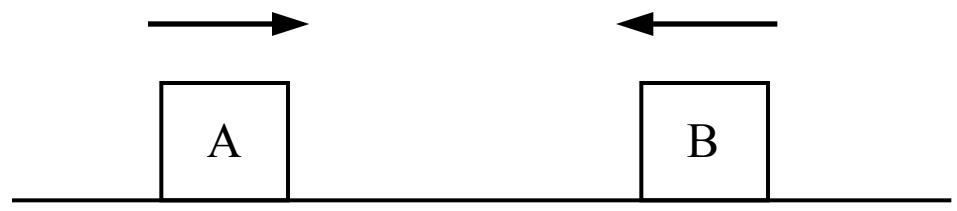
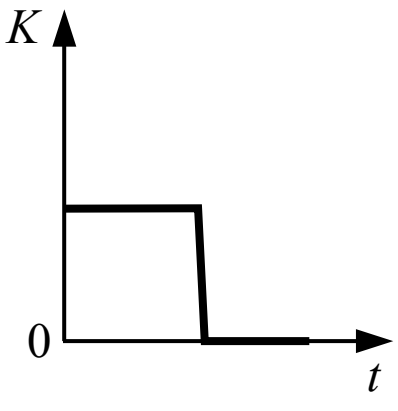
CONSERVATION OF MOMENTUM

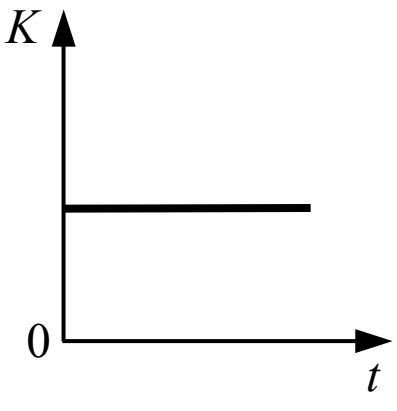
1. Two blocks are sliding towards each other on a surface with negligible friction as shown in the figure above. The blocks collide and stick together. Which direction do the blocks move after the collision?

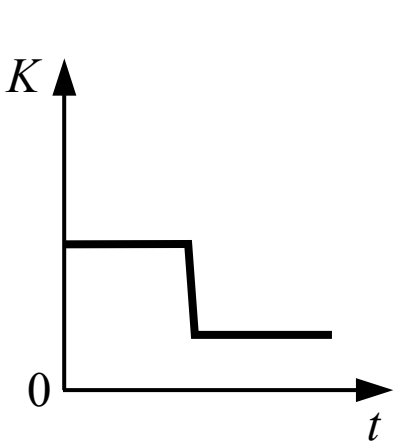
   (A) Right
   (B) Left
   (C) They do not move after the collision
   (D) Cannot be determined

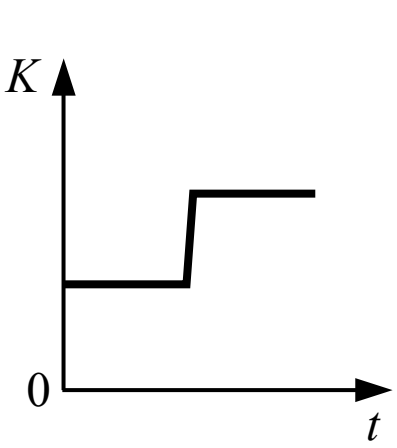


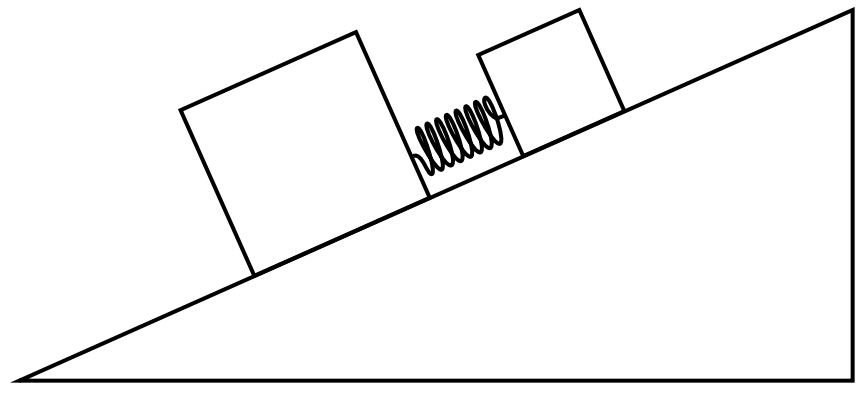
2. Two blocks are sliding towards each other on a surface with negligible friction. The blocks collide, stick together and continue moving after the collision. Which of the following graphs shows the total kinetic energy of the two block system over time?

