

KEY 12.3 Newton's Third Law and Momentum

Honors Integrated Science

Name: _____ Date: _____ Per. _____

Directions: Answer the following questions in complete sentences and thoughts, using the information from the reading/graph to support your learning. For all math questions, show your work and your final answer should include appropriate units and significant figures.

1. If an eagle and a bumblebee are traveling at 8 km/hr, which has more momentum? Explain.

Because the speeds are equal, the eagle's greater mass gives it more momentum.

2. A friend tells you that a rowboat is propelled forward by the force of its oars against the water. First explain whether the statement is correct, and then identify the action and reaction forces.

It is incorrect because it is the force of the water against the oars that propels the boat forward. The oars that propels the boat forward.

3. Explain how Newton's third law of motion is at work when you walk.

As you walk, you bend your foot and push off against the ground. This action force produces the reaction force of the ground pushing against your shoe. The reaction force pushes you forward.

4. Explain in terms of Newton's third law why someone who tries to jump from a canoe to a riverbank may fall into the water.

When you jump you push against the canoe. However, the canoe also moves in the opposite direction of your jump. Because the canoe moves away, it produces a smaller reaction force on you. This small reaction force is not strong enough to propel you to the riverbank.

5. Explain why it is impossible to identify a single isolated force. State in your first sentence the main idea of Newton's third law of motion.

Forces always exist in pairs and according to Newton's third law, every action force has an equal and opposite reaction force.

6. What is an action-reaction pair?

When a force is exerted on an object, the object responds with an equal and opposite force. The forces generated in this way are called action-reaction pairs.

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7. What must you know to determine which of two vehicles traveling at the same velocity, has the greater momentum.

You will need the mass of each vehicle.

8. When a tennis player practices by hitting a ball against a wall, which of Newton's laws of motion is the player making use of? Explain.

Newton's third law of motion describes the action and reaction forces that occur when the ball is struck by the racquet and when the ball strikes the wall.

Newton's second law of motion describes the acceleration of the tennis ball when a force from the racquet or the wall is applied to it.

9. Consider an automobile cruising at a constant speed on the highway. Write a short paragraph summarizing the forces acting on the car. Be sure to include the force supplied by the engine and at least two types of friction acting on the car.

The force applied at the drive wheels, which is supplied by the engine, is the action-reaction force pair where the tires are in contact with the road, the air resistance (fluid friction), the rolling friction of the tires on the road, and the rolling friction of the ball bearings in the engine and wheels.

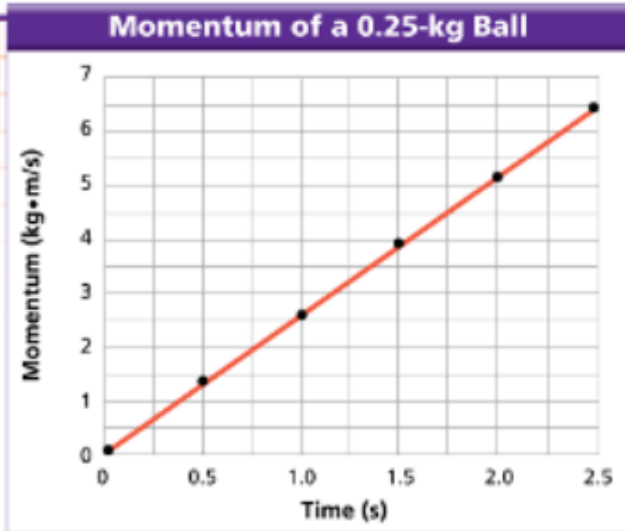
10. Draw a cartoon that illustrates Newton's third law of motion in an amusing way.

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Data Analysis: A class studied the speed and momentum of a 0.25 kg ball dropped from a bridge. The graph shows the momentum of the ball from the time it was dropped until it hit the river flowing below.



- At what time did the ball have zero momentum?
- Describe this point in the ball's motion?
- At what time did the ball have the greatest momentum?
- What was the peak momentum value?
- What is the ball's speed after 1.25 seconds? Use the graph and the momentum formula.

