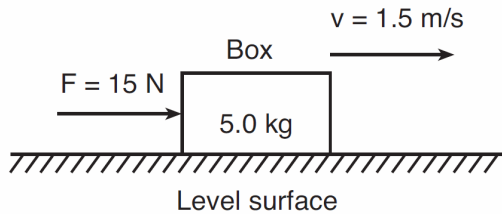


Momentum and Impulse

1. A 5.00-kilogram block slides along a horizontal, frictionless surface at 10.0 meters per second for 4.00 seconds. The magnitude of the block's momentum is
 A) 200. kg•m/s **B) 50.0 kg•m/s**
 C) 20.0 kg•m/s D) 12.5 kg•m/s
2. As shown in the diagram below, an open box and its contents have a combined mass of 5.0 kilograms. A horizontal force of 15 newtons is required to push the box at a constant speed of 1.5 meters per second across a level surface.



The inertia of the box and its contents increases if there is an increase in the

- A) speed of the box
 - B) mass of the contents of the box**
 - C) magnitude of the horizontal force applied to the box
 - D) coefficient of kinetic friction between the box and the level surface
-
3. In the diagram below, a 10-kilogram ball is fired with a velocity of 500 meters per second from a 1,000-kilogram cannon. What is the recoil velocity of the cannon?

 A) 5 m/s B) 2 m/s
 C) 10 m/s D) 500 m/s
 4. A 5-newton ball and a 10-newton ball are released simultaneously from a point 50 meters above the surface of the Earth. Neglecting air resistance, which statement is true?
 A) The 5-N ball will have a greater acceleration than the 10-N ball.
 B) The 10-N ball will have a greater acceleration than the 5-N ball.
C) At the end of 3 seconds of free-fall, the 10-N ball will have a greater momentum than the 5-N ball.
 D) At the end of 3 seconds of free-fall, the 5-N ball will have a greater momentum than the 10-N ball.
 5. An air bag is used to safely decrease the momentum of a driver in a car accident. The air bag reduces the magnitude of the force acting on the driver by
A) increasing the length of time the force acts on the driver
 B) decreasing the distance over which the force acts on the driver
 C) increasing the rate of acceleration of the driver
 D) decreasing the mass of the driver

Unit Review

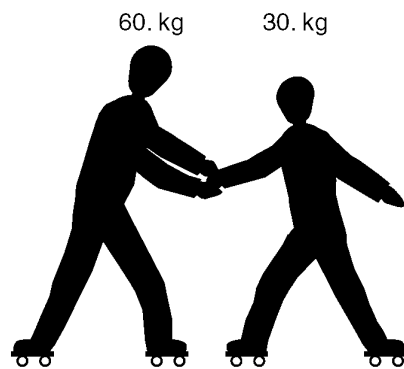
6. A 75-kilogram hockey player is skating across the ice at a speed of 6.0 meters per second. What is the magnitude of the average force required to stop the player in 0.65 second?

A) 120 N B) 290 N
C) **690 N** D) 920 N

7. A 0.45-kilogram football traveling at a speed of 22 meters per second is caught by an 84-kilogram stationary receiver. If the football comes to rest in the receiver's arms, the magnitude of the impulse imparted to the receiver by the ball is

A) 1800 N•s B) **9.9 N•s**
C) 4.4 N•s D) 3.8 N•s

8. In the diagram below, a 60.-kilogram rollerskater exerts a 10.-newton force on a 30.-kilogram rollerskater for 0.20 second.



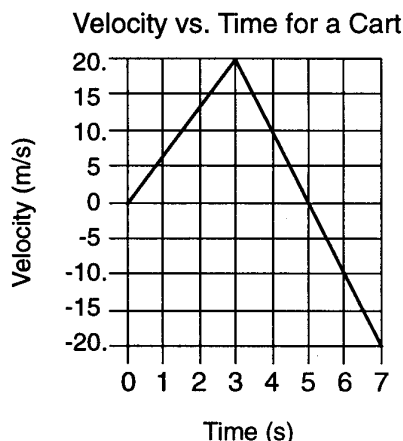
What is the magnitude of the impulse applied to the 30.-kilogram rollerskater?