(A)


(B)


(C)


(D)




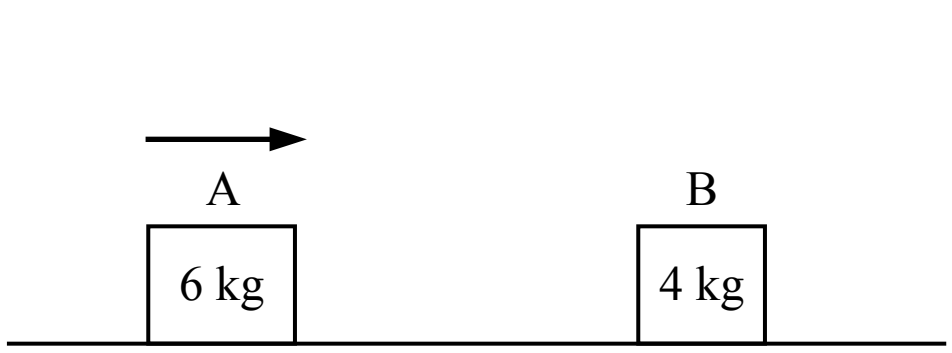
3. Two blocks are connected by a spring and placed on an incline with negligible friction. The blocks are held so that the spring is initially compressed. The blocks are then released from rest and they move apart from each other due to the spring. How does the total momentum of the blocks-spring system change after the blocks are released?

