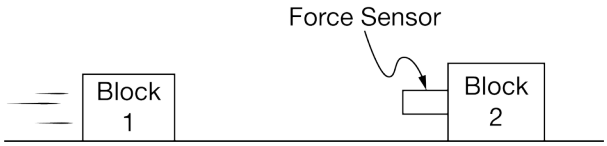
CHAPTER5PARTA

1.



On a straight horizontal track along which blocks can slide with negligible friction, block 1 slides toward block 2, which is initially at rest. Block 1 collides with an electronic force probe attached to block 2, generating a force vs. time graph and causing block 2 to start sliding. What additional measurements must be made to determine the momentum of block 2 after the collision?

(A) None

(B) The mass of block 2 only

(C) The post-collision speed of block 2 only

(D) Both the mass and the post-collision speed of block 1

2.

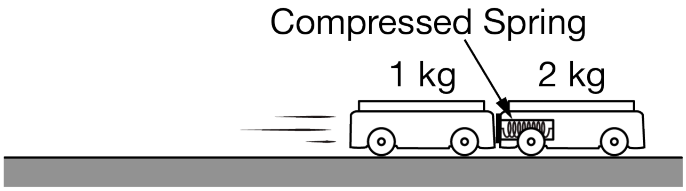


Figure 1

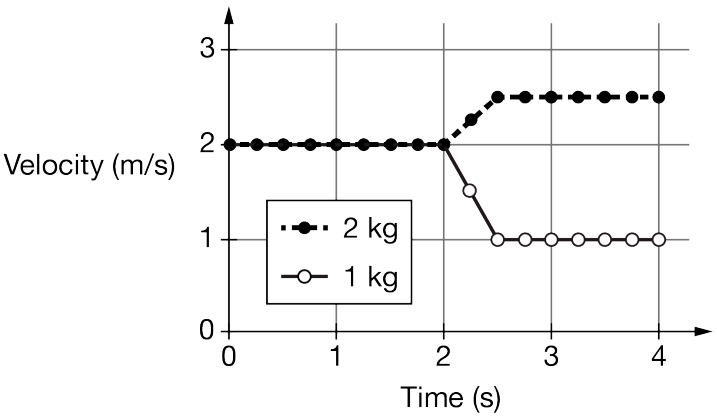


Figure 2

Two carts of masses $1\ \text{kg}$ and $2\ \text{kg}$ travel together, as shown in Figure 1. At time $t = 2\,\text{s}$, a compressed spring inside the $2\ \text{kg}$ cart expands, and the carts separate. Figure 2 shows a graph of the carts' velocities as a function of time. What is the magnitude of the change in linear momentum, if any, of the two-cart system between $t = 0\,\text{s}$ and $t = 4\,\text{s}$?

CHAPTER5PARTA

(A) $0\ \text{kg} \cdot \text{m/s}$
(B) $0.5\ \text{kg} \cdot \text{m/s}$
(C) $1.0\ \text{kg} \cdot \text{m/s}$
(D) $2.0\ \text{kg} \cdot \text{m/s}$

3. A 12 kg box sliding on a horizontal floor has an initial speed of 4.0 m/s. The coefficient of friction between the box and the floor is 0.20. The box moves a distance of 4.0 m in 2.0 s. The magnitude of the change in momentum of the box during this time is most nearly

(A) 12 kg·m/s
(B) 48 kg·m/s
(C) 60 kg·m/s
(D) 96 kg·m/s

4. A ball of mass 0.4 kg is initially at rest on the ground. It is kicked and leaves the kicker's foot with a speed of 5.0 m/s in a direction 60° above the horizontal. The magnitude of the impulse imparted by the ball to the foot is most nearly

(A) 1 N■s
(B) $\sqrt{3}N \cdot s$
(C) 2 N■s
(D) $\frac{2}{\sqrt{3}}N \cdot s$
(E) 4 N■s

5. A force of constant magnitude *F* and fixed direction acts on an object of mass *m* that is initially at rest. If the force acts for a time interval Δt over a displacement Δx , what is the magnitude of the resultant change in the linear momentum of the object?

(A) F Δt
(B) F Δx
(C) FΔt / m
(D) FΔx / m
(E) mF Δt

6. How does an air mattress protect a stunt person landing on the ground after a stunt?

(A) It reduces the kinetic energy loss of the stunt person.
(B) It reduces the momentum change of the stunt person.
(C) It increases the momentum change of the stunt person.
(D) It shortens the stopping time of the stunt person and increases the force applied during the landing.
(E) It lengthens the stopping time of the stunt person and reduces the force applied during the landing.

7. A pendulum has a length l and a bob of mass *m*. Which of the following is true of the linear momentum of the bob as it swings from its highest to lowest point?

CHAPTER5PARTA

(A) It remains constant because momentum is always conserved.

(B) It increases in magnitude and changes direction.

(C) It decreases in magnitude and does not change direction.

(D) It is converted to angular momentum.

(E) It is converted to kinetic energy.

8. A person applies an impulse of 5.0 kg·m/s to a box in order to set it in motion. If the person is in contact with the box for 0.25 s, what is the average force exerted by the person on the box?

(A) 1.25 N

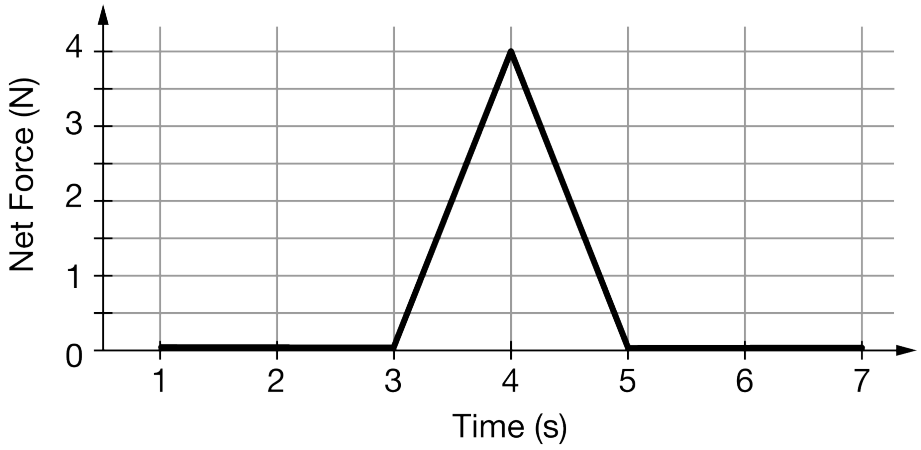
(B) 2.00 N

(C) 12.5 N

(D) 20.0 N

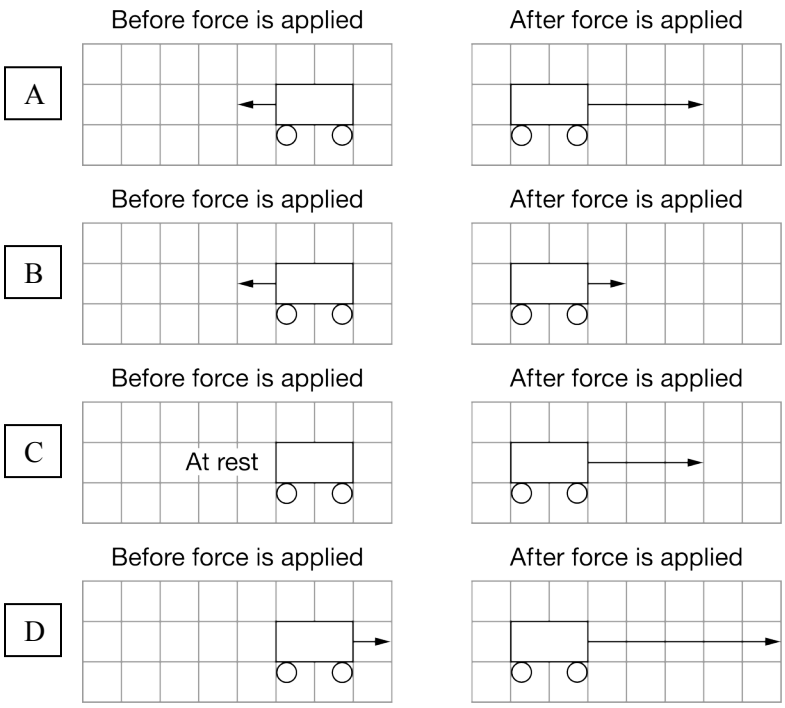
(E) 200 N

9.



A cart of mass $1\ \text{kg}$ travels along a horizontal, frictionless surface. A net force is applied to the cart. A graph of the net force applied to the cart as a function of time is shown. The initial and final direction of the cart and the direction of the net force exerted on the cart is unknown. The distance of one grid unit represents a change in velocity of $1\ \frac{\text{m}}{\text{s}}$. Which of the following diagrams could represent the direction and relative magnitude of the velocity of the cart before the force is applied and after the force is applied? Select two answers.

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10. A solid metal ball and a hollow plastic ball of the same external radius are released from rest in a large vacuum chamber. When each has fallen 1 m, they both have the same

(A) inertia
(B) speed
(C) momentum
(D) kinetic energy
(E) change in potential energy

11.

Position (m)	**Time** (s)
0.0	0.0
0.1	1.0
0.4	2.0
0.9	3.0
1.6	4.0

A block of mass $2.0\ \mathrm{kg}$, starting from rest, is pushed with a constant force across a horizontal track. The position of the block as a function of time is recorded, and the data are shown in the table. What is the magnitude of the change in momentum of the block between zero and 4.0 seconds?

(A) $0.8\ \mathrm{kg \cdot m/s}$
(B) $1.2\ \mathrm{kg \cdot m/s}$
(C) $1.6\ \mathrm{kg \cdot m/s}$
(D) $3.2\ \mathrm{kg \cdot m/s}$

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12.



A block with mass m_0 slides with negligible friction at a speed of v_0 across a horizontal surface. At $t = 0$, the block collides with a spring with unknown spring constant that is attached to the wall, as shown. At $t = t_1$, the spring is compressed a distance Δx and the block is momentarily at rest. Which of the following correctly describes how, if at all, the average force exerted on the block from $t = 0$ to $t = t_1$ could be calculated?

