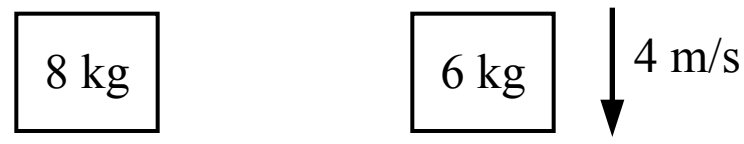
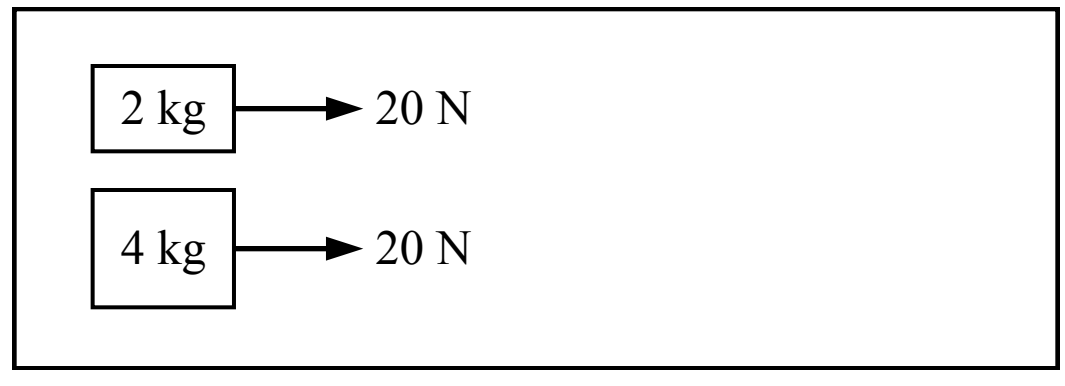
LINEAR MOMENTUM & IMPULSE



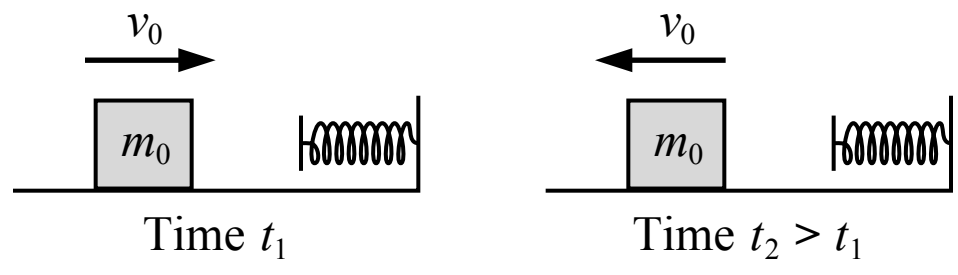
1. An 8 kg block is dropped from rest at the same time that a 6 kg block is falling at a speed of 4 m/s. Which of the two blocks has a greater momentum 2 seconds later (assuming the blocks are still falling)?

   (A) The 6 kg block
   (B) The 8 kg block
   (C) The blocks will have the same momentum
   (D) Cannot be determined



2. Two blocks are sitting on a table where the friction between the blocks and the table is negligible. A 20 N force is then exerted on each block for a period of 5 seconds. Which block experiences a greater impulse during that time?

   (A) The 2 kg block
   (B) The 4 kg block
   (C) The blocks experience the same impulse
   (D) Cannot be determined



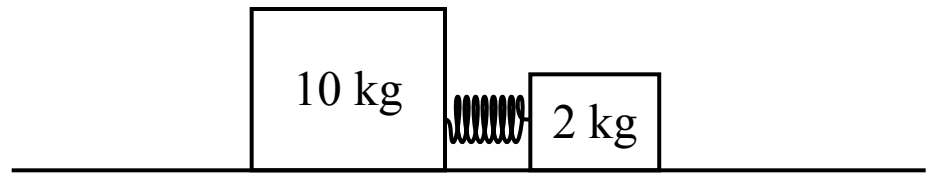
3. A block is sliding to the right on a surface with negligible friction with a speed of v_0 at time t_1. The block then compresses a spring and reverses direction. The block is moving to the left with the same speed of v_0 at a later time t_2. The magnitude of the impulse exerted on the block by the spring is