A) 50. N•s B) **2.0 N•s**
C) 6.0 N•s D) 12 N•s

9. A 40.-kilogram mass is moving across a horizontal surface at 5.0 meters per second. What is the magnitude of the net force required to bring the mass to a stop in 8.0 seconds?

A) 1.0 N B) 5.0 N C) **25 N** D) 40. N

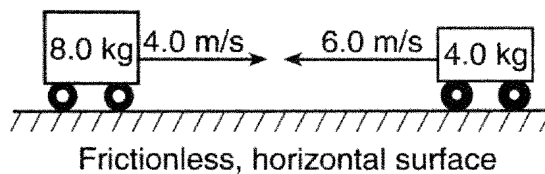
10. The velocity-time graph below represents the motion of a 3-kilogram cart along a straight line. The cart starts at $t = 0$ and initially moves north.



What is the magnitude of the change in momentum of the cart between $t = 0$ and $t = 3$ seconds?

A) 20 kg m/s B) 30 kg m/s
C) **60 kg m/s** D) 80 kg m/s

11. The diagram below shows an 8.0-kilogram cart moving to the right at 4.0 meters per second about to make a head-on collision with a 4.0-kilogram cart moving to the left at 6.0 meters per second.

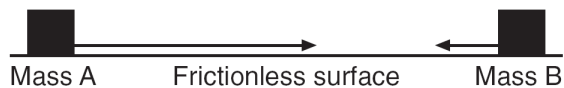


After the collision, the 4.0-kilogram cart moves to the right at 3.0 meters per second. What is the velocity of the 8.0-kilogram cart after the collision?





A) **0.50 m/s left** B) 0.50 m/s right
C) 5.5 m/s left D) 5.5 m/s right

Unit Review

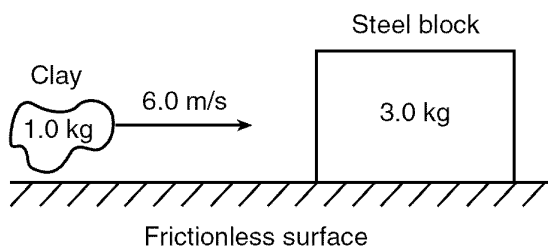
12. In the diagram below, scaled vectors represent the momentum of each of two masses, A and B , sliding toward each other on a frictionless, horizontal surface.



Which scaled vector best represents the momentum of the system after the masses collide?

- A) 
B) 
C) 
D) 

13. A 3.0-kilogram steel block is at rest on a friction-less horizontal surface. A 1.0-kilogram lump of clay is propelled horizontally at 6.0 meters per second toward the block as shown in the diagram below.

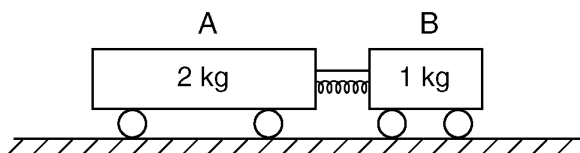


Upon collision, the clay and steel block stick together and move to the right with a speed of

- A) 1.5 m/s B) 2.0 m/s
C) 3.0 m/s D) 6.0 m/s

14. Base your answer to the following question on the information and diagram below.

The diagram shows a compressed spring between two carts initially at rest on a horizontal frictionless surface. Cart A has a mass of 2 kilograms and cart B has a mass of 1 kilogram. A string holds the carts together.



After the string is cut and the two carts move apart, the magnitude of which quantity is the same for both carts?

- A) momentum B) velocity C) inertia D) kinetic energy

Unit Review

15. A 0.050-kilogram bullet is fired from a 4.0 kilogram rifle that is initially at rest. If the bullet leaves the rifle with momentum having a magnitude of 20. kilogram•meters per second, the rifle will recoil with a momentum having a magnitude of

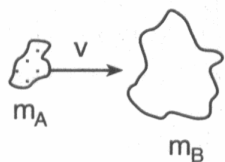
A) 1,600 kg•m/s B) 80. kg•m/s
C) **20. kg•m/s** D) 0.25 kg•m/s

16. A 3.1 kilogram gun initially at rest is free to move. When a 0.015-kilogram bullet leaves the gun with a speed of 500. meters per second, what is the speed of the gun?