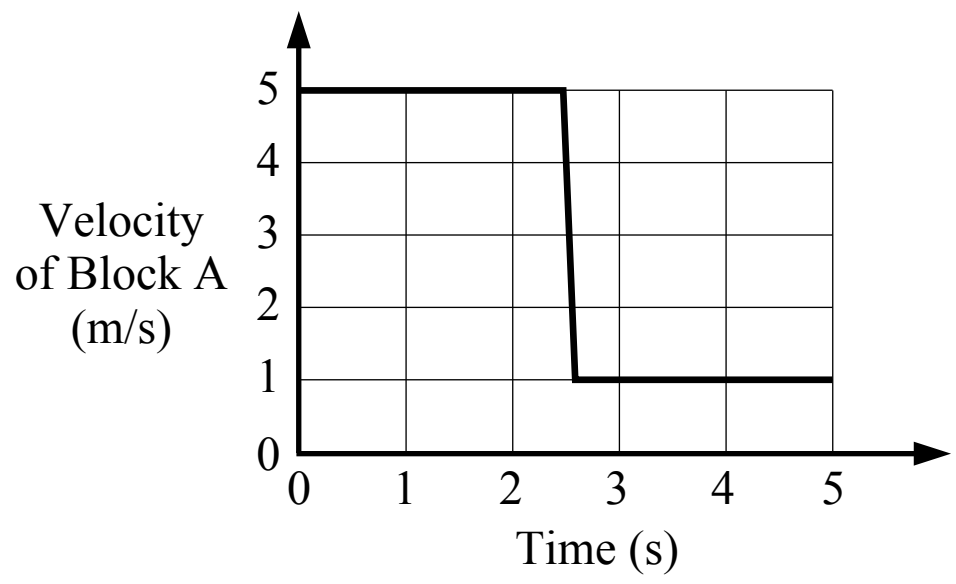
   (A) The total momentum decreases

   (B) The total momentum increases

   (C) The total momentum does not change

   (D) Cannot be determined





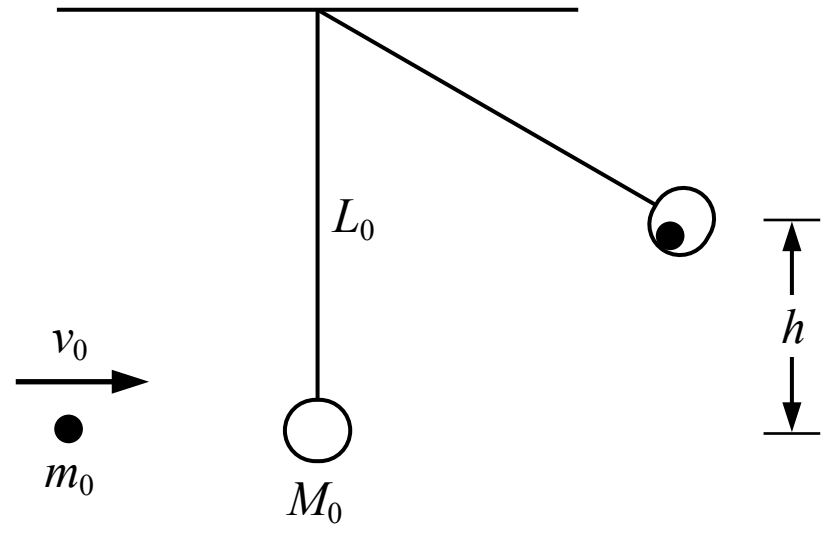
4. Block A is sliding on a surface with negligible friction towards block B which is initially at rest. The blocks collide and the collision is perfectly elastic. A graph of the velocity of block A is shown in the figure above. What is the speed of block B after the collision?

   (A) 6 m/s

   (B) 5 m/s

   (C) 4 m/s

   (D) 1 m/s



5. A small sphere of mass m_0 is shot at a ball of clay of mass M_0 which is suspended by a string with negligible mass. The ball of clay is initially at rest when the sphere impacts the ball of clay with a speed of v_0. The sphere sticks to the ball of clay and they swing upwards. What is the maximum height h that the sphere and ball of clay swing?

(A) $\dfrac{m_0 v_0}{m_0 + M_0}$

(B) $\dfrac{1}{2} m_0 v_0^2$

(C) $\dfrac{m_0 v_0^2}{2g(m_0 + M_0)}$

(D) $\dfrac{1}{2g}\left(\dfrac{m_0 v_0}{m_0 + M_0}\right)^2$

6. Block A is held in place against a spring which is initially compressed a distance of Δx_0 from its original length. Block A is then released, moves to the right and loses contact with the spring. Block A slides across the surface where friction is negligible and it collides and sticks to block B which is initially at rest. Which of the following is an expression for the speed of the blocks after the collision?

(A) $\sqrt{\dfrac{k_0 \Delta x_0^2}{m_0}}$

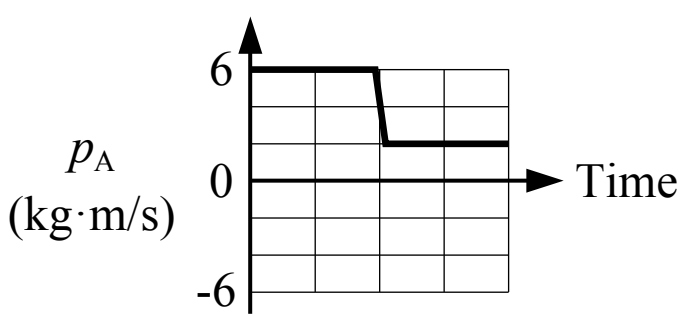
(B) $\dfrac{1}{3}\sqrt{\dfrac{k_0 \Delta x_0^2}{m_0}}$