   (A) $2\,m_0\,v_0$

   (B) $m_0\,v_0$

   (C) $m_0\,v_0/2$

   (D) 0



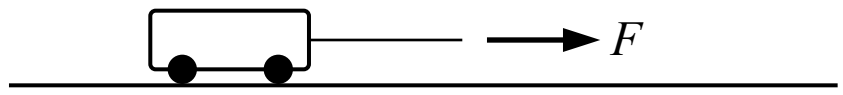
4. Two blocks are connected by a spring and are placed on a surface where the friction between the surface and the blocks is negligible. The blocks are held in place so that the spring is initially compressed. When the blocks are released, which block experiences an impulse with a greater magnitude?

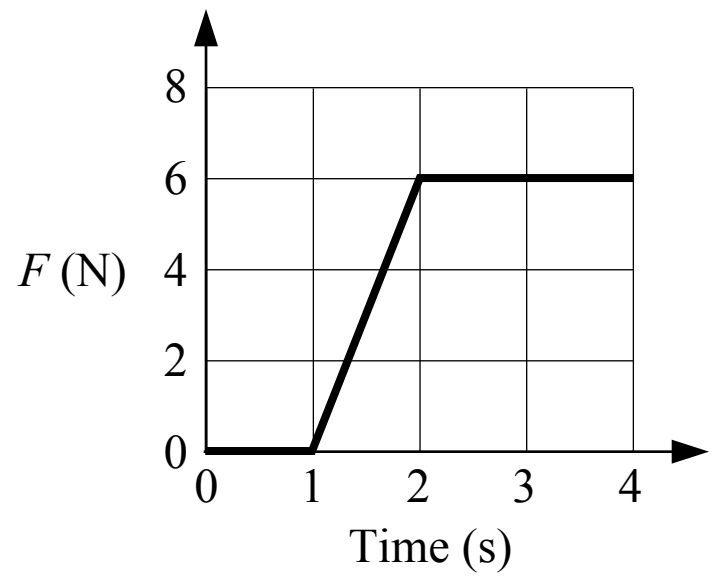
   (A) The 10 kg block

   (B) The 2 kg block

   (C) The blocks experience an impulse with the same magnitude

   (D) Cannot be determined





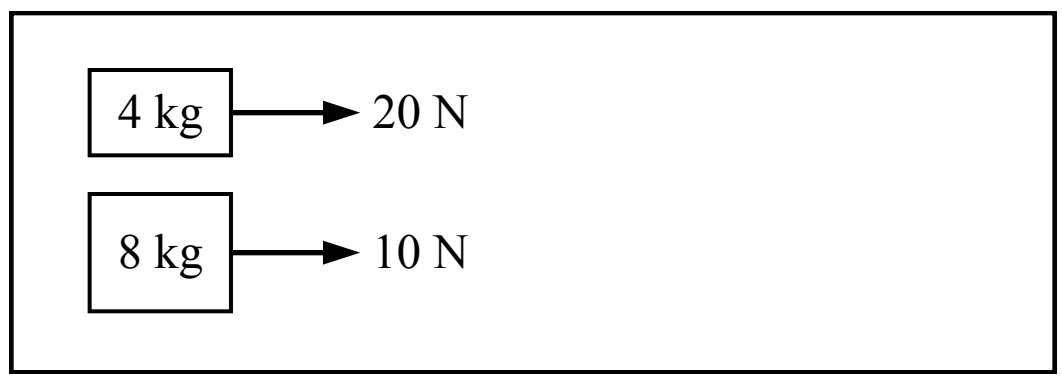
5. A cart is pulled along a horizontal track with negligible friction by a varying force F. A graph of the applied force over time is shown in the figure above. What is the change in momentum of the cart between 0 seconds and 3 seconds?