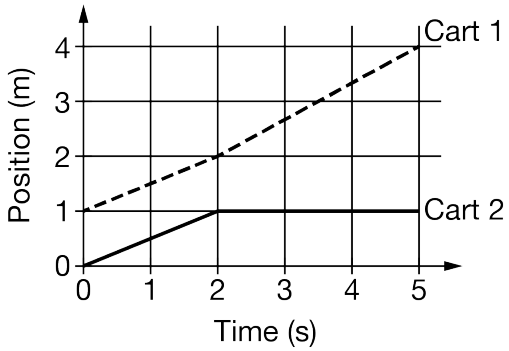
(A) Divide the change in the block's momentum from $t = 0$ to $t = t_1$ by time t_1.

(B) Multiply the change in the block's kinetic energy from $t = 0$ to $t = t_1$ by distance Δx.

(C) The average force cannot be calculated because the block's acceleration from $t = 0$ to $t = t_1$ is not constant.

(D) The average force cannot be calculated because the spring constant is not known.

13.



The graph above represents the position of two identical carts on a straight horizontal track as a function of time. Which of the following statements about the magnitude of the momentum of the two-cart system's center of mass, p_{com}, is true?

(A) p_{com} is constant from $t = 0$ s to $t = 5$ s.

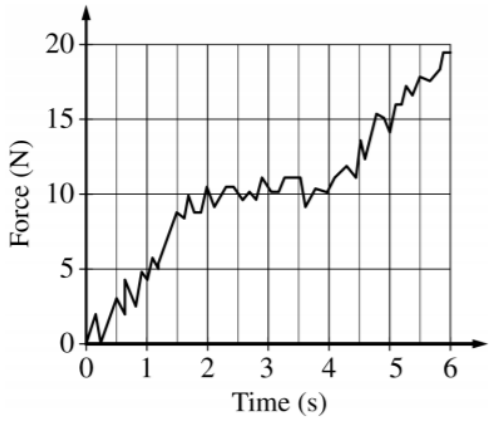
(B) p_{com} is smaller after $t = 2$ s than it is before $t = 2$ s.

(C) p_{com} is larger after $t = 2$ s than it is before $t = 2$ s.

(D) p_{com} increases at a constant rate from $t = 0$ s to $t = 5$ s.

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14.



During an experiment a student records the net horizontal force exerted on an object moving in a straight line along a horizontal frictionless track. The graph above shows the force as a function of time. Of the following, which is the best approximation of the magnitude of the change in momentum of the object between 0 s and 4 s?

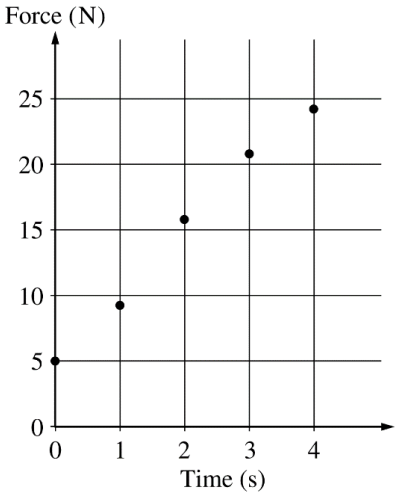
(A) 20 kg • m/s

(B) 30 kg • m/s

(C) 40 kg • m/s

(D) The magnitude of the change in momentum cannot be determined without knowing the mass of the object.

15.



A student obtains data on the magnitude of force applied to an object as a function of time and displays the data on the graph above.

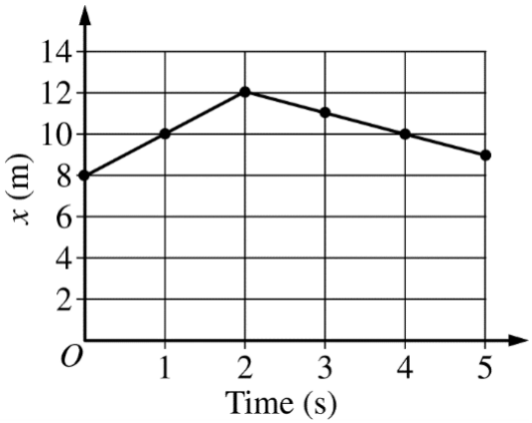
Answer the following question for the information and diagram above.

The increase in the momentum of the object between $t = 0$ s and $t = 4$ s is most nearly

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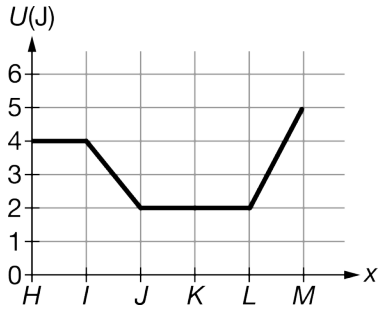
(A) 40 N·s
(B) 50 N·s
(C) 60 N·s
(D) 80 N·s
(E) 100 N·s

16.



The graph above shows the position x as a function of time for the center of mass of a system of particles of total mass 6.0 kg. For a very short time interval around 2.0 s, an external force is exerted on an object in the system. What is the resulting change in momentum of the system?

(A) 52 kg•m/s
(B) 6 kg•m/s
(C) -6 kg•m/s
(D) -18 kg•m/s



The graph above shows the potential energy U of a system as one object in the system moves along the x-axis and the rest of the system does not move. Six evenly-spaced points along the x-axis are labeled. At point H, the object is moving in the positive x-direction and the mechanical energy of the system is $5.0\ \mathrm{J}$. As the object moves, no energy enters or leaves the system.

17. Which of the following describes the magnitude of the momentum of the object in the first two straight-line segments shown in the graph as the object moves from point H to point J ?

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(A)

HI	IJ
Zero	Increasing

(B)

HI	IJ
Zero	Decreasing

(C)

HI	IJ
Constant but nonzero	Increasing

(D)

HI	IJ
Constant but nonzero	Decreasing

---

18. Cart X collides with Cart Y, which is initially at rest. After the collision, Cart X and Cart Y are moving in opposite directions. The collision lasts $0.3\ \mathrm{s}$, and the average force exerted on Cart Y by Cart X is $10\ \mathrm{N}$. What is the magnitude of the change in momentum of Cart X during the collision?

(A) $1.5\ \mathrm{kg \cdot m/s}$

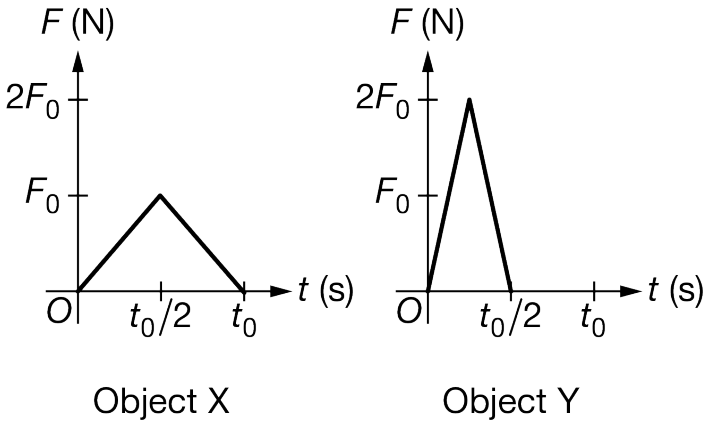
(B) $3.0\ \mathrm{kg \cdot m/s}$

(C) $3.3\ \mathrm{kg \cdot m/s}$

(D) The change in momentum of Cart X cannot be determined without knowing the masses and change in velocity of both carts.

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19.



Objects X and Y are constrained to move along a straight line. The graphs above show the net force exerted along that line on each of the objects as functions of time. Which of the following correctly ranks the change in momentum Δp of the objects?

(A) $\Delta p_{\mathrm{X}} < \Delta p_{\mathrm{Y}}$

(B) $\Delta p_{\mathrm{X}} = \Delta p_{\mathrm{Y}}$

(C) $\Delta p_{\mathrm{X}} > \Delta p_{\mathrm{Y}}$

(D) The ranking cannot be determined without knowing the masses of the objects.

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20.

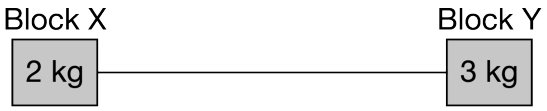


Figure 1

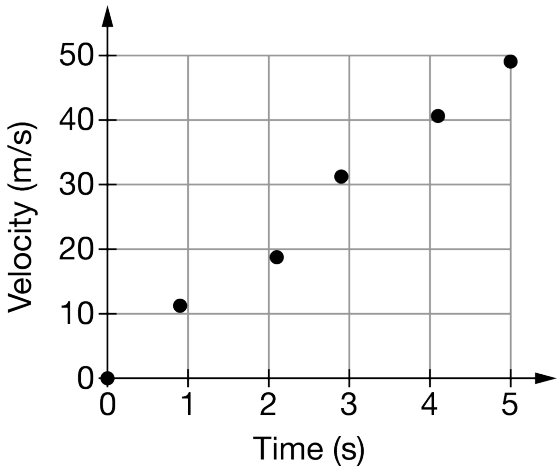


Figure 2. Data for block X

CHAPTER5PARTA

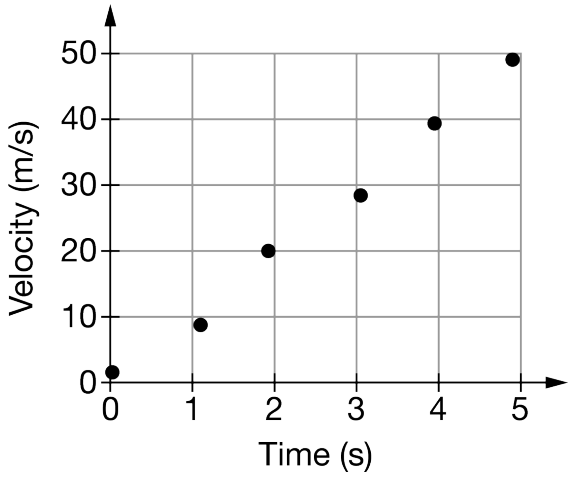


Figure 3. Data for block Y

A student performs an experiment in which two blocks, block X of mass $2\ \mathrm{kg}$ and block Y of mass $3\ \mathrm{kg}$, are tied together by a rope. The system containing Block X and Block Y is dropped above Earth's surface in the orientation shown in Figure 1. A motion detector below each block collected data that were graphed to show the velocity as a function of time for Blocks X and Y as they fell toward the ground. The graphs are shown in Figure 2 and Figure 3, respectively. The positive direction is considered to be down. The change in momentum for the system containing block X and block Y is most nearly

(A) $100\ \mathrm{kg \cdot m/s}$

(B) $125\ \mathrm{kg \cdot m/s}$

(C) $150\ \mathrm{kg \cdot m/s}$

(D) $250\ \mathrm{kg \cdot m/s}$

21.

