

# MOMENTUM REVIEW

## Part A: Multiple Multiple Choice

1. Which of the following statements are true about momentum?
  - a. Momentum is a vector quantity.
  - b. The standard unit on momentum is the Joule.
  - c. An object with mass will have momentum.
  - d. An object which is moving at a constant speed has momentum.
  - e. An object can be traveling eastward and slowing down; its momentum is westward.
  - f. Momentum is a conserved quantity; the momentum of an object is never changed.
  - g. The momentum of an object varies directly with the speed of the object.
  - h. Two objects of different mass are moving at the same speed; the more massive object will have the greatest momentum.
  - i. A less massive object can never have more momentum than a more massive object.
  - j. Two identical objects are moving in opposite directions at the same speed. The forward moving object will have the greatest momentum.
  - k. An object with a changing speed will have a changing momentum.

Answer: ADGHK

2. Which of the following are true about the relationship between momentum and energy?
  - a. Momentum is a form of energy.
  - b. If an object has momentum, then it must also have mechanical energy.
  - c. If an object does not have momentum, then it definitely does not have mechanical energy either.
  - d. Object A has more momentum than object B. Therefore, object A will also have more kinetic energy.
  - e. Two objects of varying mass have the same momentum. The least massive of the two objects will have the greatest kinetic energy.

Answer: BE

3. Which of the following statements are true about impulse?

- a. Impulse is a force.
- b. Impulse is a vector quantity.
- c. An object which is traveling east would experience a westward directed impulse in a collision.
- d. Objects involved in collisions encounter impulses.
- e. The Newton is the unit for impulse.
- f. The  $\text{kg}\cdot\text{m/s}$  is equivalent to the units on impulse.
- g. An object which experiences a net impulse will definitely experience a momentum change.
- h. In a collision, the net impulse experienced by an object is equal to its momentum change.
- i. A force of 100 N acting for 0.1 seconds would provide an equivalent impulse as a force of 5 N acting for 2.0 seconds.

Answer: BDFGHI

4. Which of the following statements are true about collisions?

- a. Two colliding objects will exert equal forces upon each other, even if their mass is significantly different.
- b. During a collision, an object always encounters an impulse and a change in momentum.
- c. During a collision, the impulse which an object experiences is equal to its velocity change.
- d. The velocity change of two respective objects involved in a collision will always be equal.
- e. While individual objects may change their velocity during a collision, the overall or total velocity of the colliding objects is conserved.
- f. In a collision, the two colliding objects could have different acceleration values.
- g. In a collision between two objects of identical mass, the acceleration values could be different.
- h. Total momentum is always conserved between any two objects involved in a collision.
- i. When a moving object collides with a stationary object of identical mass, the stationary object encounters the greater collision force.
- j. When a moving object collides with a stationary object of identical mass, the stationary object encounters the greater momentum change.

- k. A moving object collides with a stationary object; the stationary object has significantly less mass. The stationary object encounters the greater collision force.
- l. A moving object collides with a stationary object; the stationary object has significantly less mass. The stationary object encounters the greater momentum change.

Answer: ABF

5. Which of the following statements are true about elastic and inelastic collisions?

- a. Perfectly elastic and perfectly inelastic collisions are the two opposite extremes along a continuum; where a particular collision lies along the continuum is dependent upon the amount kinetic energy which is conserved by the two objects.
- b. Most collisions tend to be partially to completely elastic.
- c. Momentum is conserved in an elastic collision but not in an inelastic collision.
- d. The kinetic energy of an object remains constant during an elastic collision.
- e. Elastic collisions occur when the collision force is a non-contact force.
- f. Most collisions are not inelastic because the collision forces cause energy of motion to be transformed into sound, light and thermal energy (to name a few).
- g. A ball is dropped from rest and collides with the ground. The higher that the ball rises upon collision with the ground, the more elastic that the collision is.
- h. A moving air track glider collides with a second stationary glider of identical mass. The first glider loses all of its kinetic energy during the collision as the second glider is set in motion with the same original speed as the first glider. Since the first glider lost all of its kinetic energy, this is a perfectly inelastic collision.
- i. The collision between a tennis ball and a tennis racket tends to be more elastic in nature than a collision between a halfback and linebacker in football.