(C) $\dfrac{1}{2}\sqrt{\dfrac{k_0 \Delta x_0^2}{m_0}}$

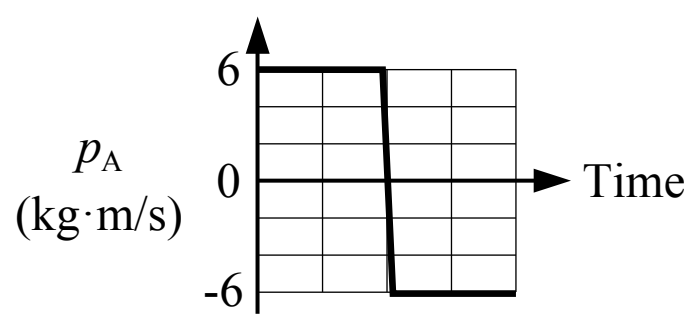
(D) 0

7. Block A is sliding on a surface with negligible friction when it collides with block B which is initially at rest. After the collision block B moves to the right at 1 m/s. Which of the following could show the momentum of block A before and after the collision?

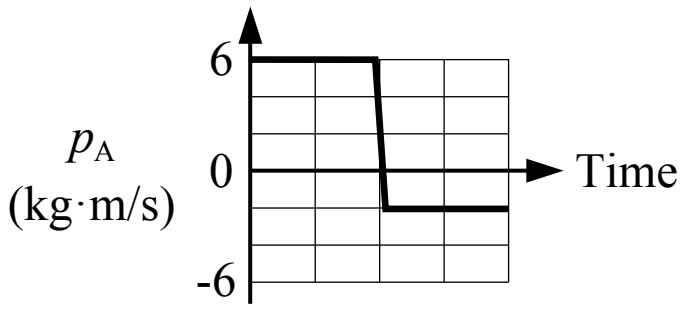
(A)



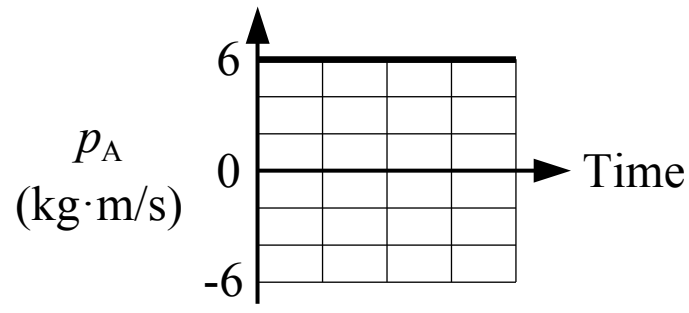
(B)



(C)



(D)



1. Two blocks are sliding towards each other on a surface with negligible friction as shown in the figure above. The blocks collide and stick together. Which direction do the blocks move after the collision?

