2025 MCAS Sample Student Work and Scoring Guide

High School Introductory Physics
Question 20: Constructed-Response

Reporting Category: Motion, Forces, and Interactions
Practice Category: Mathematics and Data
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: Analyze the forces acting on an object to explain why the object moves to the left, calculate the acceleration of the object, and determine the magnitude and direction of an additional force that would result in a given acceleration.

This item can be found in the released item sets on the MCAS Resource Center.

Scoring Guide

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

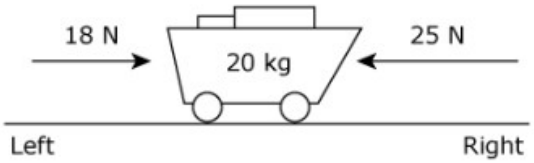
Score*	Description
4A	The response demonstrates a thorough understanding of Newton's laws. The response correctly identifies the direction the cart moves and explains the reasoning. The response correctly calculates the cart's acceleration. The response also correctly determines the magnitude and direction of the additional force that will accelerate the cart.
4B	
3	The response demonstrates a general understanding of Newton's laws.
2	The response demonstrates a limited understanding of Newton's laws.
1	The response demonstrates a minimal understanding of Newton's laws.
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., 4A and 4B).

Score Point 4A

This question has three parts.

The diagram shows the horizontal forces on a cart. Assume friction is negligible and the cart is initially at rest.



Part A

Identify the direction the cart moves. Explain your reasoning.

The cart is moving left because the net force is 7 N to the left, due to how the force on the right is stronger than the force on the left and the force on the right is pushing left.

Maximum number of characters: 1500 || Characters remaining: 1357

Part B

Calculate the cart's acceleration. Show your calculations and include units in your answer.

Fnet = mass * acceleration
7 N = 20 kg * a
7/20 = a
a = 0.35 m/s^2 to the left

Maximum number of characters: 1500 || Characters remaining: 1443

Part C

Determine the magnitude and direction of an additional force that will give the cart an acceleration of 1.5 m/s^2 to the right. Show your calculations and include units in your answer.

Fnet = mass * acceleration
Fnet = 20 kg * 1.5 m/s^2 to the right
Fnet = 30 N

Force needed = 37 N to the right
- 7 N to balance out forces, then 30 N more to get the cart moving to the right at an acceleration of 1.5 m/s^2 to the right.

Maximum number of characters: 1500 || Characters remaining: 1319

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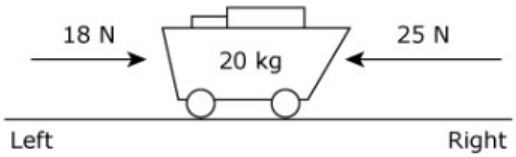
Score Point 4B

This question has three parts.

The diagram shows the horizontal forces on a cart. Assume friction is negligible and the cart is initially at rest.



Part A

Identify the direction the cart moves. Explain your reasoning.

The cart moves to the left because there is more force pushing in that direction. There is 25 N pushing to the left and only 18 N pushing to the right.

Maximum number of characters: 1500 || Characters remaining: 1379

Part B

Calculate the cart's acceleration. Show your calculations and include units in your answer.

-25N + 18N = -7N

$F_{net} = ma$

$a = \frac{F_{net}}{m} = \frac{-7N}{20kg}$

$a = \frac{0.35m}{s^2}$

Maximum number of characters: 1500 || Characters remaining: 1488

Part C

Determine the magnitude and direction of an additional force that will give the cart an acceleration of 1.5 m/s^2 to the right. Show your calculations and include units in your answer.

MATH

$$F_{net} = ma$$
$$F_{net} = 20kg\left(1.5\ \frac{m}{s^2}\right)$$
$$F_{net} = 30\ N$$
$$F_{net} = F_1 + F_2$$
$$30N = F_1 - 25N$$
$$55N = F_1$$
$$F_1 = F_{original} + F_{additional}$$
$$55N = 18N + F_{additional}$$
$$F_{additional} = 37\ N\ to\ the\ right$$

Maximum number of characters: 1500 || Characters remaining: 1500

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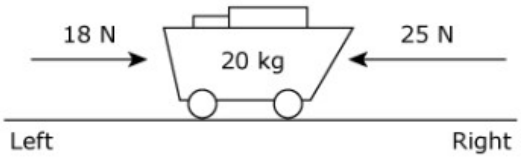
Score Point 3

This question has three parts.

The diagram shows the horizontal forces on a cart. Assume friction is negligible and the cart is initially at rest.



Part A

Identify the direction the cart moves. Explain your reasoning.

The car moves in the left direction because $F_{net} = +18\ N - 25\ N\ = -7N;$ the signs plus (+) or minus (-) show in which direction the car moves.