Answer: AEFGI

### **Part B: Multiple Choice**

6. Which of the following objects have momentum? Include all that apply.

- a. an electron orbiting the nucleus of an atom.
- b. a UPS truck stopped in front of the school building.

- c. a Yugo (a compact car) moving with a constant speed.
- d. a small flea moving with constant speed across Fido's back.
- e. Glenbrook South High School.

Answer: A, C, and D

7. A truck driving along a highway road has a large quantity of momentum. If it moves at the same speed but has twice as much mass, its momentum is \_\_\_\_\_.

a. zero	b. quadrupled	c. doubled	d. unchanged
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Answer: C

8. TRUE or FALSE:

A ball is dropped from the same height upon various flat surfaces. For the same collision time, impulses are smaller when the most bouncing take place.

a. True	b. False
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Answer: B

9. Consider a karate expert. During a talent show, she executes a swift blow to a cement block and breaks it with her bare hand. During the collision between her hand and the block, the \_\_\_\_.

- a. time of impact on both the block and the expert's hand is the same
- b. force on both the block and the expert's hand have the same magnitude
- c. impulse on both the block and the expert's hand have the same magnitude
- d. all of the above.
- e. none of the above.

Answer: D

10. It is NOT possible for a rocket to accelerate in outer space because \_\_\_\_\_. List all that apply.

- a. there is no air in space
- b. there is no friction in space
- c. there is no gravity in outer space
- d. ... nonsense! Rockets do accelerate in outer space.

Answer: D

11. In order to catch a ball, a baseball player naturally moves his or her hand backward in the direction of the ball's motion. This habit causes the force of impact on the players hand to be reduced in size principally because \_\_\_\_\_.

- a. the resulting impact velocity is lessened
- b. the momentum change is decreased
- c. the time of impact is increased
- d. the time of impact is decreased
- e. none of these

Answer: C

12. Suppose that Paul D. Trigger fires a bullet from a gun. The speed of the bullet leaving the muzzle will be the same as the speed of the recoiling gun \_\_\_\_\_.

- a. because momentum is conserved
- b. because velocity is conserved
- c. because both velocity and momentum are conserved
- d. only if the mass of the bullet equals the mass of the gun
- e. none of these

Answer: D

13. Suppose that you're driving down the highway and a moth crashes into the windshield of your car. Which undergoes the greater change in momentum?

a. the moth	b. your car	c. both the same
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Answer: C

14. Suppose that you're driving down the highway and a moth crashes into the windshield of your car. Which undergoes the greater force?

a. the moth	b. your car	c. both the same
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Answer: C

15. Suppose that you're driving down the highway and a moth crashes into the windshield of your car. Which undergoes the greater impulse?

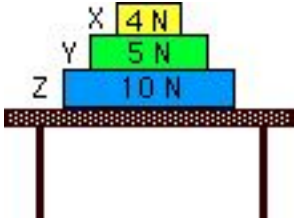
a. the moth	b. your car	c. both the same
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Answer: C

16. Suppose that you're driving down the highway and a moth crashes into the windshield of your car. Which undergoes the greater acceleration?

a. the moth	b. your car	c. both the same
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Answer: A

<p>17. Three boxes, X, Y, and Z, are at rest on a table as shown in the diagram at the right. The weight of each box is indicated in the diagram. The net or unbalanced force acting on box Y is _____.</p>	
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a. 4 N down	b. 5 N down	c. 5 N up	d. 10 N up	e. zero		
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Answer: E

