2026 MCAS Sample Student Work and Scoring Guide

High School Introductory Physics
Question 42: Constructed-Response

Reporting Category: Motion, Forces, and Interactions
Practice Category: Mathematics and Data

Standard: HS.PHY.2.2 - Use mathematical representations to show that the total momentum of a system of interacting objects is conserved when there is no net force on the system.

Item Description: Determine the momentum of a system and explain the reasoning, calculate the momentum and velocity of one of the blocks in the system, and describe how energy is conserved in the system.

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 4B	The response demonstrates a thorough understanding of conservation of momentum and energy. The response correctly determines the momentum of the system before and after the spring is released and clearly explains the reasoning. The response correctly calculates the momentum of the 10 kg block and the velocity of the 5 kg block. The response also clearly describes how energy is conserved when the spring is released.
3	The response demonstrates a general understanding of conservation of momentum and energy.
2	The response demonstrates a limited understanding of conservation of momentum and energy.
1	The response demonstrates a minimal understanding of conservation of momentum and energy.
0	The response is incorrect or contains some correct work that is irrelevant to the skill or concept being measured.

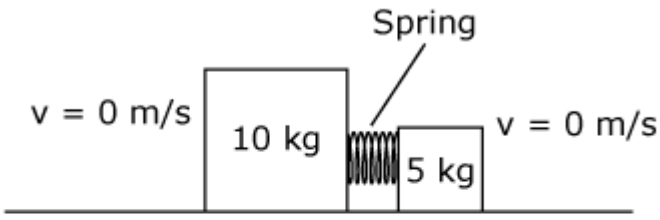
*Letters are used to distinguish between sample student responses that earned the same score (e.g., 4A and 4B).

Question Introduction

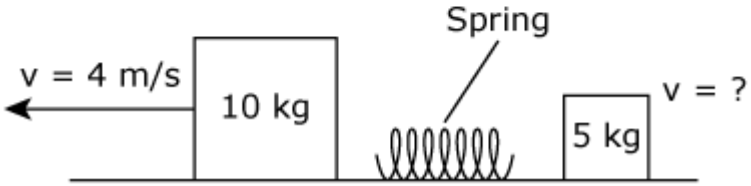
This question has four parts.

A spring is compressed between a 10 kg block and a 5 kg block that are at rest on a frictionless surface. Then the spring is released. The diagrams show the two-black system before and after the spring is released.

Before Spring Is Released



After Spring Is Released



Score Point 4A

Part A

Determine the momentum of the system before **and** after the spring is released. Explain your reasoning using the law of conservation of momentum.

The total momentum of the spring system is 0 kg · m/s before and after the spring is released, because before the spring is released the blocks have no velocity and because p=mv if v=0 regardless of m, p must be 0. After the spring is released the system must still have no momentum because of the law of conservation of momentum, stating that in a closed system momentum will always stay the same.

Maximum number of characters: 1500 || Characters remaining: 1176

Part B

Calculate the momentum of the 10 kg block after the spring is released. Show your calculations and include units in your answer.

The momentum of the 10 kg block is 40 kg m/s to the left because p=mv and m=10 kg and v= 4 m/s, so p = 10 kg · 4 m/s = 40 kg m/s

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

Part C

Calculate the magnitude of the velocity of the 5 kg block after the spring is released. Show your calculations and include units in your answer.

The velocity of the 5 kg block is 8 m/s because given the fact that the system after release must have 0 kg m/s of momentum (as discussed in part A) we know that the 5 kg block's momentum must be 10 kg m/s to the right. Therefore as $v = \frac{p}{m}$ and p=40kg m/s and m = 5 kg $v = \frac{40\ kg\ \frac{m}{s}}{5\ kg} = 8\ \frac{m}{s}$

Maximum number of characters: 1500 || Characters remaining: 1296

Part D

Energy is also conserved in this system.

Describe how energy is conserved when the spring is released. Be sure to discuss both potential **and** kinetic energy.