Time (s)	Magnitude of the Applied Force (N)
0	0
2	2
4	4

A $2\ \mathrm{kg}$ object travels in the positive direction across a horizontal surface with a constant speed of $10\ \frac{\mathrm{m}}{\mathrm{s}}$. A force is exerted on the object for $4\ \mathrm{s}$, and the force increases linearly with respect to time. The table shows data about the magnitude of the applied force exerted on the object at different times. The force is exerted on the object in the opposite direction of the object's displacement. What is the change in momentum of the object?

(A) $8\ \mathrm{N \cdot s}$ in the positive direction

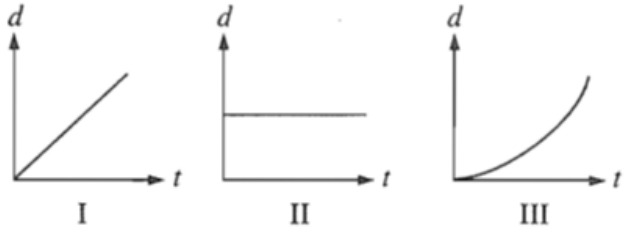
(B) $8\ \mathrm{N \cdot s}$ in the negative direction

(C) $16\ \mathrm{N \cdot s}$ in the positive direction

(D) $16\ \mathrm{N \cdot s}$ in the negative direction

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Three objects can only move along a straight, level path. The graphs below show the position *d* of each of the objects plotted as a function of time *t*.



22. The magnitude of the momentum of the object is increasing in which of the cases?

(A) II only

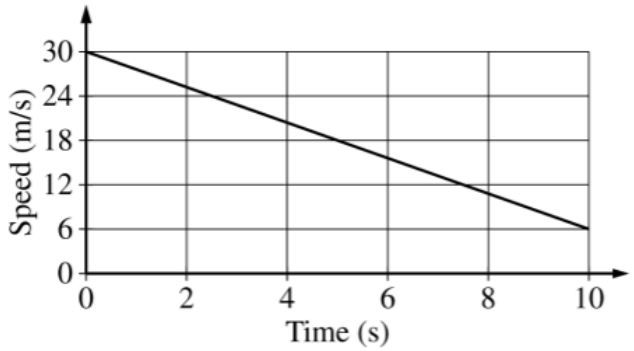
(B) III only

(C) I and II only

(D) I and III only

(E) I, II, and III

23.



The graph above shows the speed of a truck as it moves along a straight, level road. Which of the following describe a method to determine the distance d the truck travels during the 10 s time interval shown? Select two answers.

A Multiply the average speed of 18 m/s by the 10 s travel time.

B Multiply half the initial speed of 30 m / s by the 10 s travel time.

C Calculate the slope of the line in the graph to determine the acceleration a and then use $d = (1/2)at^2$, where t is the travel time.

D Calculate the area under the line in the graph.

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24.

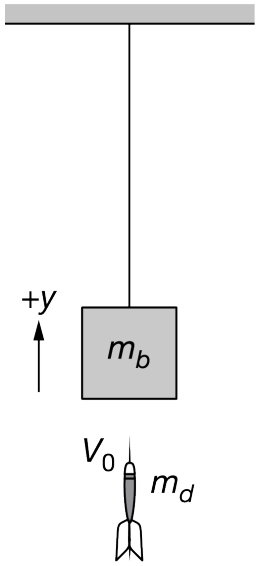


Figure 1

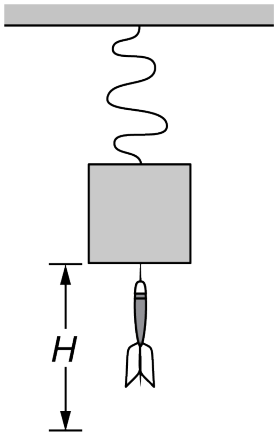


Figure 2

A dart of mass m_d is launched straight upward toward a block of mass m_b that hangs at rest from a string, as shown in Figure 1. Immediately before the dart collides with the block, the dart has a speed v_0. The dart then collides with and sticks to the block, and the dart-block system travels upward to a height H before the system comes to rest, as shown in Figure 2. What is the change in momentum of the dart-block system immediately before the collision to the instant when the system comes to rest?

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(A) Zero

(B) $-m_d v_0$

(C) $-(m_d + m_b)v_0$

(D) $-\frac{1}{2}(m_d + m_b)v_0$

25. An object of known mass M with speed v_0 travels toward a wall. The object collides with it and bounces away from the wall in the opposite direction in which the object was initially traveling. The wall exerts an average force F_0 on the object during the collision. A student must use the equation $\Delta \overrightarrow{p} = \overrightarrow{F}\Delta t$ to determine the change in momentum of the object from immediately before the collision to immediately after the collision. Which side of the equation could the student use to determine the change of the object's momentum?

(A) $\Delta \overrightarrow{p}$, because the mass of the object and the initial speed of the object are known.

(B) $\overrightarrow{F}\Delta t$, because the average force exerted on the object during the collision is known.

(C) Either side of the equation may be used because the mass of the object, the initial speed of the object, and the average force exerted on the object during the collision are known.

(D) Neither side of the equation may be used because there are too many unknown quantities before, during, and after the collision.

26. In an experiment, an object is released from rest near and above Earth's surface. A student must determine the relationship between the direction of the gravitational force exerted on the object and the change in momentum caused by that force. What data could the student collect to determine the magnitude and direction of the gravitational force and the change in momentum of the object? Justify your choices. Select two answers.

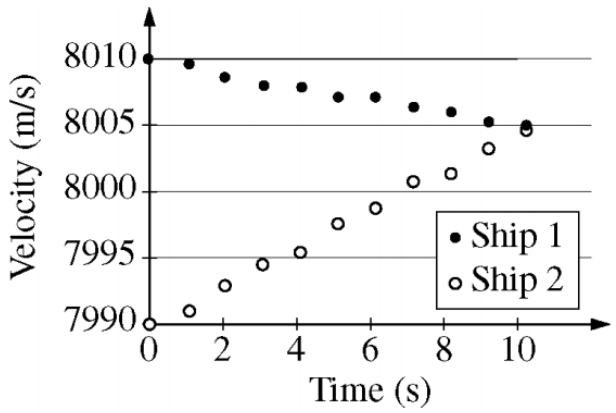
A The mass of the object, because it is required to determine the force due to gravity exerted on the object, and the velocity of the object the instant before it reaches Earth's surface, because it is required to determine the change in velocity of the object.

B The mass of the object, because it is required to determine the force due to gravity exerted on the object, and the distance fallen by the object, because the force is exerted during the entire falling distance.

C The velocity of the object the instant before it reaches Earth's surface, because it is required to determine the change in velocity of the object, and the acceleration of the object, because it is required to determine the force due to gravity exerted on the object.

D The distance fallen by the object, because the force is exerted during the entire falling distance, and the acceleration of the object, because it is required to determine the force due to gravity exerted on the object.

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Two identical spaceships are traveling in deep space, far from any planets or stars. The ships travel in the same direction, with the slower one directly behind the faster one. The ships are connected by a cable attached to a spool, so that the part of the cable outside the ships can be made longer or shorter as needed. The cable is used to bring the ships to the same speed for a transfer of cargo. The graph above shows the speed of the two ships during a 10 s interval.

27. Does at least one of the ships have its engine turned on during the time interval shown, and what evidence indicates so?

(A) Yes, because Ship 2 is speeding up.

(B) Yes, because the momentum of the two-rocket system increases.

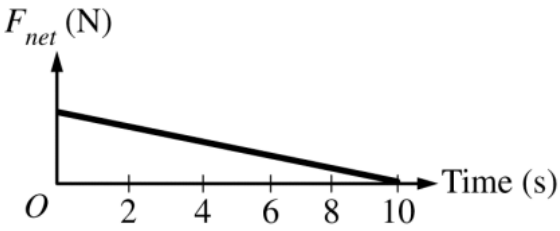
(C) Yes, because an engine is needed to keep the system moving.

(D) No, because the cable alone could be responsible for making Ship 1 slow down and Ship 2 speed up.

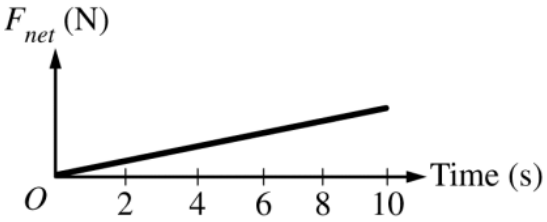
28. Which of the following graphs best represents the net force F_{net} exerted on the two-ship system?

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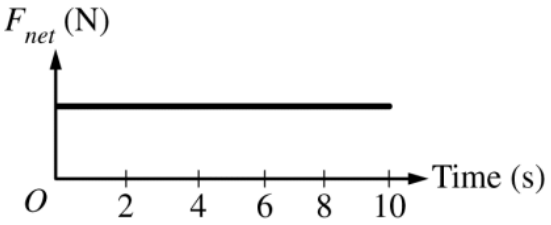
(A)



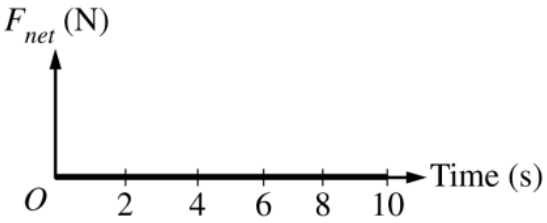
(B)



(C)

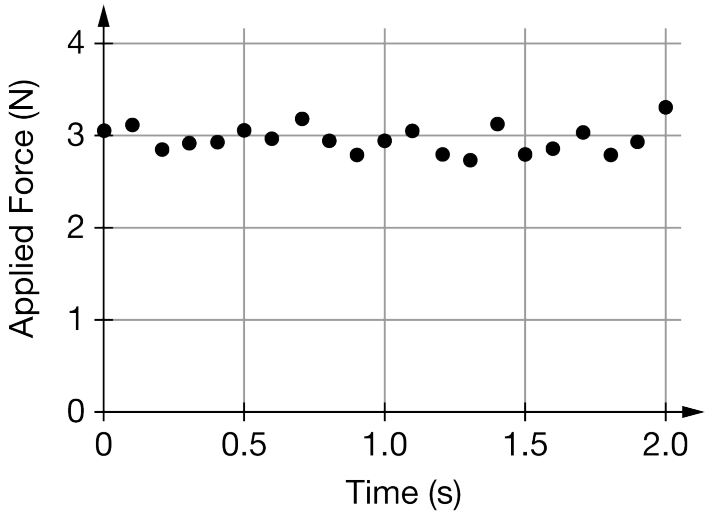


(D)



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29.