18. In a physics experiment, two equal-mass Pasco carts roll towards each other on a level, low-friction track. One cart rolls rightward at 2 m/s and the other cart rolls leftward at 1 m/s. After the carts collide, they couple (attach together) and roll together with a speed of \_\_\_\_\_. Ignore resistive forces.

a. 0.5 m/s	b. 0.33 m/s	c. 0.67 m/s	d. 1.0 m/s	e. none of these
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Answer: A

19. A physics cart rolls along a low-friction track with considerable momentum. If it rolls at the same speed but has twice as much mass, its momentum is \_\_\_\_\_.

a. zero	b. four times as large	c. twice as large	d. unchanged
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Answer: C

20. The firing of a bullet by a rifle causes the rifle to recoil backwards. The speed of the rifle's recoil is smaller than the bullet's forward speed because the \_\_\_\_\_.

a. force against the rifle is relatively small	b. speed is mainly concentrated in the bullet
c. rifle has lots of mass	d. momentum of the rifle is unchanged

e. none of these	
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Answer: C

21. Two objects, A and B, have the same size and shape. Object A is twice as massive as B. The objects are simultaneously dropped from a high window on a tall building. (Neglect the effect air resistance.) The objects will reach the ground at the same time but object A will have a greater \_\_\_\_\_. Choose all that apply.

a. speed	b. acceleration	c. momentum		
d. none of the above quantities will be greater				

Answer: C

22. Cars are equipped with padded dashboards. In collisions, the padded dashboards would be safer than non-padded ones because they \_\_\_\_\_. List all that apply.

a. increase the impact time	b. decrease an occupant's impulse
c. decrease the impact force	d. none of the above

Answer: AC

23. A 4 kg object has a momentum of 12 kg\*m/s. The object's speed is \_\_\_\_ m/s.

a. 3	b. 4	c. 12	d. 48	e. none of these.
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Answer: A



24. A wad of chewed bubble gum is moving with 1 unit of momentum when it collides with a heavy box that is initially at rest. The gum sticks to the box and both are set in motion with a combined momentum that is \_\_\_\_.

a. less than 1 unit	b. 1 unit	c. more than 1 unit	d. not enough information
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Answer: B

25. A relatively large force acting for a relatively long amount of time on a relatively small mass will produce a relatively \_\_\_\_\_. List all that apply.

a. small velocity change	b. large velocity change
c. small momentum change	d. small acceleration

Answer: B

26. Consider the recent units on Work and Energy and Momentum and Impulse. Force and time is related to momentum change in the same manner as force and displacement pertains to \_\_\_\_\_.

a. impulse	b. work	c. energy change	d. velocity	e. none of these.
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Answer: C

27. A 5-N force is applied to a 3-kg ball to change its velocity from +9 m/s to +3 m/s. This impulse causes the momentum change of the ball to be \_\_\_\_ kg\*m/s.

a. -2.5	b. -10	c. -18	d. -45	e. none of these
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Answer: C

28. A 5-N force is applied to a 3-kg ball to change its velocity from +9 m/s to +3 m/s. The impulse experienced by the ball is \_\_\_\_ N\*s.

a. -2.5	b. -10	c. -18	d. -45	e. none of these
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Answer: C

29. A 5-N force is applied to a 3-kg ball to change its velocity from +9 m/s to +3 m/s. The impulse is encountered by the ball for a time of \_\_\_\_ seconds.

a. 1.8	b. 2.5	c. 3.6	d. 10	e. none of these
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Answer: C

30. When a mass  $M$  experiences a velocity change of  $v$  in a time of  $t$ , it experiences a force of  $F$ . Assuming the same velocity change of  $v$ , the force experienced by a mass of  $2M$  in a time of  $(1/2)t$  is \_\_\_\_.

a. $2F$	b. $4F$	c. $(1/2)*F$	d. $(1/4)*F$	e. none of these
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Answer: B

31. When a mass  $M$  experiences a velocity change of  $v$  in a time of  $t$ , it experiences a force of  $F$ . Assuming the same velocity change of  $v$ , the force experienced by a mass of  $2M$  in a time of  $(1/4)t$  is \_\_\_\_.