A) 0.0 m/s **B) 2.4 m/s**
C) 7.5 m/s D) 500. m/s

17. The diagram below represents two masses before and after they collide. Before the collision, mass m_A is moving to the right with speed v , and mass m_B is at rest. Upon collision, the two masses stick together.

Before Collision



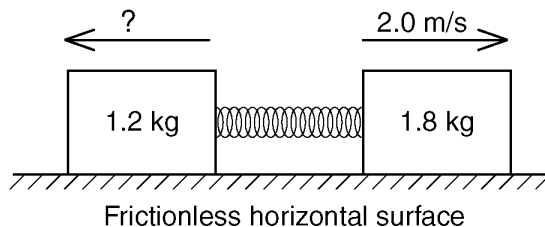
After Collision



Which expression represents the speed, v' , of the masses after the collision? [Assume no outside forces are acting on m_A or m_B .]

A) $\frac{m_A + m_B v}{m_A}$ B) $\frac{m_A + m_B}{m_A v}$
C) $\frac{m_B v}{m_A + m_B}$ **D) $\frac{m_A v}{m_A + m_B}$**

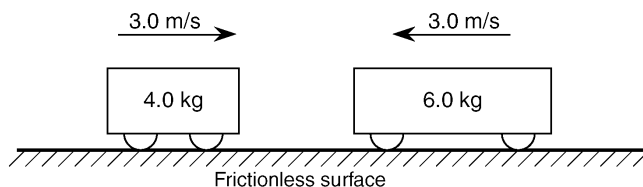
18. A 1.2-kilogram block and a 1.8-kilogram block are initially at rest on a frictionless, horizontal surface. When a compressed spring between the blocks is released, the 1.8-kilogram block moves to the right at 2.0 meters per second, as shown.



What is the speed of the 1.2-kilogram block after the spring is released?

A) 1.4 m/s B) 2.0 m/s
C) **3.0 m/s** D) 3.6 m/s

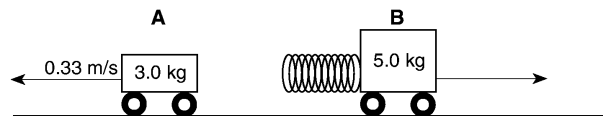
19. The diagram below shows a 4.0-kilogram cart moving to the right and a 6.0-kilogram cart moving to the left on a horizontal frictionless surface.



When the two carts collide they lock together. The magnitude of the total momentum of the two-cart system after the collision is

A) 0.0 kg•m/s **B) 6.0 kg•m/s**
C) 15 kg•m/s D) 30. kg•m/s

20. The diagram below shows two carts that were initially at rest on a horizontal, frictionless surface being pushed apart when a compressed spring attached to one of the carts is released. Cart A has a mass of 3.0 kilograms and cart B has a mass of 5.0 kilograms.

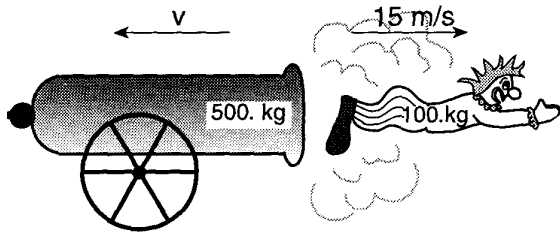


If the speed of cart A is 0.33 meter per second after the spring is released, what is the approximate speed of cart B after the spring is released?