A student conducts an experiment in which an object travels across a horizontal surface while for $2\ \text{s}$ a net force is applied to a $2\ \text{kg}$ object that initially travels with a speed of $0.5\ \text{m/s}$. Data collected from the experiment are used to create the graph of the magnitude of the applied force exerted on the object as a function of time is shown. All frictional forces are considered to be negligible. Can the student use the graph and the known data to determine the momentum of the object after the force has been applied?

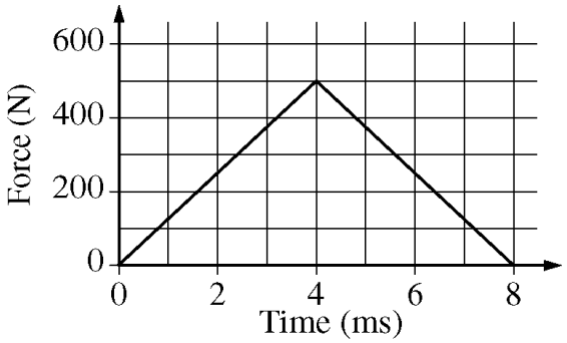
(A) Yes, because the average force exerted on the object can be used with the time interval of $2\ \text{s}$ to determine the change in momentum of the object by using $\Delta \vec{p} = \vec{F}\,\Delta t$.

(B) Yes, because the area bound by the best-fit line and the horizontal axis from $0\ \text{s}$ to $2\ \text{s}$ can be used to determine the change in momentum of the object.

(C) No, because the data is too scattered to determine the average force that is exerted on the object.

(D) No, because the student needs to know the direction that the force is applied to the object because the applied force will be in the same direction as the change in momentum of the object.

30.



A 0.050 kg tennis ball is moving to the left at 10 m/s when it is hit by a tennis racket that is moving to the right. The magnitude of the force exerted on the ball by the racket as a function of time is shown in the figure above. What is the speed of the ball after the collision with the racket?

CHAPTER5PARTA

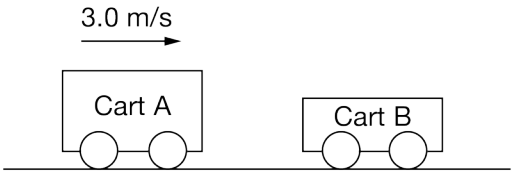
(A) 30 m/s

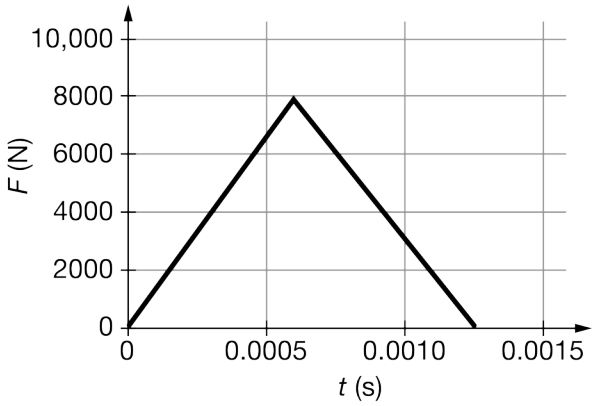
(B) 50 m/s

(C) 70 m/s

(D) 90 m/s

31.





Cart A with a mass of $2.0\ \mathrm{kg}$ travels at a constant speed of $3.0\ \frac{\mathrm{m}}{\mathrm{s}}$ to the right on a horizontal surface, as shown in the figure. Cart A then collides with cart B with a mass of $1.5\ \mathrm{kg}$ that is initially at rest. The force F exerted on cart B by cart A as a function of time t is shown in the graph, where $t = 0\ \mathrm{s}$ is the instant of initial contact between the carts. As a result of the collision, cart B moves to the right with a speed of $3.2\ \frac{\mathrm{m}}{\mathrm{s}}$. All frictional forces are considered to be negligible. A student must determine the final speed and direction of cart A and considers using the following equations.

Equation 1: $\Delta \vec{p} = \vec{F}\,\Delta t$

Equation 2: $\Sigma \vec{p}_{\,0} = \Sigma \vec{p}_{\,f}$

Identify and justify which equation or equations the student can use.

(A) Only equation 1, because the momentum lost by cart A is gained by cart B. This change in momentum can be determined using the graph.

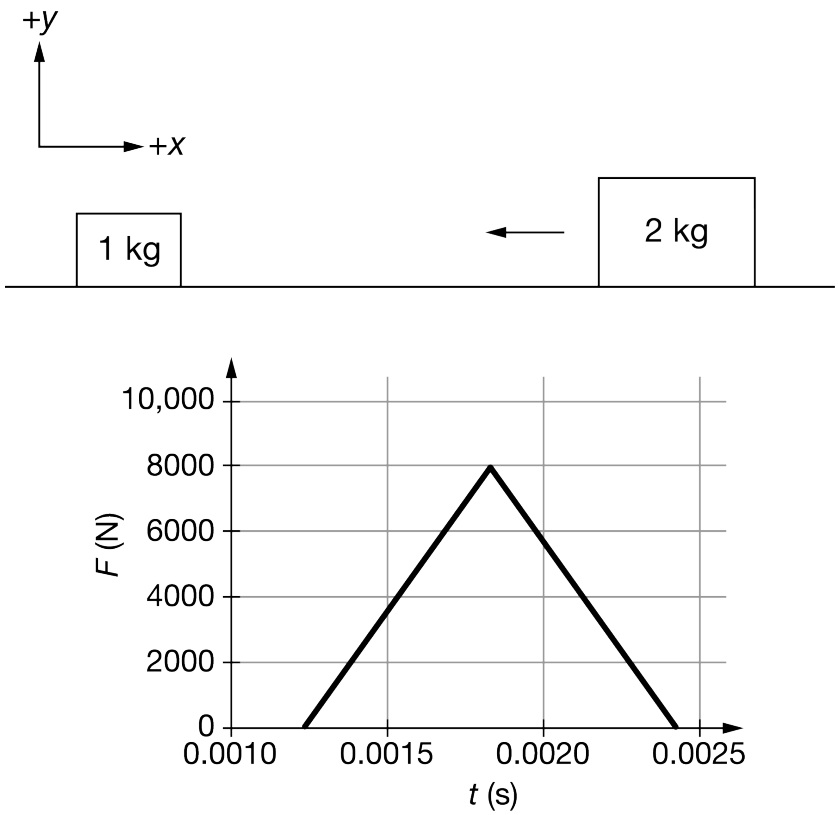
(B) Only equation 2, because the force is exerted only on cart B, so there is no information about the force exerted on cart A.

(C) Equation 1 and equation 2, because the system is closed and all quantities are known except for the final speed of cart A.

(D) Neither equation, because there are too many unknown quantities.

CHAPTER5PARTA

32.



An object of mass $2\ \text{kg}$ collides with an object of mass $1\ \text{kg}$ that is at rest, as shown in the figure. A graph of the force as a function of time that the $1\ \text{kg}$ object exerts on the $2\ \text{kg}$ object is shown. After the collision, the $2\ \text{kg}$ object has a speed of $2\ \frac{\text{m}}{\text{s}}$, and the $1\ \text{kg}$ object has a speed of $8\ \frac{\text{m}}{\text{s}}$. A student must determine the initial speed v_0 of the $2\ \text{kg}$ object. Which of the following options shows the correct substitutions into the equation $\Delta \vec{p} = \vec{F}\,\Delta t$ so that the initial speed of the unknown object can be determined?

(A) $(2\ \text{kg})(2\ \frac{\text{m}}{\text{s}} - v_0) = (8000\ \text{N})(0.00125\ \text{s})$, because the maximum force exerted on the $2\ \text{kg}$ object must be considered.

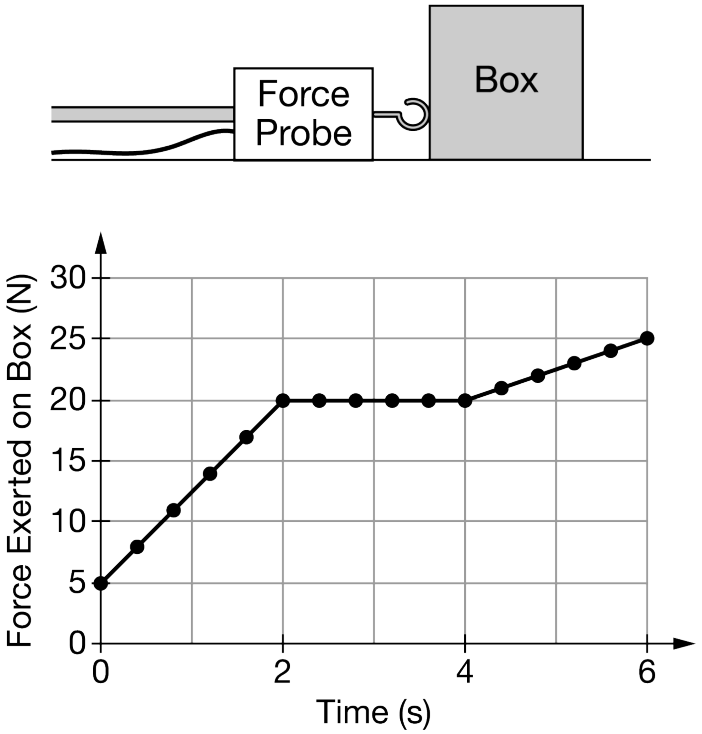
(B) $(2\ \text{kg})(2\ \frac{\text{m}}{\text{s}} - v_0) = \frac{1}{2}(8000\ \text{N})(0.00125\ \text{s})$, because the average force exerted on the $2\ \text{kg}$ object must be considered.

(C) $(2\ \text{kg} - 1\ \text{kg})(2\ \frac{\text{m}}{\text{s}} - v_0) = (8000\ \text{N})(0.00125\ \text{s})$, because the difference in mass and the maximum force exerted on the $2\ \text{kg}$ object must be considered.

(D) $(2\ \text{kg} - 1\ \text{kg})(2\ \text{m/s} - v_0) = \frac{1}{2}(8000\ \text{N})(0.00125\ \text{s})$, because the difference in mass and the average force exerted on the $2\ \text{kg}$ object must be considered.