a. $2F$	b. $8F$	c. $(1/2)*F$	d. $(1/8)*F$	e. none of these
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Answer: B

32. When a mass  $M$  experiences a velocity change of  $v$  in a time of  $t$ , it experiences a force of  $F$ . Assuming the same velocity change of  $v$ , the force experienced by a mass of  $(1/2)M$  in a time of  $(1/2)t$  is \_\_\_\_.

a. $2F$	b. $4F$	c. $(1/2)*F$	d. $(1/4)*F$	e. none of these
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Answer: E

33. When a mass  $M$  experiences a velocity change of  $v$  in a time of  $t$ , it experiences a force of  $F$ . Assuming the same velocity change of  $v$ , the force experienced by a mass of  $(1/2)M$  in a time of  $4t$  is \_\_\_\_.

a. $2F$	b. $8F$	c. $(1/2)*F$	d. $(1/8)*F$	e. none of these
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Answer: D

34. A 0.50-kg ball moving at 5.0 m/s strikes a wall and rebounds in the opposite direction with a speed of 2.0 m/s. If the impulse occurs for a time duration of 0.010 s, then the average force (magnitude only) acting upon the ball is \_\_\_\_ Newtons.

a. 0.14	b. 150	c. 350	d. 500	e. none of these
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Answer: C

35. TRUE or FALSE:

If mass and collision time are equal, then impulses are greater on objects which rebound (or bounce).

a. TRUE	b. FALSE
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Answer: A

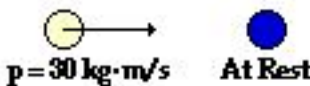
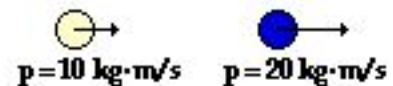
36. Consider the head-on collision between a lady bug and the windshield of a high speed bus. Which of the following statements are true? List all that apply.

- a. The magnitude of the force encountered by the bug is greater than that of the bus.
- b. The magnitude of the impulse encountered by the bug is greater than that of the bus.
- c. The magnitude of the momentum change encountered by the bug is greater than that of the bus.
- d. The magnitude of the velocity change encountered by the bug is greater than that of the bus.
- e. The magnitude of the acceleration encountered by the bug is greater than that of the bus.

Answer: D and E

### Part C: Diagramming and Analysis

For questions #37-40: Consider the before- and after-collision momentum vectors in the diagram below. Determine the magnitude and direction of the system momentum before and after the collision and identify whether or not momentum is conserved. Finally, determine the magnitude and direction of the net external impulse encountered by the system during the collision.

37.	
<div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;"> <p><b>Before Collision</b></p>  <p><math>p = 30 \text{ kg}\cdot\text{m/s}</math>    At Rest</p> </div> <div style="text-align: center;"> <p><b>After Collision</b></p>  <p><math>p = 10 \text{ kg}\cdot\text{m/s}</math>    <math>p = 20 \text{ kg}\cdot\text{m/s}</math></p> </div> </div>	
Answer:	
System Momentum Before Collision:	30 kg•m/s, right
System Momentum After Collision:	30 kg•m/s, right
Is momentum conserved?	Yes

Net External Impulse During Collision:	0 N
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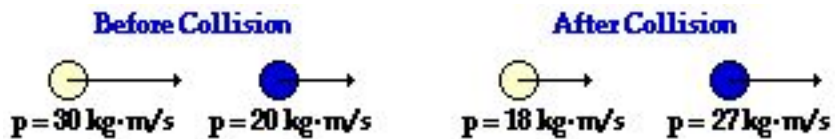
38.	
<p style="text-align: center;"><b>Before Collision</b>                      <b>After Collision</b></p> <p style="text-align: center;"> <math>p = 25 \text{ kg}\cdot\text{m/s}</math>    <math>p = 10 \text{ kg}\cdot\text{m/s}</math>      <math>p = 5 \text{ kg}\cdot\text{m/s}</math>    <math>p = 10 \text{ kg}\cdot\text{m/s}</math> </p>	
Answer:	