A) 0.12 m/s **B) 0.20 m/s**
C) 0.33 m/s D) 0.55 m/s

Unit Review

21. In the diagram below, a 100.-kilogram clown is fired from a 500.-kilogram cannon.



If the clown's speed is 15 meters per second after the firing, the recoil speed (v) of the cannon is

- A) 75 m/s B) 15 m/s
C) **3.0 m/s** D) 0 m/s
22. On a snow-covered road, a car with a mass of 1.1×10^3 kilograms collides head-on with a van having a mass of 2.5×10^3 kilograms traveling at 8.0 meters per second. As a result of the collision, the vehicles lock together and immediately come to rest. Calculate the speed of the car immediately before the collision. [Neglect friction.] [Show all work, including the equation and substitution with units.]
23. A 70-kilogram hockey player skating east on an ice rink is hit by a 0.1-kilogram hockey puck moving toward the west. The puck exerts 50-newton force toward the west on the player. Determine the magnitude of the force that the player exerts on the puck during this collision.
24. A cart travels 4.00 meters east and then 4.00 meters north. Determine the magnitude of the cart's resultant displacement.

Base your answers to questions **25** and **26** on the information below.

A 1200-kilogram car moving at 12 meters per second collides with a 2300-kilogram car that is waiting at rest at a traffic light. After the collision, the cars lock together and slide. Eventually, the combined cars are brought to rest by a force of kinetic friction as the rubber tires slide across the dry, level, asphalt road surface.

25. Calculate the magnitude of the frictional force that brings the locked-together cars to rest. [Show all work, including the equation and substitution with units.]
26. Calculate the speed of the locked-together cars immediately after the collision. [Show all work, including the equation and substitution with units.]
-

Unit Review

27. Calculate the magnitude of the impulse applied to a 0.75-kilogram cart to change its velocity from 0.50 meter per second east to 2.00 meters per second east. [Show all work, including the equation and substitution with units.]

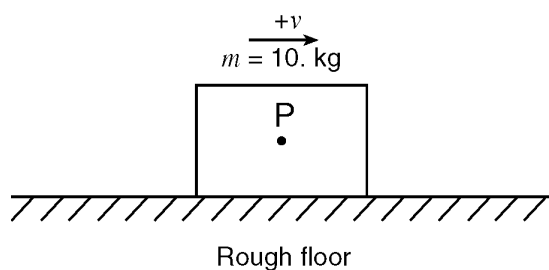
Base your answers to questions **28** and **29** on the information below.

The instant before a batter hits a 0.14-kilogram baseball, the velocity of the ball is 45 meters per second west. The instant after the batter hits the ball, the ball's velocity is 35 meters per second east. The bat and ball are in contact for 1.0×10^{-2} second.

28. Calculate the magnitude of the average force the bat exerts on the ball while they are in contact. [Show all work, including the equation and substitution with units.]
29. Determine the magnitude and direction of the average acceleration of the baseball while it is in contact with the bat.

Base your answers to questions **30** and **31** on the information and diagram below.

A 10.-kilogram box, sliding to the right across a rough horizontal floor, accelerates at -2.0 meters per second² due to the force of friction.



30. Calculate the coefficient of kinetic friction between the box and the floor. [Show all work, including the equation and substitution with units.]
31. On the diagram provided, draw a vector representing the net force acting on the box. Begin the vector at point *P* and use a scale of 1.0 centimeter = 5.0 newtons.

Base your answers to questions **32** and **33** on the information below.

An 8.00-kilogram ball is fired horizontally from a 1.00×10^3 -kilogram cannon initially at rest. After having been fired, the momentum of the ball is 2.40×10^3 kilogram•meters per second east. [Neglect friction.]

32. Identify the direction of the cannon's velocity after the ball is fired.
33. Calculate the magnitude of the cannon's velocity after the ball is fired.

Base your answers to questions **34** through **38** on the information below.

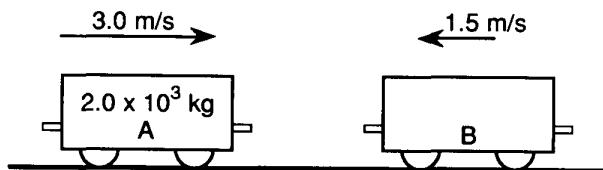
A manufacturer's advertisement claims that their 1,250-kilogram (12,300-newton) sports car can accelerate on a level road from 0 to 60.0 miles per hour (0 to 26.8 meters per second) in 3.75 seconds.