CHAPTER5PARTA

33.



A force probe is used to push a box across a smooth surface, as shown in the figure. Frictional forces are considered to be negligible. The force probe collects data about the force exerted on the box as a function of time. The data are used to create the graph that is shown. During which time interval does the box experience the greatest change in its momentum?

(A) 0 s to 2 s

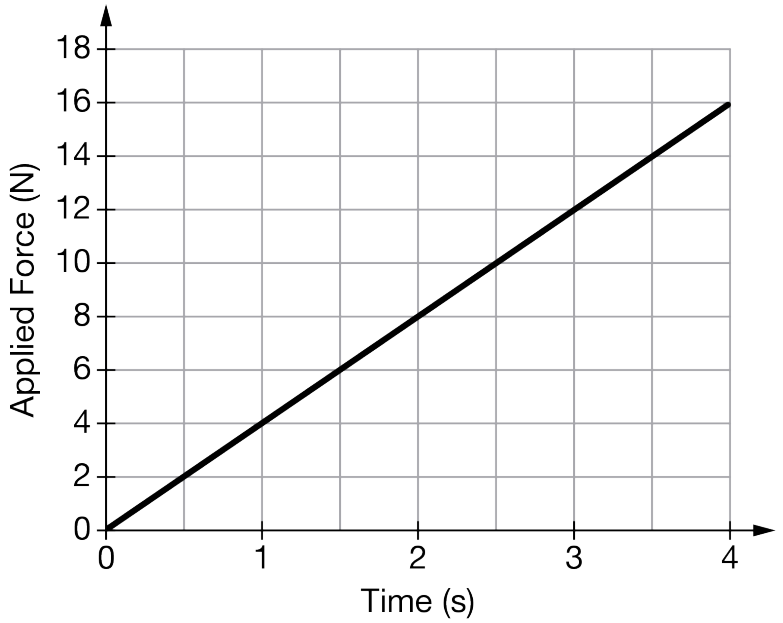
(B) 2 s to 4 s

(C) 4 s to 6 s

(D) The change in momentum is the same for each interval of time.

CHAPTER5PARTA

34.



A $2\ \text{kg}$ object travels across a horizontal surface with a constant speed of $6\ \frac{\text{m}}{\text{s}}$. An applied force that increases with time is then exerted on the object. A graph of the force exerted on the object as a function of time is shown. The applied force is in the direction of the object's displacement. All frictional forces are considered to be negligible. What is the object's speed after the force has been applied for $4\ \text{s}$?

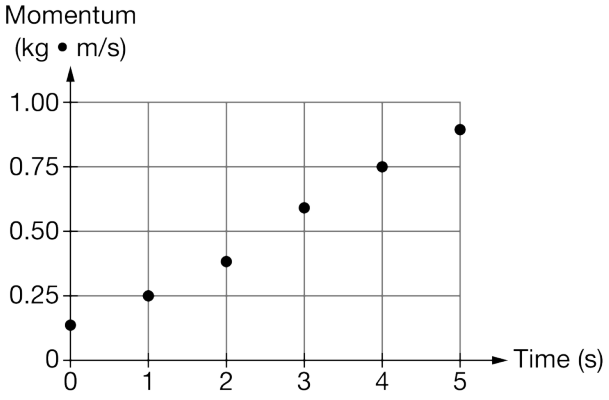
(A) $16\ \frac{\text{m}}{\text{s}}$

(B) $22\ \frac{\text{m}}{\text{s}}$

(C) $32\ \frac{\text{m}}{\text{s}}$

(D) $44\ \frac{\text{m}}{\text{s}}$

35.



A cart travels toward the right on a track where friction between the cart and track is negligible. The momentum of the cart as a function of time is modeled in the graph. Which of the following statements are true for the time recorded? Select two answers.

CHAPTER5PARTA

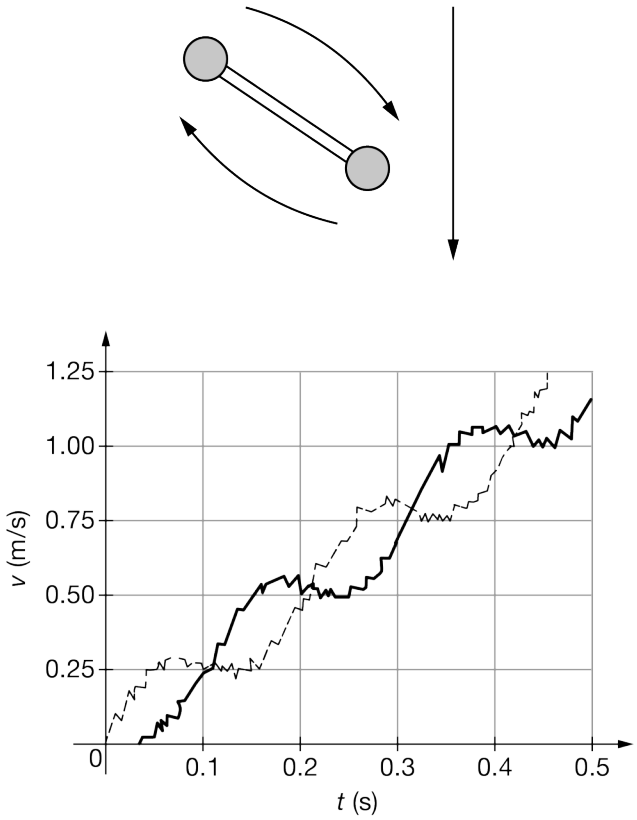
A The change in momentum of the cart is nearly equal to $1.9\ \text{kg} \cdot \text{m/s}$.

B The impulse delivered to the cart is nearly equal to $0.75\ \text{kg} \cdot \text{m/s}$.

C The net external force exerted on the cart is nearly equal to $0.15\ \text{N}$.

D The work done on the cart is nearly equal to $1.5\ \text{J}$.

36.



Two identical spheres of known mass M are attached to opposite ends of a rod of negligible mass. The mass-rod-mass system is spun in the vertical plane and then released so the system falls downward as it rotates, as shown in the figure. Data are collected and shown in the graph of the vertical velocity, v, of the two spheres as a function of time t. The positive direction is considered to be downward. A student uses the graph to make three claims.
Claim 1: Change in linear momentum of the center of mass of the system from $0.0\ \text{s}$ to $0.5\ \text{s}$ can be determined.
Claim 2: The average applied force exerted on the center of mass of the system from $0.0\ \text{s}$ to $0.5\ \text{s}$ can be determined.
Claim 3: The change in the kinetic energy of the system from $0.0\ \text{s}$ to $0.5\ \text{s}$ can be determined.
Which of the student's claims are correct?

(A) Claim 1 and claim 2 only

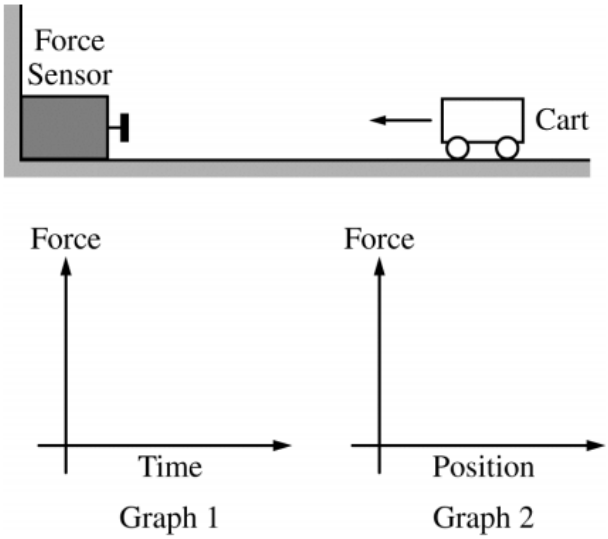
(B) Claim 1 and claim 3 only

(C) Claim 2 and claim 3 only

(D) Claim 1, claim 2, and claim 3

CHAPTER5PARTA

37.



A cart of known mass moves with known speed along a level, frictionless track, as shown in the figure above. The cart hits a force sensor and rebounds. The force sensor measures the force exerted on the cart as a function of time and as a function of the position of the cart. The results will be graphed on the axes shown. Which of the two graphs can be used to determine the cart's speed after it rebounds?

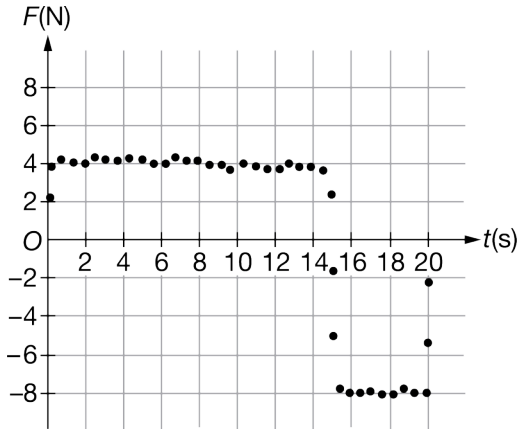
(A) Only graph 1; graph 2 will have no information useful for finding the speed.

(B) Only graph 2; graph 1 will have no information useful for finding the speed.

(C) Either graph 1 or graph 2 can be used.

(D) Neither graph alone is sufficient; both graph 1 and graph 2 are needed.

38.



A stationary cart attached to a force gauge is on a straight, horizontal, frictionless track. A student uses the force gauge to move the cart, and the gauge produces the graph of force as a function of time shown above. How does the momentum of the cart change during the time interval 0 s to 20 s ?

CHAPTER5PARTA

(A) The momentum increases in magnitude during the entire time interval.

(B) The momentum decreases in magnitude during the entire time interval.

(C) The momentum increases in magnitude at first, then decreases and reverses direction.

(D) The momentum increases in magnitude at first, then decreases without reversing direction.

39. Ball X of mass $1.0\ \mathrm{kg}$ and ball Y of mass $0.5\ \mathrm{kg}$ travel toward each other on a horizontal surface. Both balls travel with a constant speed of $5\ \mathrm{m/s}$ until they collide. During the collision, ball Y exerts an average force with a magnitude of $40\ \mathrm{N}$ for $\frac{1}{6}\ \mathrm{s}$ on ball X. Which of the following best predicts ball Y's momentum after the collision?