System Momentum Before Collision:	15 kg·m/s, right
System Momentum After Collision:	15 kg·m/s, right
Is momentum conserved?	Yes
Net External Impulse During Collision:	0 N

39.	
<p style="text-align: center;"><b>Before Collision</b>                      <b>After Collision</b></p> <p style="text-align: center;"> <math>p = 30 \text{ kg}\cdot\text{m/s}</math>    <b>At Rest</b>              <math>p = 20 \text{ kg}\cdot\text{m/s}</math>    <math>p = 10 \text{ kg}\cdot\text{m/s}</math> </p>	
Answer:	

System Momentum Before Collision:	30 kg·m/s, right
System Momentum After Collision:	10 kg·m/s, left
Is momentum conserved?	No
Net External Impulse During Collision:	40 N·s, left

40.



Answer:

System Momentum Before Collision:	50 kg•m/s, right
System Momentum After Collision:	45 kg•m/s, right
Is momentum conserved?	No
Net External Impulse During Collision:	5 N•s, left

For questions #41-44: Repeat the procedure performed in questions #37-40. Note that these diagrams give velocity and mass values before and after the collision.

41.



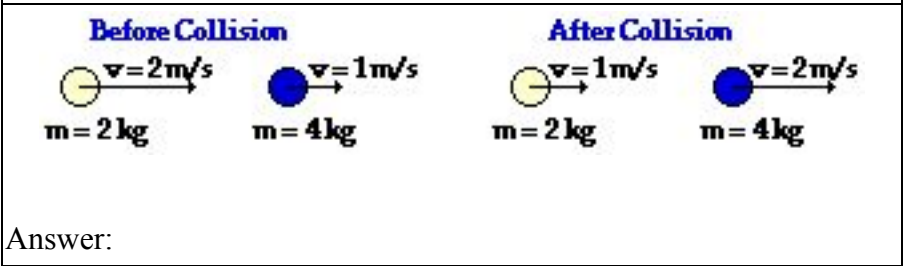
Answer:

System Momentum Before Collision:	3 kg•m/s, right
System Momentum After Collision:	3 kg•m/s, right

Is momentum conserved?	Yes
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Net External Impulse During Collision:	0
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42.



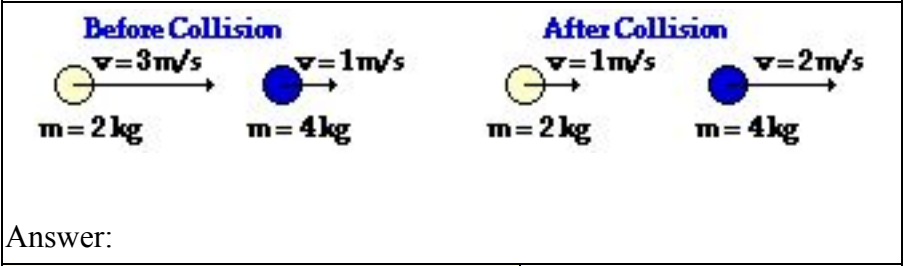
System Momentum Before Collision:	8 kg•m/s, right
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System Momentum After Collision:	10 kg•m/s, right
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Is momentum conserved?	No
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Net External Impulse During Collision:	2 N•s, right
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43.