Energy is conserved in this system because in the beginning the spring has lots of potential energy which it then turns to kennetic energy which it transfers to the blocks. No energy in this system is taken away or added, it's just changed.

Maximum number of characters: 1500 || Characters remaining: 1302

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Score Point 4B

Part A

Determine the momentum of the system before **and** after the spring is released. Explain your reasoning using the law of conservation of momentum.

$p = mv \quad m_1 = 10\ kg \quad m_2 = 5\ kg \quad v_{1i} = 0\ \frac{m}{s} \quad v_{2i} = 0\ \frac{m}{s}$

$p_1 = 10 \cdot 0 \quad p_1 = 0\ kg \cdot \frac{m}{s} \quad p_2 = 5 \cdot 0 \quad p_2 = 0\ kg \cdot \frac{m}{s} \quad p_1 + p_2 = p_{tot}$

before $p_{tot} = 0\ kg \cdot \frac{m}{s}$ and **after** $p_{tot} = 0\ kg \cdot \frac{m}{s}$

This is b/c of the law of conservation of momentum that momentum will stay constant before + after in system w/o outside forces (friction etc.)

Maximum number of characters: 1500 | | Characters remaining: 641

Part B

Calculate the momentum of the 10 kg block after the spring is released. Show your calculations and include units in your answer.

$p = mv \quad m_1 = 10\ kg \quad v_{1f} = -4\ \frac{m}{s} \quad p_{1f} = 10 \cdot -4$

$p_{1f} = -40\ kg \cdot \frac{m}{s}$

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

Part C

Calculate the magnitude of the velocity of the 5 kg block after the spring is released. Show your calculations and include units in your answer.

$p_{tot} = p_{1f} + p_{2f} \quad p_{tot} = 0\ kg \cdot \frac{m}{s} \quad p_{1f} = -40\ kg \cdot \frac{m}{s} \quad 0 = -40 + p_{2f} \quad p_{2f} = 40\ kg \cdot \frac{m}{s}$

$p = mv \quad m_2 = 5\ kg \quad 40 = 5 \cdot v$

$v_{2f} = 8\ \frac{m}{s}$

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

Part D

Energy is also conserved in this system.

Describe how energy is conserved when the spring is released. Be sure to discuss both potential **and** kinetic energy.

When the spring is compressed at the beginning, potential spring energy is being stored in the spring. As the explosion happens (spring is released), the potential energy turns into kinetic energy, as the PE decreases the KE increases, so there is always the same amount of total energy. Once the spring is totally released, all of the energy is kinetic.

Maximum number of characters: 1500 | | Characters remaining: 1205

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Score Point 3

Part A

Determine the momentum of the system before **and** after the spring is released. Explain your reasoning using the law of conservation of momentum.

The momentum of the system before the spring is released is 0 because both momentums of each block are 0 because their momentums have to be equal. The total momentum of the system after the block is released is 80 m/s x kg. Each block has a momentum of 40 m/s x kg because according to the law of conservation of momentum both blocks have the same momentum after an action takes place.

Maximum number of characters: 1500 || Characters remaining: 1187

Part B

Calculate the momentum of the 10 kg block after the spring is released. Show your calculations and include units in your answer.

$p = mv \quad v = 4\ \frac{m}{s} \quad m = 10\ kg \quad 10\ kg \times 4\ \frac{m}{s} = 40\ kg \times \frac{m}{s}$

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

Part C

Calculate the magnitude of the velocity of the 5 kg block after the spring is released. Show your calculations and include units in your answer.

$m_1 v_1 = m_2 v_2 \quad m_1 = 10\ kg \quad m_2 = 5\ kg \quad v_1 = 4\ \frac{m}{s} \quad \frac{10\ kg \times 4\ \frac{m}{s}}{5\ kg} = 8\ \frac{m}{s}$

$V_2 = 8\ \frac{m}{s}$ v of 5 kg block

Maximum number of characters: 1500 || Characters remaining: 1489

Part D

Energy is also conserved in this system.