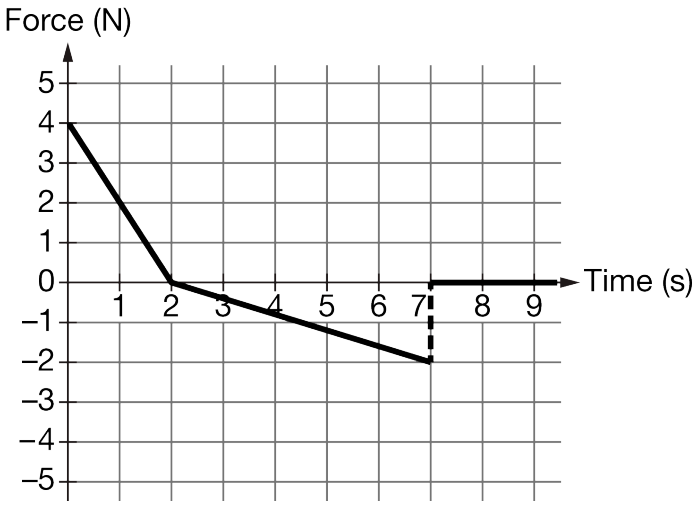
(A) Ball Y will travel at a speed less than $5\ \mathrm{m/s}$ in the same direction of travel as before the collision.

(B) Ball Y will travel at a speed less than $5\ \mathrm{m/s}$ in the opposite direction of travel as before the collision.

(C) Ball Y will travel at a speed greater than $5\ \mathrm{m/s}$ in the opposite direction of travel as before the collision.

(D) Ball Y's motion cannot be predicted because the impulse on it is not known.

40.



An object is initially at rest. A varying force is applied to the object as shown in the graph. Which of the following correctly explains the momentum of the object at time $t = 7\ \mathrm{s}$?

(A) The final momentum of the object is negative because the slope of the graph is negative the entire time from $t = 0\ \mathrm{s}$ to $t = 7\ \mathrm{s}$.

(B) The final momentum of the object is positive because the maximum magnitude of the force in the positive direction is twice the maximum magnitude of the force in the negative direction.

(C) The final momentum of the object is negative because the magnitude of the area bounded by the graph and the horizontal axis is less from $t = 0\ \mathrm{s}$ to $t = 2\ \mathrm{s}$ than from $t = 2\ \mathrm{s}$ to $t = 7\ \mathrm{s}$.

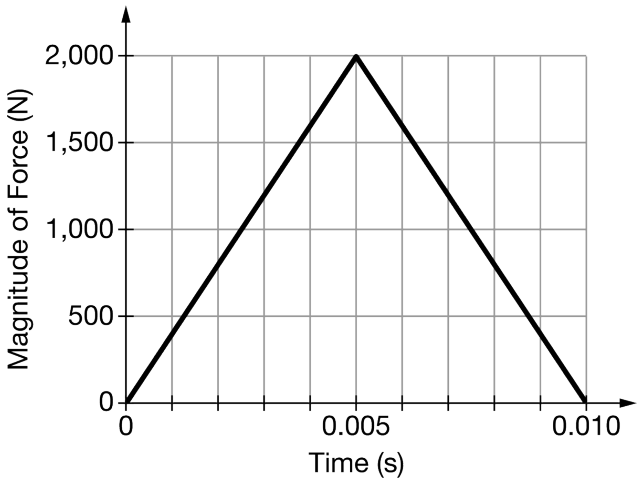
(D) The final momentum of the object is positive because the average magnitude of the force is higher from $t = 0\ \mathrm{s}$ to $t = 2\ \mathrm{s}$ than the average magnitude of the force from $t = 2\ \mathrm{s}$ to $t = 7\ \mathrm{s}$.

CHAPTER5PARTA

Scenario Number	Final Velocity of Cart X	Final Velocity of Cart Y
1	0	v_{Y1}
2	v_{X2}	v_{Y2}
3	$-v_{X3}$	v_{Y3}

Cart X of mass m_0 travels along a horizontal surface with a constant speed in the positive horizontal direction. Cart X then collides with cart Y of mass M_0, which was initially at rest. After the collision, cart Y has a positive velocity. Immediately after the collision, cart X and cart Y could have one of three final velocities that are indicated in the table. In all scenarios, the total momentum of the two-cart system is the same before and after the collision.

41.



Assume that the collision in each scenario is elastic. A graph of the magnitude of the force exerted on Cart Y as a function of time for scenario 1 is shown. During which interval of time does the magnitude of the momentum of Cart Y change the most?

(A) 0. s to 0.002 s

(B) 0.004 s to 0.006 s

(C) 0.008 s to 0.010 s

(D) The change in momentum is the same for each time interval listed.

CHAPTER5PARTA

42.

Velocity of Object X Before Collision	Velocity of Object Y Before Collision	Velocity of Object X After Collision	Velocity of Object Y After Collision
$4v_0$	$-v_0$	$\frac{2v_0}{3}$	$\frac{2v_0}{3}$

Object X of mass M travels toward object Y of mass 2M in such a way that they collide. The table contains data about the velocities of object X and object Y immediately before the collision and immediately after the collision. What are the change in momentum of the two-object system and the change in momentum of each object from immediately before the collision to immediately after the collision?

(A)

Change in Momentum of the System	Change in Momentum of Object X	Change in Momentum of Object Y
Zero	$-\frac{10Mv_0}{3}$	$\frac{10Mv_0}{3}$

(B)

Change in Momentum of the System	Change in Momentum of Object X	Change in Momentum of Object Y
Zero	$\frac{10Mv_0}{3}$	$-\frac{10Mv_0}{3}$

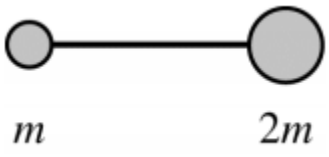
(C)

Change in Momentum of the System	Change in Momentum of Object X	Change in Momentum of Object Y
$\frac{20Mv_0}{3}$	$-\frac{10Mv_0}{3}$	$\frac{10Mv_0}{3}$

(D)

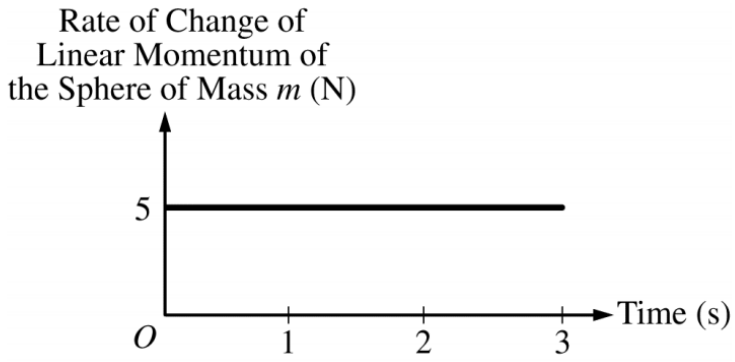
Change in Momentum of the System	Change in Momentum of Object X	Change in Momentum of Object Y
Zero	Zero	Zero

CHAPTER5PARTA



A system consists of two spheres, of mass m and $2m$, connected by a rod of negligible mass, as shown above. The system is held at its center of mass with the rod horizontal and released from rest near Earth's surface at time $t = 0$.

43.



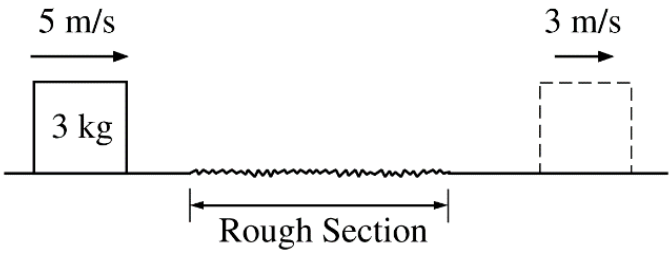
The graph above shows the rate of change of linear momentum of the sphere of mass m as a function of time. What is the linear momentum of the two-sphere system at time $t = 3.0$ s ?

(A) 5 kg· m/s

(B) 15 kg· m/s

(C) 45 kg· m/s

(D) 60 kg· m/s



A block of mass 3 kg slides along a horizontal surface that has negligible friction except for one section, as shown above. The block arrives at the rough section with a speed of 5 m/s and leaves it 0.5 s later with a speed of 3 m/s.

44. What is the magnitude of the average frictional force exerted on the block by the rough section of the surface?

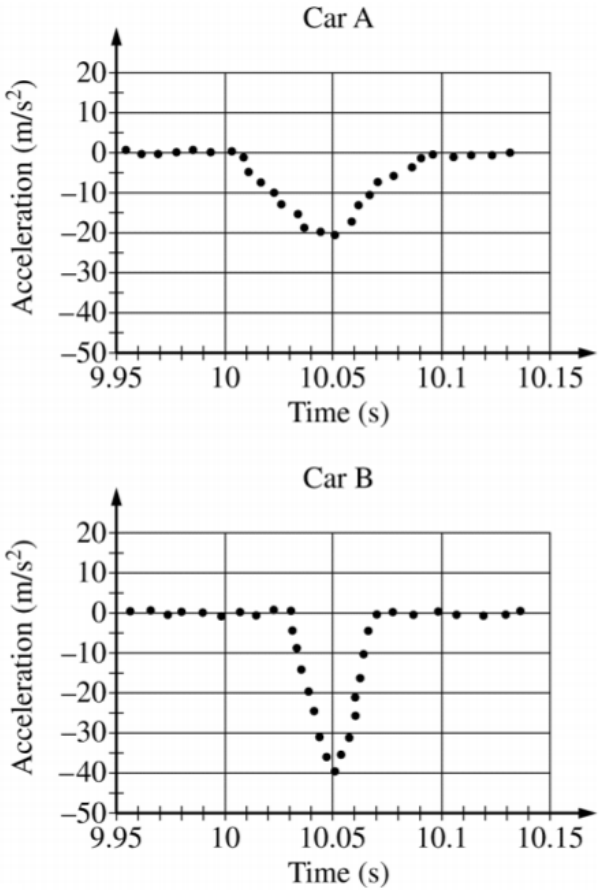
CHAPTER5PARTA

(A) 30 N
(B) 12 N
(C) 4.5 N
(D) 4 N
(E) 3 N

45. What is the magnitude of the work done by the frictional force exerted on the block by the rough section of the surface?

(A) 24 J
(B) 16 J
(C) 8 J
(D) 6 J
(E) 3 J

46.



Two model cars, A and B, have the same mass but different bumpers. The acceleration of each car during its collision with a wall is measured, and the data are shown in the graphs above. Which of the following statements about the collisions are correct? Select two answers.