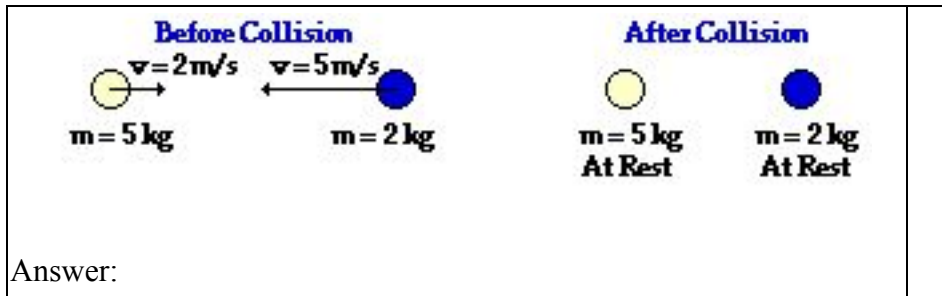
System Momentum Before Collision:	10 kg•m/s, right
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System Momentum After Collision:	10 kg•m/s, right
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Is momentum conserved?	Yes
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Net External Impulse During Collision:	0
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44.

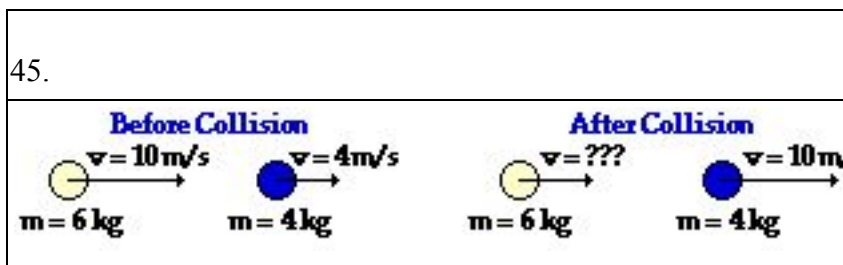


System Momentum Before Collision:	0
System Momentum After Collision:	0
Is momentum conserved?	Yes
Net External Impulse During Collision:	0

For questions #45-49, determine the unknown velocity value. Assume that the collisions occur in an isolated system.

General Note about Q#45-49:

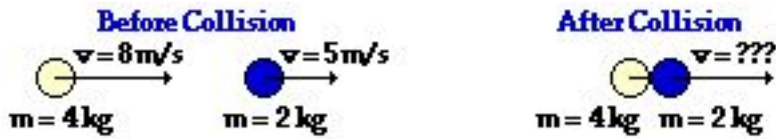
In each of these problems, an expression for the total momentum before the collision is written by summing the product of mass and velocity for each object. The same is done with the total momentum after the collision. One must be careful to assign a negative momentum to any object which is moving leftward. When the velocity of an object is not known, the variable  $v$  should be placed in the expression in place of the actual velocity value. The two expressions for total momentum before and after the collision are set equal to each other and algebraic operations are used to determine the unknown velocities.



Answer: 6 m/s



46.



Answer: 7 m/s

47.



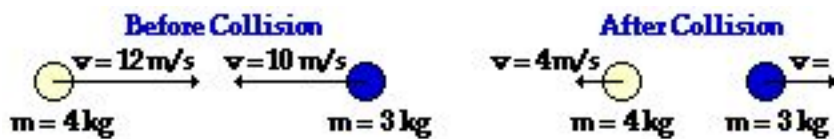
Answer: 9 m/s

48.



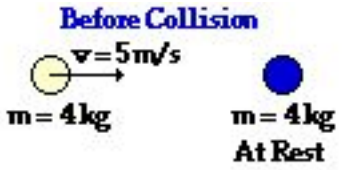
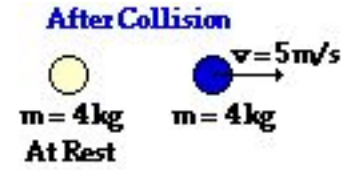
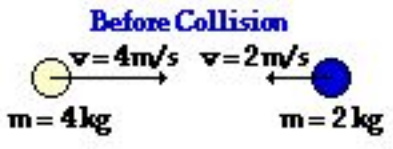
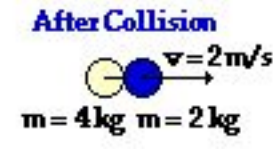
Answer: 4 m/s

49.