(A) Right

(B) Left

(C) They do not move after the collision

(D) Cannot be determined

A Incorrect

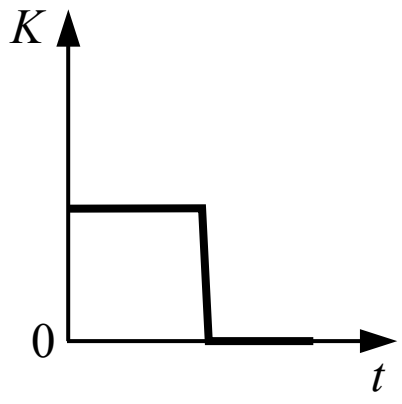
B Incorrect

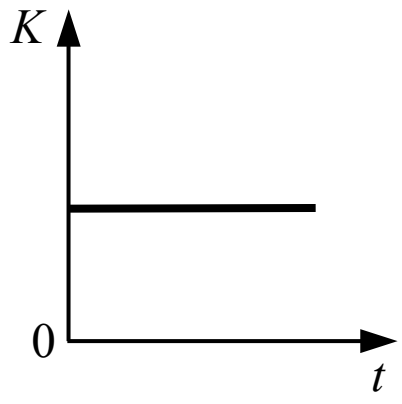
C Incorrect

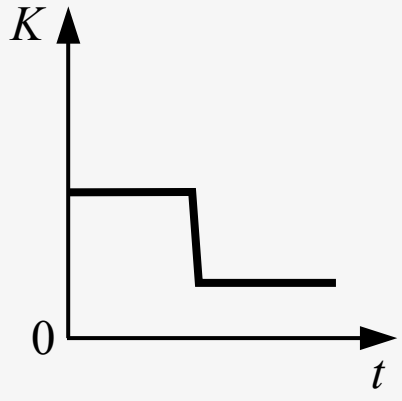
D Correct

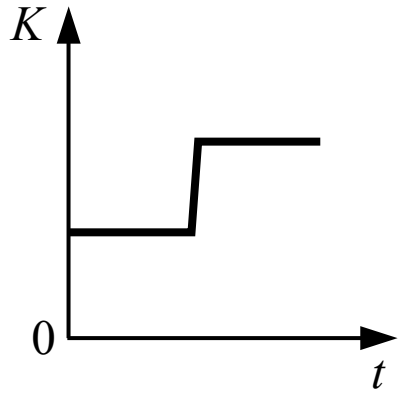
The total momentum of the two block system is conserved during the collision so the direction of the total momentum does not change. The mass of each block must be known in order to find the momentum of each block and the direction of the total momentum of the system.

2. Two blocks are sliding towards each other on a surface with negligible friction. The blocks collide, stick together and continue moving after the collision. Which of the following graphs shows the total kinetic energy of the two block system over time?

(A)


(B)


(C)


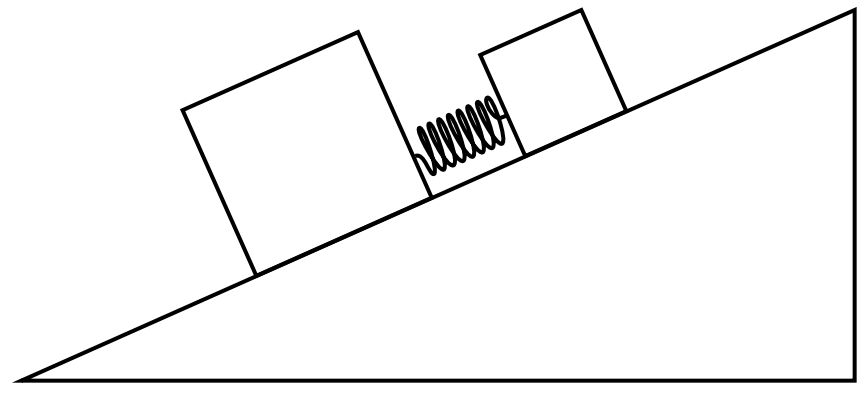
(D)


A Incorrect
This would be a graph of the total kinetic energy if the blocks were not moving after the collision.

B Incorrect
This would be a graph of the total kinetic energy during a perfectly elastic collision.

C Correct
The blocks stick together so the collision is perfectly inelastic. Momentum is conserved during the collision but kinetic energy is not conserved during a perfectly inelastic collision so it decreases. The blocks are still moving after the collision so the kinetic energy does not decrease to zero.

D Incorrect
This graph would not be possible during a collision like this because energy is not added to the system.



3. Two blocks are connected by a spring and placed on an incline with negligible friction. The blocks are held so that the spring is initially compressed. The blocks are then released from rest and they move apart from each other due to the spring. How does the total momentum of the blocks-spring system change after the blocks are released?