CHAPTER5PARTA

A Both cars reach their maximum speed at 10.05 s.

B The cars experience approximately the same impulse.

C Car B experiences a nonzero force for a longer time than car A.

D The change in momentum for car B occurs over a shorter period of time than for car A.

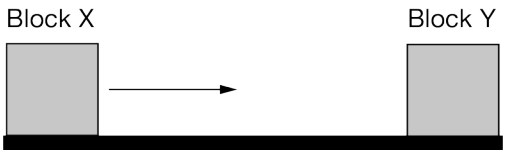
47. A student drops an object from rest above a force plate that records information about the force exerted on the object as a function of time during the time interval in which the object is in contact with the force plate. Which of the following measurements should the student take, in addition to the measurements from the force plate, to determine the change in momentum of the object from immediately before the collision to immediately after the collision?

(A) The mass of the object

(B) The final speed of the object

(C) The distance fallen by the object

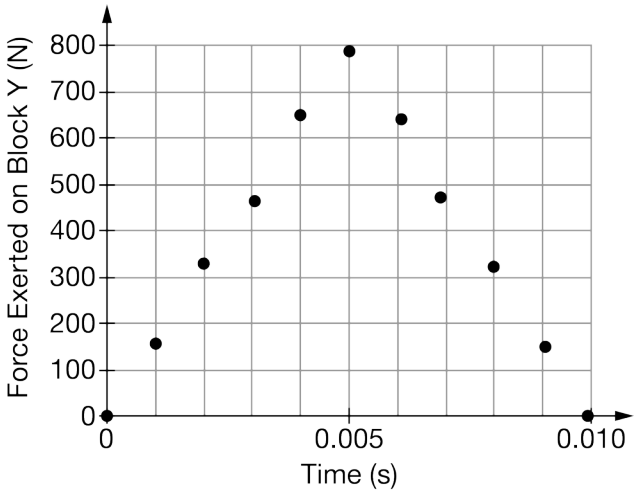
(D) The student has enough information to make the determination.



A student plans to conduct an experiment in which the momentum of a two-object system can be determined immediately before and after a collision takes place. The student slides block X at an unknown constant speed toward an identical block, block Y, that is initially at rest, as shown in the figure. There is negligible friction between the blocks and the surface.

CHAPTER5PARTA

48.



The student conducts a second experiment in which the magnitude of the force exerted on block X from block Y is measured over the time in which the collision takes place. A graph of the force as a function of time is shown. In a third experiment, the student creates a collision such that the force exerted on block X from block Y is constant for $0.020\ \mathrm{s}$. Which of the following constant forces, if exerted on block X from block Y, would produce the same change in momentum as is shown by the graph?

(A) $100\ \mathrm{N}$

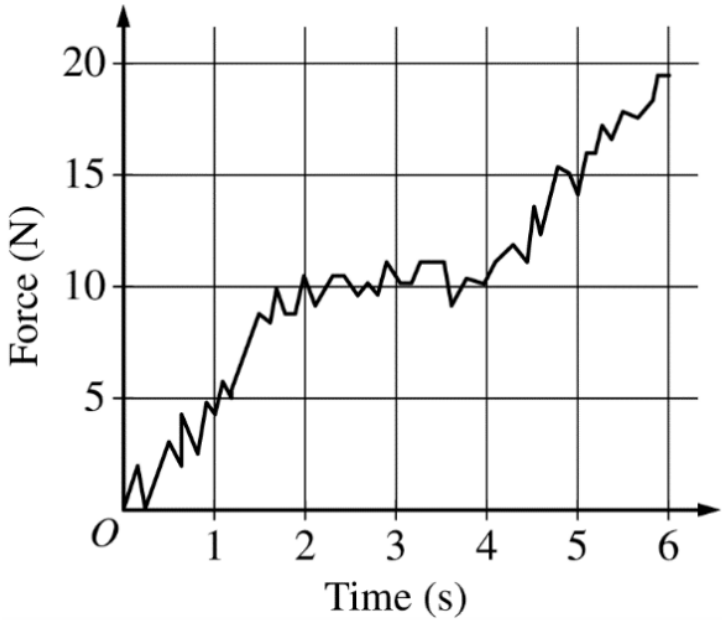
(B) $200\ \mathrm{N}$

(C) $400\ \mathrm{N}$

(D) $800\ \mathrm{N}$

CHAPTER5PARTA

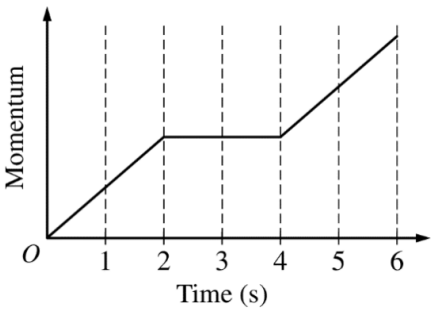
49.



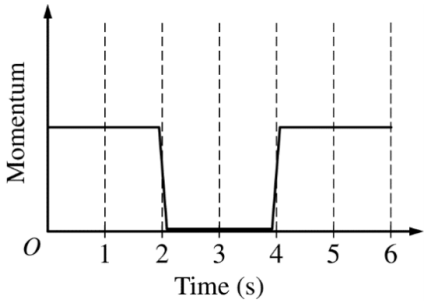
Using a force probe, a student generates the graph above of the force exerted on a small wagon as a function of time. The wagon starts from rest and rolls with negligible friction in the axles. Which of the following graphs best represents the wagon's momentum as a function of time?

CHAPTER5PARTA

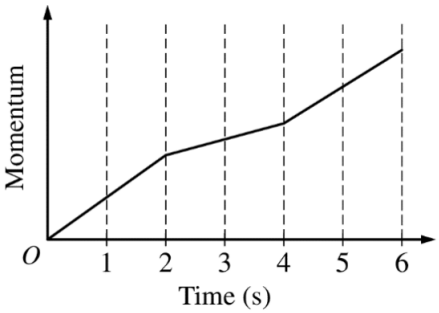
(A)



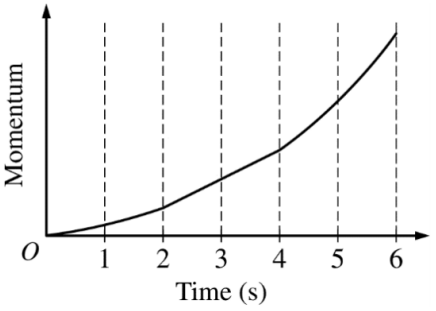
(B)



(C)



(D)



50. A student must determine a nonzero change in momentum of an object for a specific interval of time. Which of the following experiments could the student conduct? Select two answers.

CHAPTER5PARTA

A Drop a ball of known mass above a motion detector, and record the final speed of the ball before it reaches the motion sensor.

B Drop a coffee filter of known mass from a known height above a motion sensor, and record the terminal speed of the coffee filter as it falls.

C Pull a block of known mass across a rough surface with a spring such that the block travels at a constant speed for 5 s as measured by a stopwatch. Record the force necessary to pull the block at a constant speed.

D Give a block of known mass an initial velocity so that it slides across a rough surface in front of a motion detector, slows down, and eventually stops. Use the motion detector to record the initial velocity of the block.

51. A student must conduct an experiment in which a block is pulled across a horizontal surface by a spring scale so that a nonzero change in momentum of the block can be determined for a specific time interval. The student also has access to measuring tools that are found in a typical physics laboratory. Which of the following experiments could the student conduct to determine the change in momentum of the cart? Select two answers.

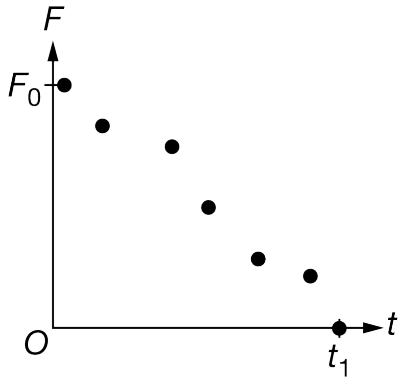
A Attach the spring scale to the block, and pull the block at a constant speed as it travels across the horizontal surface. Record the force that the spring scale exerts on the block. Use a stopwatch to determine the time that the block is in motion.

B Attach the spring scale to the block, and pull the block so that its speed increases as it travels across the horizontal surface. Record the force that the spring scale exerts on the block. Use a stopwatch to determine the time that the block is in motion.

C Attach the spring scale to the block, and pull the block so that its speed increases as it travels across the horizontal surface. Use the motion detector to record the speed of the block at the beginning of the time interval and at the end of the time interval. Use a mass balance to measure the mass of the block.

D Attach the spring scale to the block, and pull the block so that its speed increases as it travels across the horizontal surface. Use the motion detector to record the speed of the block at the beginning of the time interval and at the end of the time interval. Use a meterstick to measure the distance traveled by the block in the given time interval.

52.



An object of mass m is moving in the positive x-direction with an initial speed v. Starting at time $t = 0$, a time-varying force F with initial magnitude F_0 is exerted on the object in the positive x-direction. Measurements of the force as a function of time are represented in the graph above. Which of the following statements is true about the motion of the object between $t = 0$ and $t = t_1$?

CHAPTER5PARTA

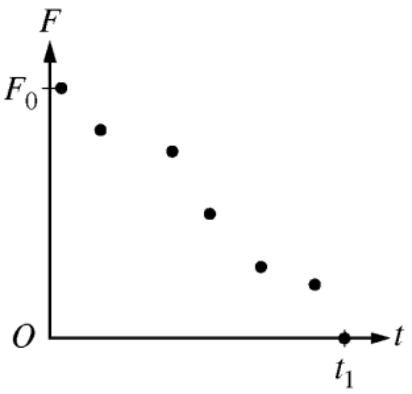
(A) The momentum of the object has decreased to zero at time t_1.

(B) The momentum of the object has increased by approximately $\frac{1}{2}F_0t_1$.

(C) The momentum of the object has decreased by approximately $\frac{1}{2}F_0t_1$.

(D) The momentum of the object at time t_1 is $mv + F_0t_1$.

53.



A soft foam block of mass *m* slides without friction in the positive *x*-direction with speed *v*. At time *t* = 0 , a student briefly pushes the block with a force probe in the positive *x*-direction. The graph above shows the force probe's measurements as a function of time during the push. Which of the following statements is true about the block's momentum between *t* = 0 and *t* = t_1?

(A) The momentum of the block has decreased to zero at time t_1.