34. Using the values for the forces you have calculated, explain whether or not the manufacturer's claim for the car's acceleration is possible.
35. The coefficient of friction between the car's tires and the road is 0.80. Calculate the maximum force of friction between the car's tires and the road. [Show all work, including the equation and substitution with units.]
36. What is the normal force exerted by the road on the car?
37. Calculate the net force required to give the car the acceleration claimed in the advertisement. [Show all work, including the equation and substitution with units.]
38. Determine the acceleration, in meters per second², of the car according to the advertisement.

Unit Review

39. Base your answers to parts a through c on the diagram and information below.

Two railroad carts, A and B, are on a frictionless, level track. Cart A has a mass of 2.0×10^3 kilograms and a velocity of 3.0 meters per second toward the right. Cart B has a velocity of 1.5 meters per second toward the left. The magnitude of the momentum of cart B is 6.0×10^3 kilogram-meters per second. When the two carts collide, they lock together.



a

What is the magnitude of the momentum of cart A before the collision? (Show all calculations, including equations and substitutions with units.)

b

Below the drawing of Cart A, construct a scaled vector that represents the momentum of cart A before the collision. The momentum vector must be drawn to a scale of 1.0 centimeter = 1,000 kilogram-meters per second. Be sure your final answer appears with correct labels (numbers and units).

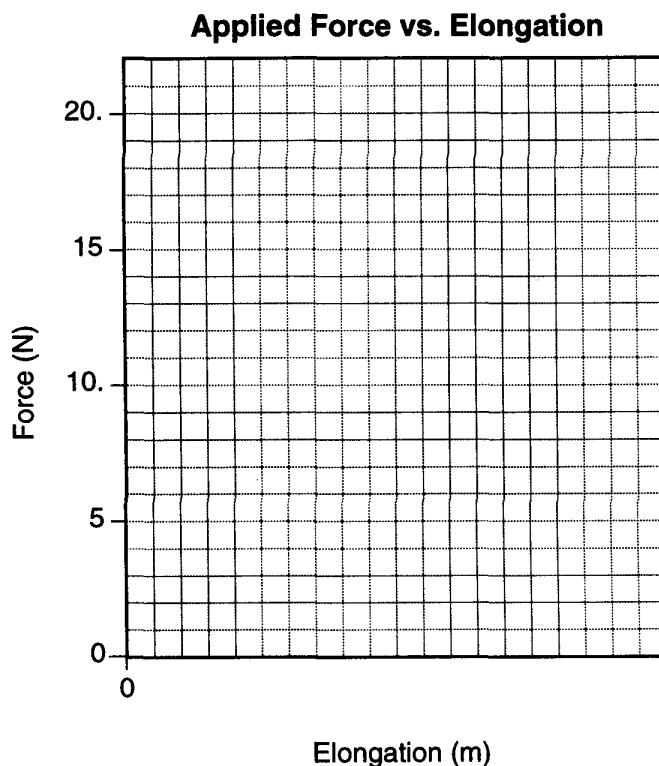
c

In one or more complete sentences, describe the momentum of the two carts after the collision and justify your answer based on the initial momenta of both carts.

Unit Review

Base your answers to questions 40 through 43 on the information in the data table below. The data were obtained by varying the force applied to a spring and measuring the corresponding elongation of the spring.

Applied Force (N)	Elongation of Spring (m)
0.0	0.00
4.0	0.16
8.0	0.27
12.0	0.42
16.0	0.54
20.0	0.71



40. Using the best-fit line, determine the spring constant of the spring. [Show all calculations, including the equation and substitution with units.]
41. Draw the best-fit line.
42. Plot the data points for force versus elongation.
43. Mark an appropriate scale on the axis labeled "Elongation (m)."