(A) The total momentum decreases

(B) The total momentum increases

(C) The total momentum does not change

(D) Cannot be determined

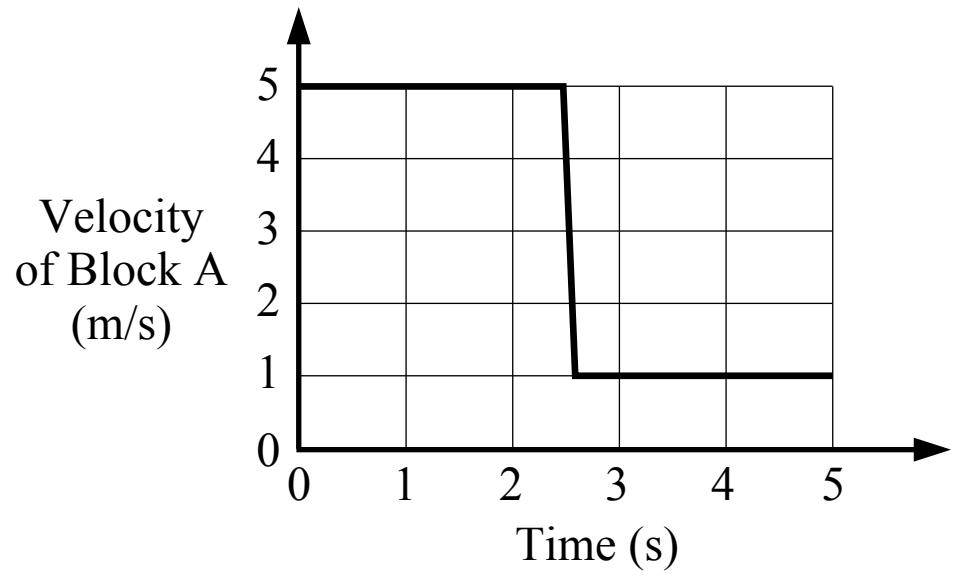
A Incorrect

B Correct

The blocks-spring system is not isolated because there is an external weight force acting on each block which has a component parallel to the incline (parallel to the block's motion). There is an impulse exerted by the weight forces which changes the momentum of the blocks-spring system (the center of mass of the system will accelerate down the incline due to the weight force). The total momentum of the system does not increase because of the spring force, which is an internal force. If the blocks were on a horizontal surface the weight forces would be perpendicular to the motion and the total momentum of the system would not change.

C Incorrect

D Incorrect



4. Block A is sliding on a surface with negligible friction towards block B which is initially at rest. The blocks collide and the collision is perfectly elastic. A graph of the velocity of block A is shown in the figure above. What is the speed of block B after the collision?

(A) 6 m/s

(B) 5 m/s

(C) 4 m/s

(D) 1 m/s

A **Correct**

The total momentum of the two block system is conserved during the collision.

$p_i = p_f \qquad m_A v_{Ai} + m_B v_{Bi} = m_A v_{Af} + m_B v_{Bf} \qquad (6\text{ kg})(5\text{ m/s}) + (4\text{ kg})(0\text{ m/s}) = (6\text{ kg})(1\text{ m/s}) + (4\text{ kg})\,v_{Bf}$

$v_{Bf} = 6\text{ m/s}$

B Incorrect

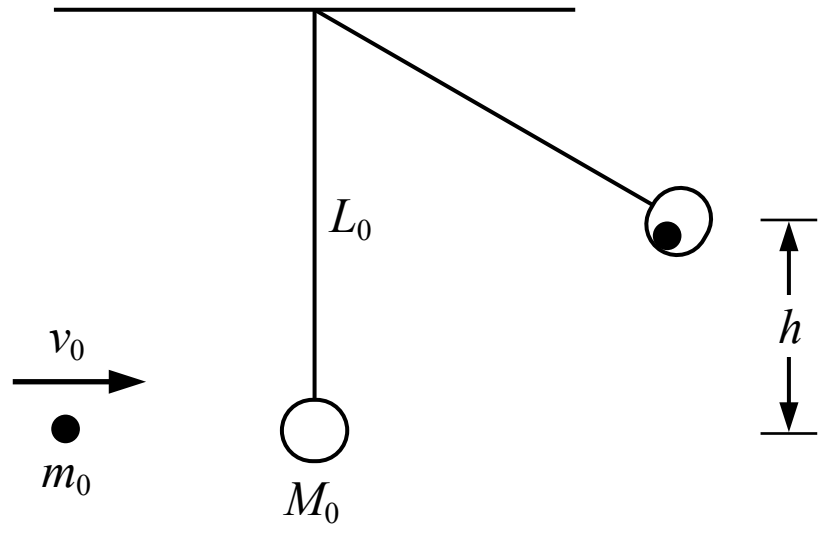
This answer is the initial speed of block A before the collision.