(B) The momentum of the block has increased by approximately 1/2 F_0t_1

(C) The momentum of the block has decreased by approximately 1/2 F_0t_1

(D) The change in momentum cannot be determined without knowing the distance by which the force probe compressed the block.

54.

Experiment Number	Mass of Object (kg)	Magnitude of Net Force (N)	Time that Force Is Applied (s)	Initial Velocity $(\mathrm{m/s})$	Final Velocity $(\mathrm{m/s})$
1	2	4.0	3	0	6
2	2	4.0	3	3	-3
3	2	4.0	3	-3	-9

An object is used in three different experiments so that a student can analyze the motion of the object when a net force is exerted on it. The data obtained from the three experiments are shown in the table. How can the student use the data to determine the relationship between the object's change in momentum and the direction of the net force exerted on the object?

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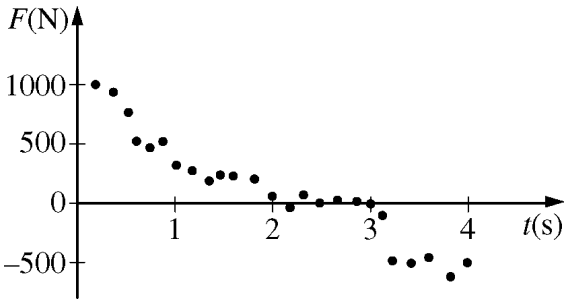
(A) Observe that the magnitude of the net force and the amount of time that the force is applied remain the same in each experiment. Therefore, the net force changes the momentum of the object in the same direction for all experiments.

(B) Observe that the magnitude of the net force, the amount of time that the force is applied, and the mass of the object remain the same in each experiment. Therefore, the net force changes the momentum of the object in the same direction for all experiments.

(C) Observe the direction of the velocity vectors for the initial and final velocity measurements for each experiment. If the final velocity is negative, the net force changes the momentum in the opposite direction of motion. If the final velocity is positive, the net force changes the momentum in the same direction of motion.

(D) The student can calculate the change in the velocity of the object for each experiment. If the object decreases its speed or changes direction, the net force changes the momentum in the opposite direction of motion. If the object increases its speed and travels in the same direction, the net force changes the momentum in the same direction of motion.

55.



A spacecraft of mass 4000 kg is traveling in a straight line in the positive direction. Engines can be fired so that the force exerted on the spacecraft is in the positive or negative direction. The graph above shows data for the force during one interval. Which of the following is the best estimate of the net change in the speed of the spacecraft from time $t = 0$ to time $t = 4$ s?

(A) +0.4 m/s

(B) +0.1 m/s

(C) -0.1 m/s

(D) -0.4 m/s

56. An object of mass $5\ \text{kg}$ travels in the positive direction with a speed of $1\ \frac{\text{m}}{\text{s}}$. The object collides with a second object that exerts an average net force over an interval of time such that the $5\ \text{kg}$ object comes to rest. Which of the following best predicts the change in momentum for the $5\ \text{kg}$ object?

(A) The change in momentum is in the negative direction.

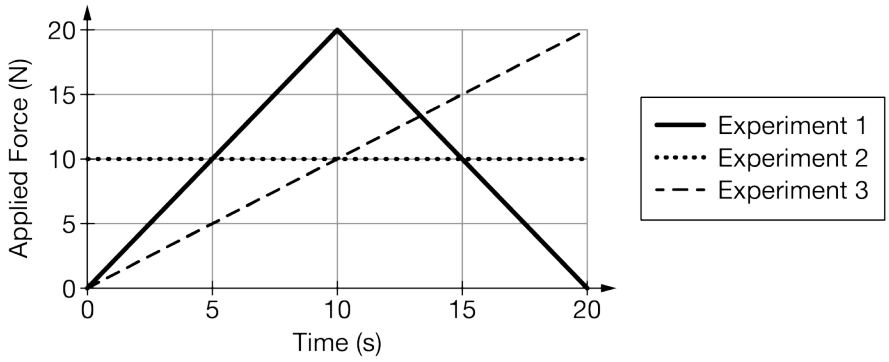
(B) The change in momentum is in the positive direction.

(C) The change in momentum is zero.

(D) The direction of the change in momentum cannot be determined without knowing the value of the average force and time in which the force is exerted.

CHAPTER5PARTA

57.



A student conducts three experiments in which a cart of mass M is pushed along a horizontal surface of negligible friction for 20 s by an applied force. The graph shows the force as a function of time for each experiment. Which of the following correctly ranks the greatest change in the cart's momentum from 0 s to 20 s?

(A) Experiment $3 >$ Experiment $2 >$ Experiment 1

(B) Experiment $1 =$ Experiment $3 >$ Experiment 2

(C) Experiment $1 >$ Experiment $3 >$ Experiment 2

(D) Experiment $3 =$ Experiment $2 =$ Experiment 1

58. A ball, of mass 1.0kg, is released from rest above a horizontal surface. The ball falls downward and collides with the surface with a speed of $2.0\ \frac{\text{m}}{\text{s}}$. The average force exerted during the collision is 20 N over a time interval of 0.1 s. Which of the following best predicts what will happen to the ball immediately after the collision?

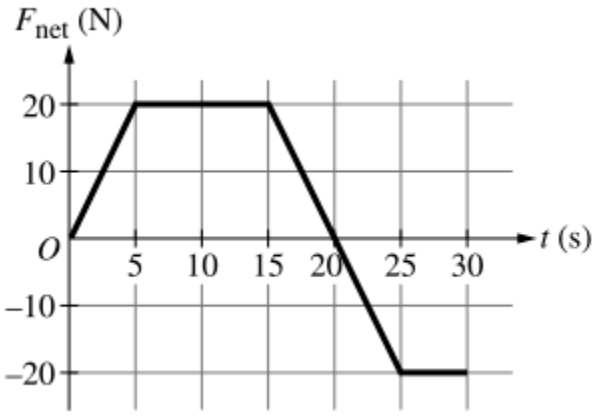
(A) The ball will come to rest on the surface.

(B) The ball will bounce up from the surface with a speed lower than what it had before the collision.

(C) The ball will bounce up from the surface with the same speed as it had before the collision.

(D) The ball will bounce up from the surface with a speed greater than what it had before the collision.

59.

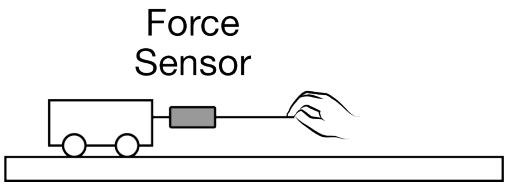


A crate of mass 75 kg is initially at rest on a horizontal surface. The graph shows the net horizontal force F_{net} exerted on the crate as a function of time t. At $t = 30$ s, what is the approximate speed of the crate?

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(A) $2\ \mathrm{m/s}$
(B) $4\ \mathrm{m/s}$
(C) $6\ \mathrm{m/s}$
(D) $8\ \mathrm{m/s}$

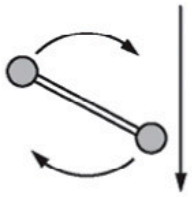
60.

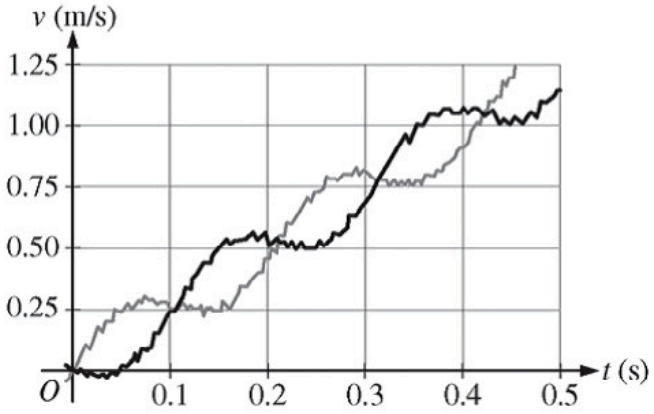


A cart of known mass M is initially at rest on a straight horizontal track, and a force sensor attached to a string is used to pull on the cart. The wheels of the cart have negligible mass and negligible internal friction. Which of the following indicates how a graph of the force sensor reading as a function of time can be used to estimate the final speed of the cart?

(A) By multiplying the area under the graph by M
(B) By dividing the area under the graph by M
(C) By multiplying the slope of the graph by M
(D) By dividing the slope of the graph by M

61.





A student on another planet has two identical spheres, each of mass 0.6 kg, attached to the ends of a rod of negligible mass. The student gives the assembly a rotation in the vertical plane and then releases it so it falls, as shown in the top figure above. Sensors record the vertical velocity of the two spheres, and the data is shown in the graph of velocity v as a function of time t. Another student wants to calculate the assembly's angular speed and the change in the linear momentum of the center of mass of the assembly between 0 s and 0.3 s. Which of these quantities can be determined using the graph?

CHAPTER5PARTA

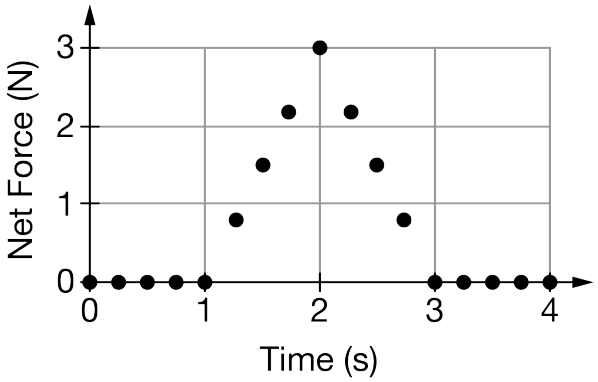
(A) Angular speed only

(B) Change in linear momentum only

(C) Angular speed and change in linear momentum

(D) Neither of these quantities can be determined using the graph.

62.



In an experiment, a variable net force is applied to an object. A graph of the net force exerted on the object as a function of time is shown. Which of the following experiments could have been conducted to represent the variable net force shown in the graph?

(A) A $0.2\ \text{kg}$ object increases its speed from $2\ \text{m/s}$ to $8\ \text{m/s}$.

(B) A $1\ \text{kg}$ object increases its speed from $2\ \text{m/s}$ to $4\ \text{m/s}$.

(C) A $2\ \text{kg}$ object increases its speed from $1\ \text{m/s}$ to $3\ \text{m/s}$.

(D) A $3\ \text{kg}$ object increases its speed from $0\ \text{m/s}$ to $1\ \text{m/s}$.