Answer: 11.3 m/s

For questions #50-52, determine the total kinetic energy of the system before and after the collision and identify the collision as being either perfectly elastic, partially inelastic/elastic or perfectly inelastic.

50.		
<p><b>Before Collision</b></p>  <p><b>After Collision</b></p> 		
Answer:		
Total System Kinetic Energy Before Collision:	50 J	
Total System Kinetic Energy After Collision:	50 J	
Perfectly Elastic, Partially Inelastic/Elastic or Perfectly Inelastic?	Perfectly Elastic	
51.		
<p><b>Before Collision</b></p>  <p><b>After Collision</b></p> 		
Answer:		
Total System Kinetic Energy Before Collision:	36 J	
Total System Kinetic Energy After Collision:	12 J	
Perfectly Elastic, Partially Inelastic/Elastic or Perfectly Inelastic?	Perfectly Inelastic	
52.		

<p style="text-align: center;"><b>Before Collision</b></p> <p style="text-align: center;"><b>After Collision</b></p>	
Answer:	
Total System Kinetic Energy Before Collision:	183 J
Total System Kinetic Energy After Collision:	153 J
Perfectly Elastic, Partially Inelastic/Elastic or Perfectly Inelastic?	Partially Inelastic

### Part D: Qualitative Relationships Between Variables

53. An object with a mass  $M$  and a velocity  $v$  has a momentum of  $32 \text{ kg}\cdot\text{m/s}$ . An object with a mass of ...

- ...  $2M$  and a velocity of  $2v$  would have a momentum of \_\_\_\_\_.
- ...  $2M$  and a velocity of  $0.5v$  would have a momentum of \_\_\_\_\_.
- ...  $0.5M$  and a velocity of  $2v$  would have a momentum of \_\_\_\_\_.
- ...  $0.5M$  and a velocity of  $0.5v$  would have a momentum of \_\_\_\_\_.
- ...  $4M$  and a velocity of  $v$  would have a momentum of \_\_\_\_\_.
- ...  $4M$  and a velocity of  $0.5v$  would have a momentum of \_\_\_\_\_.
- ...  $0.5M$  and a velocity of  $4v$  would have a momentum of \_\_\_\_\_.
- ...  $3M$  and a velocity of  $2v$  would have a momentum of \_\_\_\_\_.

Answer:

- ...  $2M$  and a velocity of  $2v$  would have a momentum of  $64 \text{ kg}\cdot\text{m/s}$ .
- ...  $2M$  and a velocity of  $0.5v$  would have a momentum of  $32 \text{ kg}\cdot\text{m/s}$ .
- ...  $0.5M$  and a velocity of  $2v$  would have a momentum of  $32 \text{ kg}\cdot\text{m/s}$ .
- ...  $0.5M$  and a velocity of  $0.5v$  would have a momentum of  $8 \text{ kg}\cdot\text{m/s}$ .
- ...  $4M$  and a velocity of  $v$  would have a momentum of  $128 \text{ kg}\cdot\text{m/s}$ .
- ...  $4M$  and a velocity of  $0.5v$  would have a momentum of  $64 \text{ kg}\cdot\text{m/s}$ .
- ...  $0.5M$  and a velocity of  $4v$  would have a momentum of  $64 \text{ kg}\cdot\text{m/s}$ .
- ...  $3M$  and a velocity of  $2v$  would have a momentum of  $192 \text{ kg}\cdot\text{m/s}$ .

54. Two carts are placed next to each other on a low-friction track. The carts are equipped with a spring-loaded mechanism which allows them to impart an impulse to each other. Cart A has a mass of  $M$  and Cart B has a mass of  $M$ . The spring-loaded mechanism is engaged and then released. The impulse causes Cart A to be propelled forward with a velocity of 40 cm/s.