C Incorrect

This answer is the change in the speed of block A.

D Incorrect

This answer is the final speed of block A after the collision.



5. A small sphere of mass m_0 is shot at a ball of clay of mass M_0 which is suspended by a string with negligible mass. The ball of clay is initially at rest when the sphere impacts the ball of clay with a speed of v_0. The sphere sticks to the ball of clay and they swing upwards. What is the maximum height h that the sphere and ball of clay swing?

(A) $\dfrac{m_0 v_0}{m_0 + M_0}$

(B) $\dfrac{1}{2} m_0 v_0^2$

(C) $\dfrac{m_0 v_0^2}{2g(m_0 + M_0)}$

(D) $\dfrac{1}{2g}\left(\dfrac{m_0 v_0}{m_0 + M_0}\right)^2$

A Incorrect
This answer is the final speed of the sphere and clay immediately after the collision.

B Incorrect
This answer is the kinetic energy of the sphere before the collision.

C Incorrect
This answer incorrectly assumes that energy is conserved throughout the entire motion, and that the initial kinetic energy of the sphere is equal to the final gravitational potential energy of the sphere and clay. Energy is not conserved during the collision.

D Correct
This problem is solved in two parts. The sphere and the clay collide in a perfectly inelastic collision so kinetic energy is not conserved during the collision and therefore not conserved between the time before the collision and the time when the sphere and clay reach a maximum height. Momentum is conserved during the collision and energy is conserved between the moment after the collision and the time when the objects reach the maximum height, so both conservation equations must be used for different periods of time.

Collision: $p_\text{i} = p_\text{f}$ $\quad m_0 v_0 + M_0(0\ \text{m/s}) = (m_0 + M_0) v_\text{fl}$ $\quad v_\text{fl} = \dfrac{m_0 v_0}{m_0 + M_0}$

Swing: $E_\text{i} = E_\text{f}$ $\quad K_\text{i} = U_\text{gf}$ $\quad \dfrac{1}{2} m v_\text{i}^2 = mgh_\text{f}$ $\quad h_\text{f} = \dfrac{1}{2g} v_\text{i}^2 = \dfrac{1}{2g}\left(\dfrac{m_0 v_0}{m_0 + M_0}\right)^2$

6. Block A is held in place against a spring which is initially compressed a distance of Δx_0 from its original length. Block A is then released, moves to the right and loses contact with the spring. Block A slides across the surface where friction is negligible and it collides and sticks to block B which is initially at rest. Which of the following is an expression for the speed of the blocks after the collision?

(A) $\sqrt{\dfrac{k_0 \Delta x_0^2}{m_0}}$

(B) $\dfrac{1}{3}\sqrt{\dfrac{k_0 \Delta x_0^2}{m_0}}$

(C) $\dfrac{1}{2}\sqrt{\dfrac{k_0 \Delta x_0^2}{m_0}}$

(D) 0

A Incorrect

This is an expression for the speed of block A after losing contact with the spring.

B Correct

The speed of block A after losing contact with the spring can be found using conservation of energy (the energy of the block-spring system is conserved so the initial spring potential energy is transformed into the the final kinetic energy of block A when it loses contact with the spring). The collision between the blocks is perfectly inelastic because they stick together, and the final speed of the two blocks together can be found using conservation of momentum.

Spring and block A: $E_\text{i} = E_\text{f} \qquad U_\text{sp i} = K_\text{f} \qquad \dfrac{1}{2} k_0 \Delta x_0^2 = \dfrac{1}{2} m_0 v_\text{A}^2 \qquad v_\text{A} = \sqrt{\dfrac{k_0 \Delta x_0^2}{m_0}}$