Maximum number of characters: 1500 || Characters remaining: 1407

Part B

Calculate the cart's acceleration. Show your calculations and include units in your answer.

F = -7N (equation in the first question)
m = 20 kg (given)
a = ?

$F = ma$

$\frac{-7}{20} = \frac{20a}{20}$ $\qquad a = -.35\ \frac{m}{s^2}$

Maximum number of characters: 1500 || Characters remaining: 1500

Part C

Determine the magnitude and direction of an additional force that will give the cart an acceleration of 1.5 m/s^2 to the right. Show your calculations and include units in your answer.

$F = ?$
$m = 20\ kg\ (given)$
$a = -.35\ \frac{m}{s^2} + 1.5\ \frac{m}{s} = 1.15\ \frac{m}{s^2}$
$F = ma = 20 \cdot 1.15 = +23\ N$ direction of the force = on the left

Maximum number of characters: 1500 || Characters remaining: 1427

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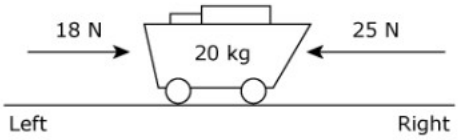
Score Point 2

This question has three parts.

The diagram shows the horizontal forces on a cart. Assume friction is negligible and the cart is initially at rest.



Part A

Identify the direction the cart moves. Explain your reasoning.

the cart will move to the right because the greater force is pushing from the right side. 25 N > 18 N.

Maximum number of characters: 1500 || Characters remaining: 1419

Part B

Calculate the cart's acceleration. Show your calculations and include units in your answer.

25N-18N = 7N

$$a = \frac{F}{m} = \frac{7N}{20kg} = 0.35\ \frac{m}{s^2}$$

Maximum number of characters: 1500 || Characters remaining: 1500

Part C

Determine the magnitude and direction of an additional force that will give the cart an acceleration of 1.5 m/s^2 to the right. Show your calculations and include units in your answer.

$$a = \frac{F}{m} = 1.5\ \frac{m}{s^2} = \frac{F}{20kg}$$

$$1.5\ \frac{m}{s^2} \cdot 20kg\ = 30\ N$$

$$F\ =\ 30\ N$$

$$30N - 25N = 5N\ to\ the\ right$$

Maximum number of characters: 1500 || Characters remaining: 1500

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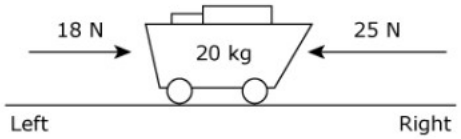
Score Point 1

This question has three parts.

The diagram shows the horizontal forces on a cart. Assume friction is negligible and the cart is initially at rest.



Part A

Identify the direction the cart moves. Explain your reasoning.

The 20 kg cart moves to the left. This is because there is more force being pushed on the cart from the right side (25N) than on the left side (18 N). So the right outweighs the left and it is pushed to the left.

Maximum number of characters: 1500 || Characters remaining: 1332

Part B

Calculate the cart's acceleration. Show your calculations and include units in your answer.

The carts acceleration is 3.5 m/s squared. The calculations are

$\Delta v = 7$

$\Delta T = 2$

$\frac{\Delta v}{\Delta T} = average\ acceleration$

$\frac{7}{2} = 3.5\ \frac{m}{s^2}$

Maximum number of characters: 1500 || Characters remaining: 1446

Part C

Determine the magnitude and direction of an additional force that will give the cart an acceleration of 1.5 m/s^2 to the right. Show your calculations and include units in your answer.

An additional force of 8 N from the left will give the cart an acceleration of 1.5 m/s squared to the right. This is because now, the force from the left outweighs the force from the right.

Maximum number of characters: 1500 || Characters remaining: 1347

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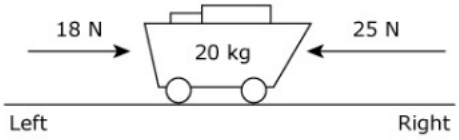
Score Point 0

This question has three parts.

The diagram shows the horizontal forces on a cart. Assume friction is negligible and the cart is initially at rest.



Part A

Identify the direction the cart moves. Explain your reasoning.

The object would stay at rest because of Newtons first law. Which says that an object would stay at rest unless an object moves it.

Maximum number of characters: 1500 || Characters remaining: 1393

Part B

Calculate the cart's acceleration. Show your calculations and include units in your answer.

The acceleration is 7 N because it went from 18 to 25 and that 7 N difference.

Maximum number of characters: 1500 || Characters remaining: 1438

Part C

Determine the magnitude and direction of an additional force that will give the cart an acceleration of 1.5 m/s^2 to the right. Show your calculations and include units in your answer.

It would be 3N.

Maximum number of characters: 1500 || Characters remaining: 1500

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