(A) 9 kg·m/s

(B) 12 kg·m/s

(C) 18 kg·m/s

(D) Cannot be determined



Top view

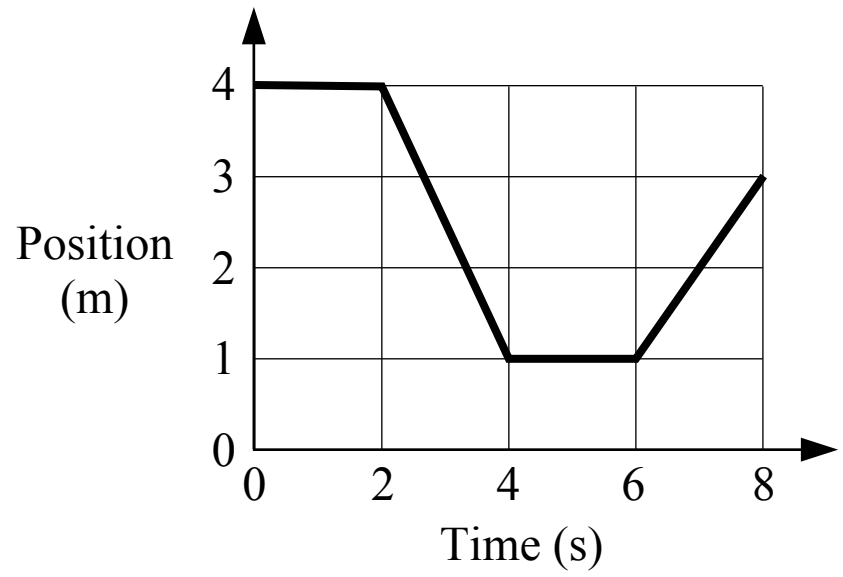
6. Two blocks are initially at rest on a table where the friction is negligible. A force is then applied to each block as shown in the figure above. Which block has a momentum with a greater magnitude after 3 seconds?

(A) The 4 kg block

(B) The 8 kg block

(C) The blocks have momentums with equal magnitudes

(D) Cannot be determined



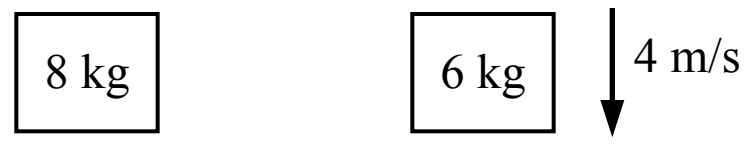
7. A cart moves on a horizontal track and its motion is shown in the graph above. Which of the following statements is true about the momentum of the cart?

(A) The magnitude of the momentum is decreasing from 2 seconds to 4 seconds

(B) The magnitude of the momentum from 0 seconds to 2 seconds is greater than it is from 4 seconds to 6 seconds

(C) The magnitude of the momentum from 2 seconds to 4 seconds is greater than it is from 6 seconds to 8 seconds

(D) The magnitude of the momentum is changing from 6 seconds to 8 seconds



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   (A) The 6 kg block

   (B) The 8 kg block

   (C) The blocks will have the same momentum

   (D) Cannot be determined

A Incorrect

B Correct

The momentum of each block is equal to its mass multiplied by its velocity. The velocity of each block 2 seconds later can be found using kinematics:

8 kg block: $v_f = v_i + a\Delta t = (0\text{ m/s}) + g(2\text{ s}) = 20\text{ m/s}$ $\quad p = mv = (8\text{ kg})(20\text{ m/s}) = 160\text{ kg·m/s}$

6 kg block: $v_f = v_i + a\Delta t = (4\text{ m/s}) + g(2\text{ s}) = 24\text{ m/s}$ $\quad p = mv = (6\text{ kg})(24\text{ m/s}) = 144\text{ kg·m/s}$

