2022 MCAS Sample Student Work and Scoring Guide

High School Introductory Physics
Question 16: Constructed-Response

Reporting Category: Motion, Forces, and Interactions
Practice Category: Investigations and Questioning
Standard: HS.PHY.2.1 - Analyze data to support the claim that Newton's second law of motion is a mathematical model describing change in motion (the acceleration) of objects when acted on by a net force.
Item Description: Calculate an object's acceleration, describe how changing the distance over which a force is applied to the object affects its velocity, and describe one way to change the object's acceleration.

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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 Newton's second law of motion. The response correctly calculates the average acceleration of a system. The response correctly determines that the velocity of the block at position Y was less than 2.65 m/s and clearly explains the reasoning. The response also clearly describes one way to decrease the acceleration of the system and clearly explains the reasoning.
3B	
2	The response demonstrates a partial understanding of Newton's second law of motion.
1	The response demonstrates a minimal understanding of Newton's second law of motion.
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 has three parts.

For a new trial, the students used the same setup, but the hanging object was 0.6 kg, and they collected different data. During the trial, the students recorded the time it took the block to travel from position X to position Y and the change in velocity of the block between those positions. The table shows the data.

Mass of Block (kg)	Mass of Hanging Object (kg)	Time from X to Y (s)	Change in Velocity between X and Y (m/s)
0.4	0.6	0.6	2.65

Part A

Calculate the average acceleration of the system during the new trial. Show your calculations and include units in your answer.

$$a_{avg} = \frac{\Delta v}{\Delta t}$$

$$a_{avg} = \frac{2.65 \cdot \frac{m}{s}}{0.6s}$$

$$a_{avg} = 4.42m \ / \ s^2$$

Part B

The original distance between positions X and Y was 0.8 m. The students reduced the distance to 0.4 m. The students released the block from rest, allowing it to move the 0.4 m.

Determine whether the velocity of the block at position Y was greater than, less than, or equal to 2.65 m/s. Explain your reasoning.

The velocity will be less than 2.65m/s. Since the velocity of the block at position Y was 2.65m/s when it was 0.8m away, by decreasing distance we are decreasing the time the block has to speed up. By decreasing the time the block has to speed up, it has less time to accelerate and thus will not reach the same velocity as before.

Part C

Describe one way the students could decrease the acceleration of the system without changing the mass of the hanging object. Explain your reasoning.

One way they could decrease the acceleration of the system would be to increase the mass of the object/block rather than the hanging object. As F=ma, by leaving the mass of the hanging object constant the force remains constant. Thus, to decrease the acceleration we have to increase the mass. So by increasing the mass, we will be able to decrease the acceleration.

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Score Point 3B

This question has three parts.

For a new trial, the students used the same setup, but the hanging object was 0.6 kg, and they collected different data. During the trial, the students recorded the time it took the block to travel from position X to position Y and the change in velocity of the block between those positions. The table shows the data.

Mass of Block (kg)	Mass of Hanging Object (kg)	Time from X to Y (s)	Change in Velocity between X and Y (m/s)
0.4	0.6	0.6	2.65

Part A

Calculate the average acceleration of the system during the new trial. Show your calculations and include units in your answer.

$\frac{2.65}{.6} = 4.417 \cdot \frac{m}{s^2}$

Part B

The original distance between positions X and Y was 0.8 m. The students reduced the distance to 0.4 m. The students released the block from rest, allowing it to move the 0.4 m.

Determine whether the velocity of the block at position Y was greater than, less than, or equal to 2.65 m/s. Explain your reasoning.

it is less than 2.65 because it has less time to accelerate

Part C

Describe one way the students could decrease the acceleration of the system without changing the mass of the hanging object. Explain your reasoning.

he could make the block out of a rougher material giving it more friction making its net force less making its acceleration less

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Score Point 2

This question has three parts.

For a new trial, the students used the same setup, but the hanging object was 0.6 kg, and they collected different data. During the trial, the students recorded the time it took the block to travel from position X to position Y and the change in velocity of the block between those positions. The table shows the data.

Mass of Block (kg)	Mass of Hanging Object (kg)	Time from X to Y (s)	Change in Velocity between X and Y (m/s)
0.4	0.6	0.6	2.65

Part A

Calculate the average acceleration of the system during the new trial. Show your calculations and include units in your answer.

acceleration = $\Delta v \div \Delta t = 2.65 \ \frac{m}{s} \div 0.6 \ s = 4.42 \ m \ / \ s^2$

Part B

The original distance between positions X and Y was 0.8 m. The students reduced the distance to 0.4 m. The students released the block from rest, allowing it to move the 0.4 m.

Determine whether the velocity of the block at position Y was greater than, less than, or equal to 2.65 m/s. Explain your reasoning.

The velocity at position Y is less than 2.65 m/s because acceleration is constant, so if the block doesn't travel as far, it will not take as much time, meaning that there will be less velocity becausetheres less time for acceleration to increase the velocity.

Part C

Describe one way the students could decrease the acceleration of the system without changing the mass of the hanging object. Explain your reasoning.

Students could decrease the acceleration by increasing the distance which would increase the change in time.

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Score Point 1

This question has three parts.

For a new trial, the students used the same setup, but the hanging object was 0.6 kg, and they collected different data. During the trial, the students recorded the time it took the block to travel from position X to position Y and the change in velocity of the block between those positions. The table shows the data.

Mass of Block (kg)	Mass of Hanging Object (kg)	Time from X to Y (s)	Change in Velocity between X and Y (m/s)
0.4	0.6	0.6	2.65

Part A

Calculate the average acceleration of the system during the new trial. Show your calculations and include units in your answer.

$2.65 \div 0.6 = 4.42$ meters per second squared to the right.

Part B

The original distance between positions X and Y was 0.8 m. The students reduced the distance to 0.4 m. The students released the block from rest, allowing it to move the 0.4 m.

Determine whether the velocity of the block at position Y was greater than, less than, or equal to 2.65 m/s. Explain your reasoning.

The velocity was greater than because 2.65 is the average velocity between the two blocks.

Part C

Describe one way the students could decrease the acceleration of the system without changing the mass of the hanging object. Explain your reasoning.

They could decrease the acceleration by adding more time to their data.

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Score Point 0

This question has three parts.

For a new trial, the students used the same setup, but the hanging object was 0.6 kg, and they collected different data. During the trial, the students recorded the time it took the block to travel from position X to position Y and the change in velocity of the block between those positions. The table shows the data.

Mass of Block (kg)	Mass of Hanging Object (kg)	Time from X to Y (s)	Change in Velocity between X and Y (m/s)
0.4	0.6	0.6	2.65

Part A

Calculate the average acceleration of the system during the new trial. Show your calculations and include units in your answer.

average acceleration: ? $\frac{m}{s}$ $(squared)$

change in velocity: 2.65 $\frac{m}{s}$

change in time: 0.6 seconds

2.65 x $.6 = 1.59$

Part B

The original distance between positions X and Y was 0.8 m. The students reduced the distance to 0.4 m. The students released the block from rest, allowing it to move the 0.4 m.

Determine whether the velocity of the block at position Y was greater than, less than, or equal to 2.65 m/s. Explain your reasoning.

It was greater because the block was accelerating.

Part C

Describe one way the students could decrease the acceleration of the system without changing the mass of the hanging object. Explain your reasoning.

The falling object would have to fall slower.

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