Answer Key

Part I Review: Momentum and Impulse

1. **B**

2. **B**

3. **A**

4. **C**

5. **A**

6. **C**

7. **B**

8. **B**

9. **C**

10. **C**

11. **A**

12. **B**

13. **A**

14. **A**

15. **C**

16. **B**

17. **D**

18. **C**

19. **B**

20. **B**

21. **C**

22.
$$p_{\text{before}} = p_{\text{after}}$$
$$m_1 v_1 + m_2 v_2 = 0$$
$$v_1 = -\frac{m_2 v_2}{m_1}$$
$$v_1 = \frac{-(2.5 \times 10^3 \text{ kg})(8.0 \text{ m/s})}{1.1 \times 10^3 \text{ kg}}$$
$$v_1 = -18 \text{ m/s} \text{ or } 18 \text{ m/s}$$

23. 50 N

24. 5.66 m

25.
$$F_f = \mu F_N \quad F_N = mg$$
$$F_f = \mu mg$$
$$F_f = (0.67)(1200 \text{ kg} + 2300 \text{ kg})(9.81 \text{ m/s}^2)$$
$$F_f = 2.3 \times 10^4 \text{ N}$$

26.

$$p_{\text{before}} = p_{\text{after}}$$
$$(m_1 v_1 + m_2 v_2)_{\text{before}} = (m_1 + m_2) v_{\text{after}}$$
$$v_{\text{after}} = \frac{(m_1 v_1 + m_2 v_2)_{\text{before}}}{(m_1 + m_2)}$$
$$v_{\text{after}} = \frac{(1200 \text{ kg})(12 \text{ m/s}) + (3500 \text{ kg})(0 \text{ m/s})}{1200 \text{ kg} + 3500 \text{ kg}}$$
$$v_{\text{after}} = 4.1 \text{ m/s}$$

27.
$$J = \Delta p = m \Delta v$$
$$J = (0.75 \text{ kg})(1.50 \text{ m/s})$$
$$J = 1.1 \text{ N} \cdot \text{s}$$

28.
$$a = \frac{F_{\text{net}}}{m}$$
$$F_{\text{net}} = ma$$
$$F_{\text{net}} = (0.14 \text{ kg})(8.0 \times 10^3 \text{ m/s}^2)$$
$$F_{\text{net}} = 1.1 \times 10^3 \text{ N}$$

or
$$J = F_{\text{net}} t = \Delta p$$
$$F_{\text{net}} = \frac{\Delta p}{t}$$
$$F_{\text{net}} = \frac{(0.14 \text{ kg})(80 \text{ m/s})}{1.0 \times 10^{-3} \text{ s}}$$
$$F_{\text{net}} = 1.1 \times 10^3 \text{ N}$$

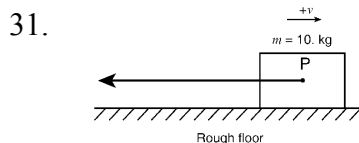
29. a magnitude of $8.0 \times 10^3 \text{ m/s}^2$ in a direction of east

30.
$$F_f = \mu F_N$$

$$\mu = \frac{F_f}{F_N}$$

$$\mu = \frac{20. \text{ N}}{98.1 \text{ N}}$$

$$\mu = 0.20$$



32. west, opposite, backward

33. $v = 2.40 \text{ m/s}$

34. Acceptable responses include, but are not limited to: — Yes. It is reasonable, because the available friction force is greater than the needed acceleration force. — Yes. The friction force is greater. — Yes. The accelerating force is less.

35.
$$F_f = \mu F_N$$
$$F_f =$$
$$(.80)(12,300 \text{ N})$$
$$F_f = 9,800 \text{ N or } 9.8 \times 10^3 \text{ N}$$

36. Allow credit for 12,300 N.

37.
$$Ft = \Delta p$$

$$F = \frac{m \Delta v}{t}$$

$$F = \frac{(1250 \text{ kg})(26.8 \text{ m/s})}{3.75 \text{ s}}$$

$$F = 8,930 \text{ N}$$

38. Allow credit for **7.15 m/s²**

39. A) 6000 kg•m/s; B) Drawing; C) After collision momentum is zero. Total momentum before and after the collision is zero.

40. $k \approx 28.2$

41. graph

42. graph

43. graph