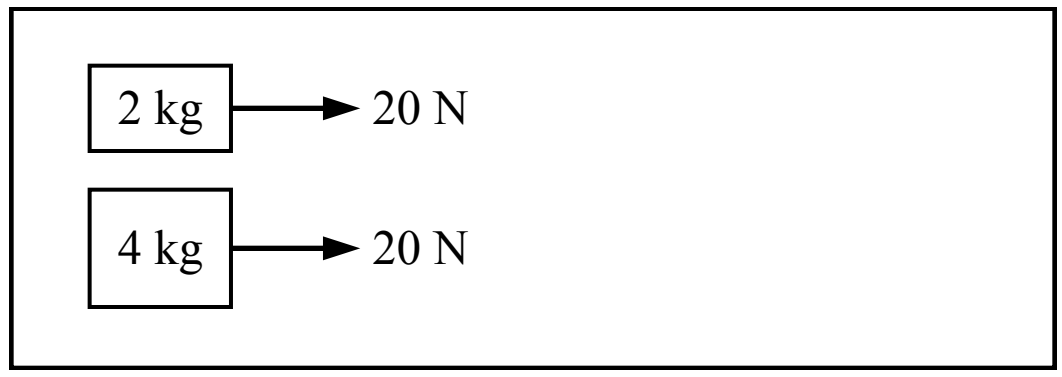
We can also find the change in momentum (impulse) of each block during the 2 second period due to the gravitational force and add that to the initial momentum:

8 kg block: $\Delta p = F\Delta t$ $\quad p_f - p_i = mg\Delta t$ $\quad p_f - (8\text{ kg})(0\text{ m/s}) = (8\text{ kg})g(2\text{ s})$ $\quad p_f = 160\text{ kg·m/s}$

6 kg block: $\Delta p = F\Delta t$ $\quad p_f - p_i = mg\Delta t$ $\quad p_f - (6\text{ kg})(4\text{ m/s}) = (6\text{ kg})g(2\text{ s})$ $\quad p_f = 144\text{ kg·m/s}$

C Incorrect

D Incorrect



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(A) The 2 kg block

(B) The 4 kg block

(C) The blocks experience the same impulse

(D) Cannot be determined

A Incorrect

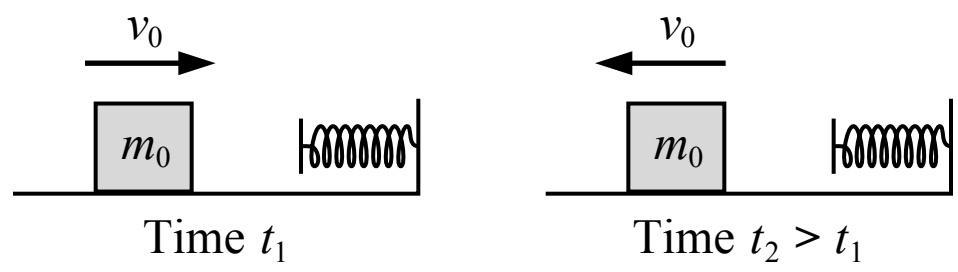
B Incorrect

C Correct

The impulse exerted on a block is equal to the force applied multiplied by the period of time the force is applied. The same force is applied to each block for the same period of time so the impulses are the same.

$J = F\Delta t$

D Incorrect



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(A) $2\,m_0\,v_0$

(B) $m_0\,v_0$

(C) $m_0\,v_0/2$

(D) 0

A Correct

The impulse exerted on the block is equal to the change in the block's momentum. Momentum is a vector so it has a direction. If we say right is the positive direction:

$J = \Delta p = p_{\mathrm{f}} - p_{\mathrm{i}} = m_0\,v_0 - m_0(-v_0) = 2\,m_0\,v_0$

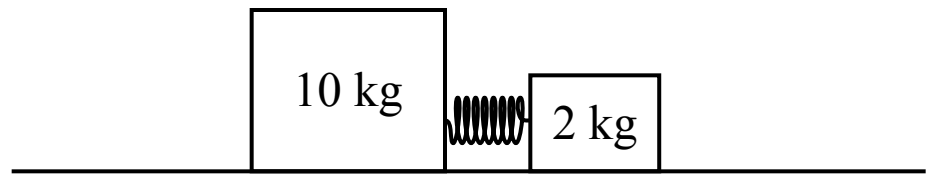
B Incorrect

This would be the impulse exerted on the block if the spring only stopped the block and the final momentum of the block was zero.