Describe how energy is conserved when the spring is released. Be sure to discuss both potential **and** kinetic energy.

Energy is conserved in this also because the potencial energy in the system before the spring is released is equal to the kinetic energy in the system after the spring is released. PE=KE

Maximum number of characters: 1500 || Characters remaining: 1346

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Score Point 2

Part A

Determine the momentum of the system before **and** after the spring is released. Explain your reasoning using the law of conservation of momentum.

The momentum before the spring releases and after the spring releases is the same.

Maximum number of characters: 1500 | | Characters remaining: 1431

Part B

Calculate the momentum of the 10 kg block after the spring is released. Show your calculations and include units in your answer.

P = m x v P = 10 kg x 4 m/s
P = 40 kg · m/s

Maximum number of characters: 1500 | | Characters remaining: 1475

Part C

Calculate the magnitude of the velocity of the 5 kg block after the spring is released. Show your calculations and include units in your answer.

P = m x v
40 kg · m/s = 5 kg v
v = 8 m/s

Maximum number of characters: 1500 | | Characters remaining: 1477

Part D

Energy is also conserved in this system.

Describe how energy is conserved when the spring is released. Be sure to discuss both potential **and** kinetic energy.

Energy is conserved when the spring is released because of change in energy. Before the spring released, potential energy was being collected. When the potential energy is being collected, it means that energy is being collected and then it will release an energy called kinetic energy.

Maximum number of characters: 1500 | | Characters remaining: 1259

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Score Point 1

Part A

Determine the momentum of the system before **and** after the spring is released. Explain your reasoning using the law of conservation of momentum.

Before the spring is realesed the momentum is 0 kg m/s because the velocity is 0 and the two masses added together is 15 kg and anything multiplied by 0 is 0. After the spring is released the momentum of the system is 60 kg m/s because if you add the masses and then multiply by the velocity you get 60.

Maximum number of characters: 1500 || Characters remaining: 1257

Part B

Calculate the momentum of the 10 kg block after the spring is released. Show your calculations and include units in your answer.

P=mv P= 4 x 10 = 40 kg m/s this is the momentum of the 10 kg block

Maximum number of characters: 1500 || Characters remaining: 1451

Part C

Calculate the magnitude of the velocity of the 5 kg block after the spring is released. Show your calculations and include units in your answer.

P=mv P=5x2=10 kg m/s this is the momentum of the 5 kg box

Maximum number of characters: 1500 || Characters remaining: 1455

Part D

Energy is also conserved in this system.

Describe how energy is conserved when the spring is released. Be sure to discuss both potential **and** kinetic energy.

Energy is conserved when the spring is released because the potential energy is stored and some of it had to go to each side so it spread out.

Maximum number of characters: 1500 || Characters remaining: 1385

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Score Point 0

Part A

Determine the momentum of the system before **and** after the spring is released. Explain your reasoning using the law of conservation of momentum.

Before the spring is realesed the blocks are close to eachother and after the spring is realesed the blocks are distance.

Maximum number of characters: 1500 | | Characters remaining: 1399

Part B

Calculate the momentum of the 10 kg block after the spring is released. Show your calculations and include units in your answer.

When the spring is released the momentum of the 10 kg block is 4 m/s because when the spring wasn't released block kg 10 and block kg 5 had the same momentum.

Maximum number of characters: 1500 | | Characters remaining: 1373

Part C

Calculate the magnitude of the velocity of the 5 kg block after the spring is released. Show your calculations and include units in your answer.

5 kg block is 4 m/s.

Maximum number of characters: 1500 | | Characters remaining: 1485

Part D

Energy is also conserved in this system.

Describe how energy is conserved when the spring is released. Be sure to discuss both potential **and** kinetic energy.

The momentum changed when the spring was released.

Maximum number of characters: 1500 | | Characters remaining: 1457

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