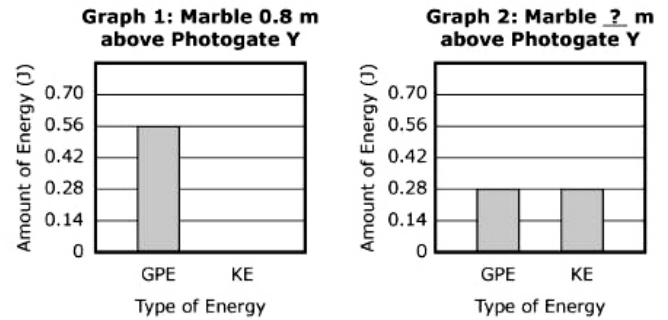
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Graph 1: Marble 0.8 m above Photogate Y

Graph 2: Marble _?_ m above Photogate Y

Part A

Identify the position of the marble above photogate Y in Graph 2. Explain your reasoning.

it should be 0.4 m because that is half of graph ones height, and the gpe in graph to is also half of graph ones so it makes sense that it decreased by 0.4 m.

Part B

Drag the top of **each** bar to show the amount of GPE **and** the amount of KE the marble had when it was 0.2 m above photogate Y in trial 1.

Graph 3: Marble 0.2 m above Photogate Y
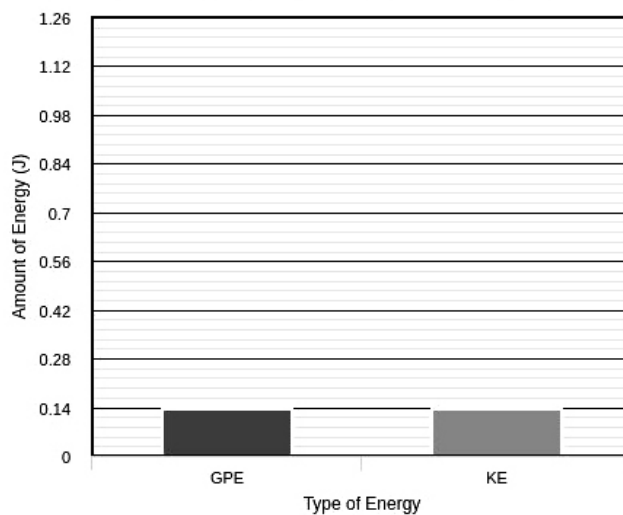
Part C

In Graph 2, the students ignored the effect of air resistance.

Describe how the marble's GPE **and** the marble's KE would have been affected if there had been a large amount of air resistance acting on the marble.
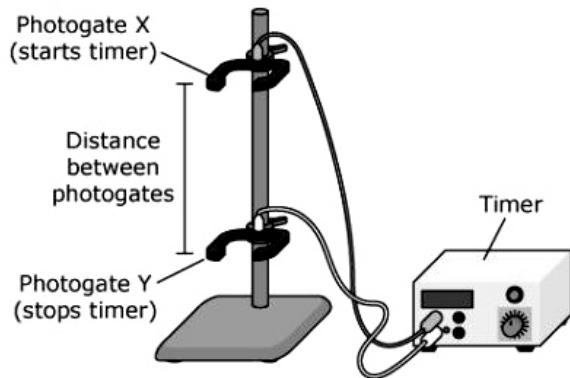
> the gpe and the ke would most likely decrease because of the increased resistance.

Score Point 0

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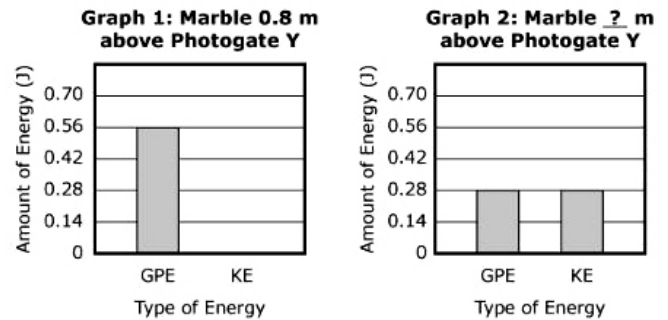
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Photogate Y (stops timer)

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Graph 1: Marble 0.8 m above Photogate Y

Amount of Energy (J)
0.70
0.56
0.42
0.28
0.14
0

GPE   KE
Type of Energy

Graph 2: Marble _?_ m above Photogate Y

Amount of Energy (J)
0.70
0.56
0.42
0.28
0.14
0

GPE   KE
Type of Energy

Part A

Identify the position of the marble above photogate Y in Graph 2. Explain your reasoning.

> The postion of the marble above photogate Y in Graph 2 was 0.28 beacuse that is where the GPE and the KE equal the same thing, making them at rest with each other before the marble was dropped.

Part B

Drag the top of **each** bar to show the amount of GPE **and** the amount of KE the marble had when it was 0.2 m above photogate Y in trial 1.

Graph 3: Marble 0.2 m above Photogate Y
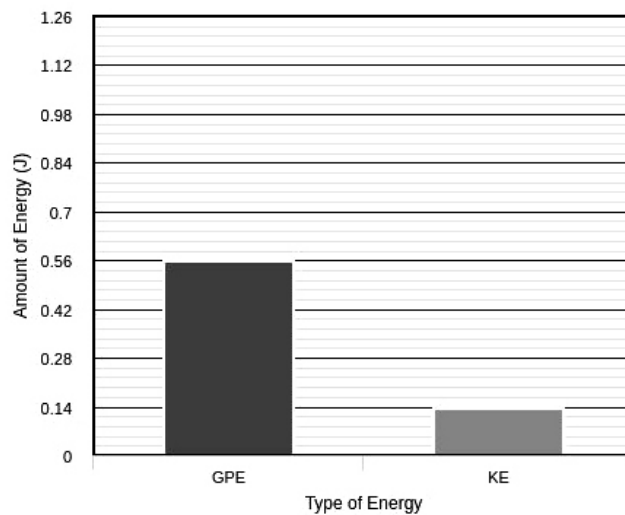
Part C

In Graph 2, the students ignored the effect of air resistance.

Describe how the marble's GPE **and** the marble's KE would have been affected if there had been a large amount of air resistance acting on the marble.

> The GPE and the KE would have been affected because the air resistance affects the way the marble will fall.