C Incorrect

D Incorrect

This answer incorrectly treats momentum as a scalar without a direction, and assumes the change in momentum is zero because the magnitude of the momentum is the same at both times. The change in momentum cannot be zero because momentum is a vector and the momentum changes direction.



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(A) The 10 kg block

(B) The 2 kg block

(C) The blocks experience an impulse with the same magnitude

(D) Cannot be determined

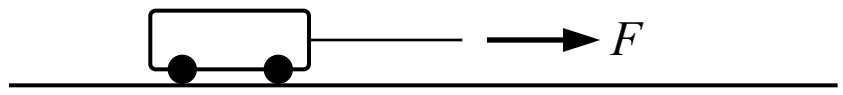
A Incorrect

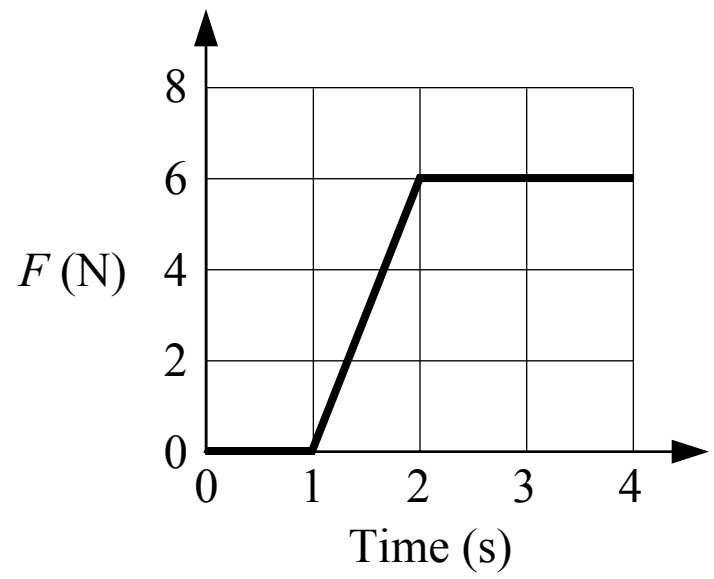
B Incorrect

C **Correct**

The impulse exerted on a block is equal to the force applied multiplied by the period of time the force is applied. The same spring force is applied to each block for the same period of time so the impulses have the same magnitude.

D Incorrect





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(A) 9 kg·m/s

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(D) Cannot be determined

A **Correct**

The change in momentum of the car (the impulse exerted on the cart) between 0 seconds and 3 seconds is the average force during that time multiplied by the period of time, which is also equal to the area under the force-time graph from 0 seconds to 3 seconds. The area can be split into a triangle from 1-2 seconds and a rectangle from 2-3 seconds.

$\Delta p = F_{\text{avg}} \Delta t =$ area under force-time graph

$$\Delta p = A_{\text{1-2s}} + A_{\text{2-3s}} = \frac{1}{2}(2\text{ s} - 1\text{ s})(6\text{ N}) + (3\text{ s} - 2\text{ s})(6\text{ N}) = 9\text{ N·s} = 9\text{ kg·m/s}$$