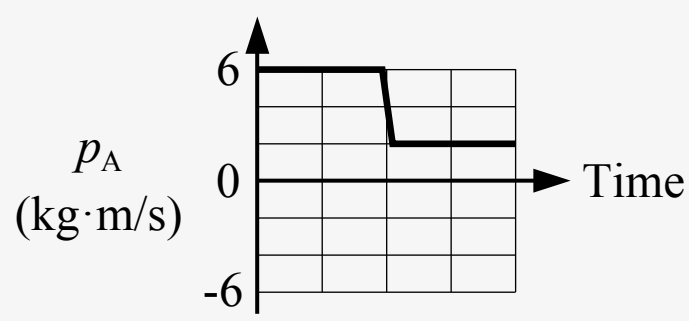
Collision: $m_\text{A} v_\text{Ai} + m_\text{B} v_\text{Bi} = (m_\text{A} + m_\text{B}) v_\text{f} \qquad (m_0)\sqrt{\dfrac{k_0 \Delta x_0^2}{m_0}} + (2\,m_0)(0) = (m_0 + 2\,m_0) v_\text{f} \qquad v_\text{f} = \dfrac{1}{3}\sqrt{\dfrac{k_0 \Delta x_0^2}{m_0}}$

C Incorrect

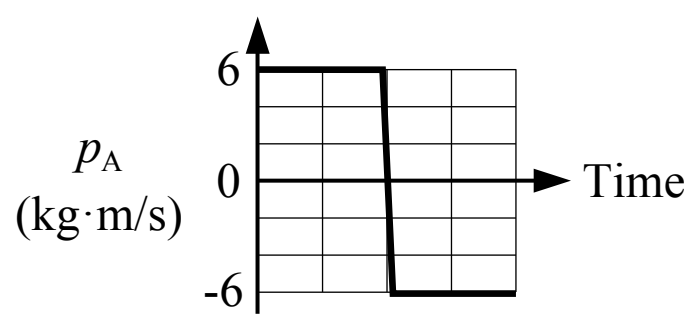
D Incorrect

7. Block A is sliding on a surface with negligible friction when it collides with block B which is initially at rest. After the collision block B moves to the right at 1 m/s. Which of the following could show the momentum of block A before and after the collision?

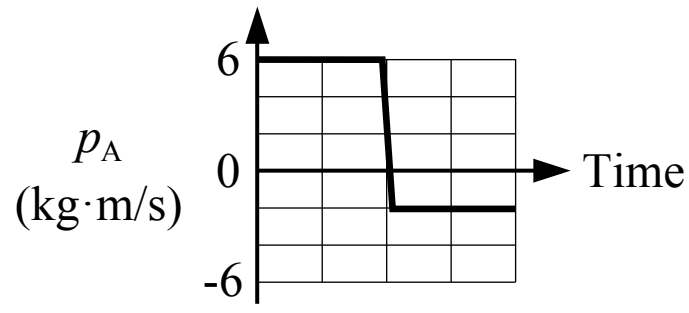
(A)



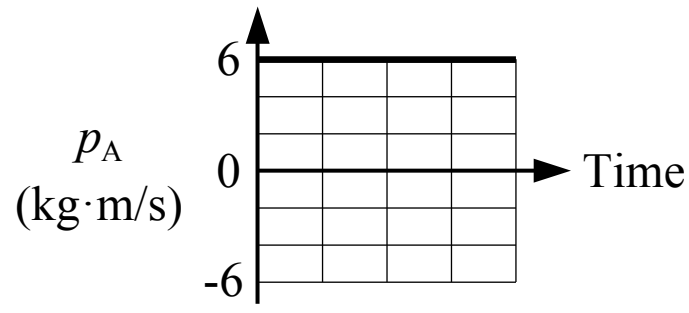
(B)



(C)



(D)



A **Correct**

The total momentum of the system of the two blocks is conserved (it doesn't change over time). Block B has zero momentum before the collision and 4 kg·m/s of momentum after the collision, so its momentum increases 4 kg·m/s. The momentum of block A must decrease by 4 kg·m/s if the total momentum stays the same.

$\Sigma p_i = \Sigma p_f \qquad p_{Ai} + p_{Bi} = p_{Af} + p_{Bf} \qquad (6\ \text{kg·m/s}) + (0\ \text{kg·m/s}) = p_{Af} + (4\ \text{kg·m/s}) \qquad p_{Af} = 2\ \text{kg·m/s}$

B Incorrect

C Incorrect

D Incorrect