- a. Cart B will be propelled backward with a velocity of \_\_\_\_\_.
- b. ... If Cart B had a mass of  $2M$  then it would be propelled backwards with a velocity of \_\_\_\_\_.
- c. ... If Cart B had a mass of  $0.5M$  then it would be propelled backwards with a velocity of \_\_\_\_\_.
- d. ... If Cart B has a mass of  $2M$  then it would be propelled backwards with a momentum which is \_\_\_\_\_ original momentum.
- e. ... If Cart B has a mass of  $2M$  then it would encounter an impulse which is \_\_\_\_\_ original impulse.

Answer:

- a. Cart B will be propelled backward with a velocity of 40 cm/s.
- b. ... If Cart B had a mass of  $2M$  then it would be propelled backwards with a velocity of 20 cm/s.
- c. ... If Cart B had a mass of  $0.5M$  then it would be propelled backwards with a velocity of 80 cm/s.
- d. ... If Cart B has a mass of  $2M$  then it would be propelled backwards with a momentum which is the same as the original momentum.
- e. ... If Cart B has a mass of  $2M$  then it would encounter an impulse which is the same as the original impulse.

### Part E: Problem-Solving

55. A 0.530-kg basketball hits a wall head-on with a forward speed of 18.0 m/s. It rebounds with a speed of 13.5 m/s. The contact time is 0.100 seconds. (a) determine the impulse with the wall, (b) determine the force of the wall on the ball.

Answer: (a) -16.7 N s; (b) -167 N

56. A 4.0-kg object has a forward momentum of 20.0 kg•m/s. A 60.0 N•s impulse acts upon it in the direction of motion for 5.0 seconds. A resistive force of 6.0 N then impedes its motion for 8.0 seconds. Determine the final velocity of the object.

Answer:  $v_f = 8.0$  m/s

57. A 3.0-kg object is moving forward with a speed of 6.0 m/s. The object then encounters a force of 2.5 N for 8.0 seconds in the direction of its motion. The object then collides head-on with a wall and heads in the opposite direction with a speed of 5.0 m/s. Determine the impulse delivered by the wall to the object.

Answer: 53 N•s

58. A 46-gram tennis ball is launched from a 1.35-kg homemade cannon. If the cannon recoils with a speed of 2.1 m/s, determine the muzzle speed of the tennis ball.

Answer: 62 m/s

59. A 2.0-kg box is attached by a string to a 5.0-kg box. A compressed spring is placed between them. The two boxes are initially at rest on a friction-free track. The string is cut and the spring applies an impulse to both boxes, setting them in motion. The 2.0-kg box is propelled backwards and moves 1.2 meters to the end of the track in 0.50 seconds. Determine the time it takes the 5.0-kg box to move 0.90 meters to the opposite end of the track.

Answer: 0.94 s

60. A 2.80-kg physics cart is moving forward with a speed of 45.0 cm/s. A 1.90-kg brick is dropped from rest and lands on the cart. The cart and brick move together across the horizontal surface. Assume an isolated system.

- a. Determine the post-collision speed of the cart and the brick.
- b. Determine the momentum change of the cart.
- c. Determine the momentum change of the brick.
- d. Determine the net impulse upon the cart.
- e. Determine the net impulse upon the system of cart and brick.

Answers: (a)  $v = 26.8 \text{ cm/s}$

(b)  $\Delta p_{\text{cart}} = -50.9 \text{ kg} \cdot \text{cm/s}$

(c)  $\Delta p_{\text{brick}} = +50.9 \text{ kg} \cdot \text{cm/s}$

(d) Impulse on cart =  $-50.9 \text{ kg} \cdot \text{cm/s}$

(e) Impulse on brick =  $+50.9 \text{ kg} \cdot \text{cm/s}$

61. Two ice skaters collide on the ice. A 39.6-kg skater moving South at 6.21 m/s collides with a 52.1-kg skater moving East at 4.33 m/s. The two skaters entangle and move together across the ice. Determine the magnitude and direction of their post-collision velocity.

Answer: 3.64 m/s at 42.5 degrees east of south (312.5 degrees)