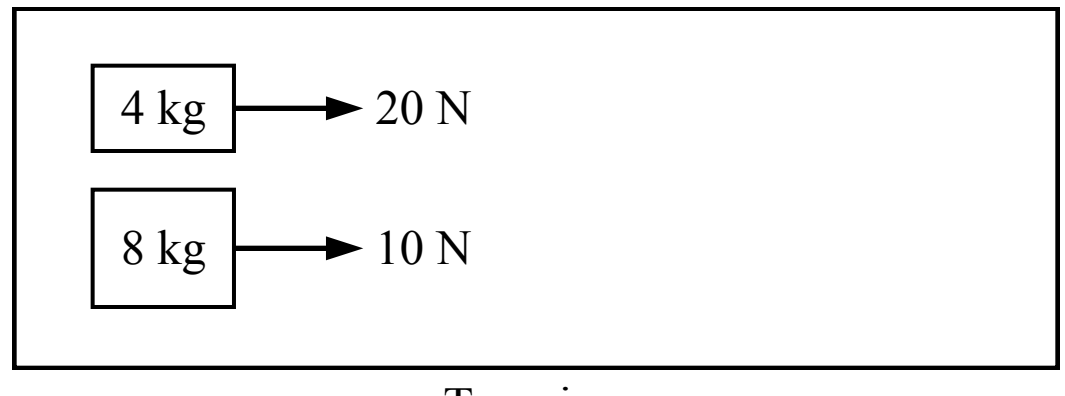
B Incorrect

This answer incorrectly multiplies 6 N by 2 seconds.

C Incorrect

This answer incorrectly multiplies 6 N by 3 seconds.

D Incorrect



Top view

6. Two blocks are initially at rest on a table where the friction is negligible. A force is then applied to each block as shown in the figure above. Which block has a momentum with a greater magnitude after 3 seconds?

(A) The 4 kg block

(B) The 8 kg block

(C) The blocks have momentums with equal magnitudes

(D) Cannot be determined

A **Correct**

The change in momentum of a block (the impulse) is equal to the average force applied to the block multiplied by the period of time the force is applied. Both blocks start from rest with zero momentum and the forces are applied for the same period of time (3 seconds). The 4 kg block experiences a greater force so it has a greater increase in momentum and a greater momentum after 3 seconds.

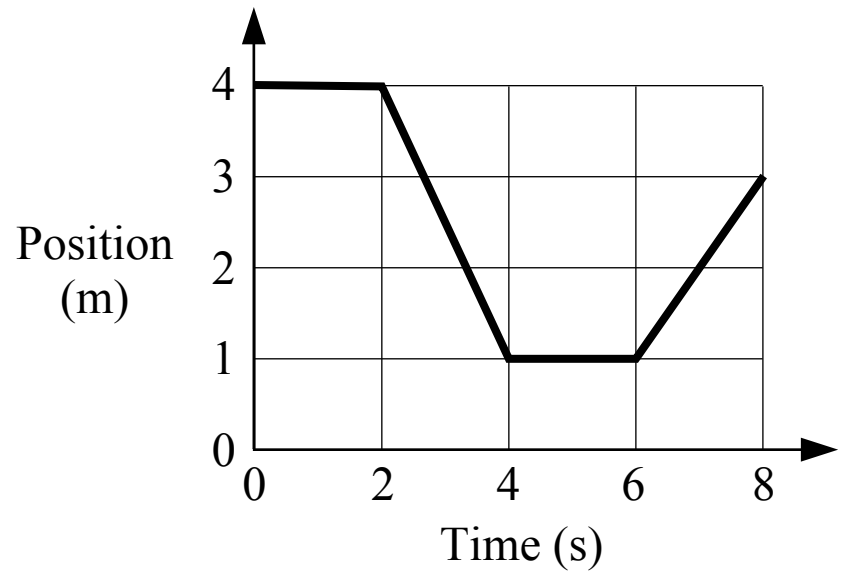
4 kg block: $\Delta p = F_{\text{avg}} \Delta t = (20\ \text{N})(3\ \text{s}) = 60\ \text{kg·m/s}$

8 kg block: $\Delta p = F_{\text{avg}} \Delta t = (10\ \text{N})(3\ \text{s}) = 30\ \text{kg·m/s}$

B Incorrect

C Incorrect

D Incorrect



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(D) The magnitude of the momentum is changing from 6 seconds to 8 seconds

A Incorrect

B Incorrect

C Correct

The slope of the position-time graph is the velocity of the cart, and the momentum of the cart is the mass of the cart multiplied by the velocity. The magnitude of the slope of the graph from 2 seconds to 4 seconds is greater than the magnitude of the slope from 6 seconds to 8 seconds so the magnitude of the momentum is also greater.

D Incorrect