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Practice Calculating **Momentum**

1. Calculate the momentum of a 1200 kg car with a velocity of 25m/s.

$$p = m \times v = 1200 \text{ kg} \times 25 \text{ m/s} =$$

2. What is the momentum of a child and wagon if the total mass of the child and wagon is 22kg and the velocity is 1.5m/s?

$$p = m \times v = 22 \text{ kg} \times 1.5 \text{ m/s} =$$

3. The parking brake on a 1200 kg automobile has broken, and the vehicle has reached a momentum of 7800 kg.m/s. What is the velocity of the vehicle?

$$v = p / m = (7800 \text{ kg}\cdot\text{m/s}) / 1200 \text{ kg} =$$

4. A toy dart gun generates a dart with 0.140 kg.m/s momentum and a velocity of 4m/s. What is the mass of the dart in grams? (**hint:** figure kg, then convert answer to grams)

$$m = p / v = (0.140 \text{ kg}\cdot\text{m/s}) / (4 \text{ m/s}) =$$

$$\text{mass in grams} = \text{mass in kg} \times 1000 =$$

5. A bowling ball of 35.2 kg, generates 218 kg.m/s units of momentum. What is the velocity of the bowling ball?

$$v = p / m = (218 \text{ kg}\cdot\text{m/s}) / 35.2 \text{ kg} =$$

6. A school bus traveling at 40 km/hr. (11.1m/s) has a momentum of 152,625 kg.m/s. What is the mass of the bus?

$$m = p / v = (152,625 \text{ kg}\cdot\text{m/s}) / (11.1 \text{ m/s}) =$$

7. If the truck has a mass of 2,000 kilograms, what is its momentum if its velocity is 35 m/s?

$$p = m \times v = 2,000 \text{ kg} \times 35 \text{ m/s} =$$

8. If the car has a mass of 1,000 kilograms, what is its momentum if its velocity is also 35 m/s?

$$p = m \times v = 1,000 \text{ kg} \times 35 \text{ m/s} =$$

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9. An 8-kilogram bowling ball is rolling in a straight line toward the pins. If it's traveling 2 m/s, what is its momentum?

$$p = m \times v = 8 \text{ kg} \times 2 \text{ m/s} =$$

10. A beach ball starts from rest and is rolling in a straight line toward you at a velocity of 0.5 m/s. What is its momentum if it has a mass of 0.5 kg?

$$\Delta v = 0.5 \text{ m/s} - 0 \text{ m/s}$$

$$p = m \times \Delta v = 0.5 \text{ kg} \times \quad \text{m/s} =$$

11. A 4,000-kilogram truck travels in a straight line at 10.0 m/s and comes to a complete stop. What is its momentum?

$$\Delta v = 0 \text{ m/s} - 10.0 \text{ m/s} =$$

*The negative sign indicates the direction of velocity, the car is slowing down!

$$p = m \times \Delta v = 4,000 \text{ kg} \times \quad \text{m/s} =$$

12. A 0.14-kilogram baseball is thrown with an initial velocity of 30 m/s the ball is caught with a final velocity of 50 m/s. What is the momentum of baseball?

$$\Delta v = 50 \text{ m/s} - 30 \text{ m/s} =$$

$$p = m \times \Delta v = 0.14 \text{ kg} \times \quad \text{m/s} =$$

13. A 1.5-kilogram turtle crawls in a straight line at a velocity of 0.125 m/s and stops at a bowl of lettuce. What is the turtle's momentum?

$$\Delta v = 0 \text{ m/s} - 0.125 \text{ m/s} =$$

*The negative sign indicates the direction of velocity, the turtle is slowing down!

$$p = m \times \Delta v = 1.5 \text{ kg} \times \quad \text{m/s} =$$

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14. Which would take more force to stop in 10 seconds?

- a. BALL **A** (8.0-kilogram) rolling in a straight line at a speed of 0.2 m/s.

$$p = m \times v = 8 \text{ kg} \times 0.2 \text{ m/s} =$$

- b. BALL **B** (4.0-kilogram) rolling along the same path at a speed of 1.0 m/s.

$$p = m \times v = 4 \text{ kg} \times 1.0 \text{ m/s} =$$

15. The momentum of a car traveling in a straight line at 20 m/s is 24,500 kg·m/s. What is the car's mass?

$$m = p / v = (24,500 \text{ kg} \cdot \text{m/s}) / (20 \text{ m/s}) =$$

16. A pitcher throws the 0.14-kilogram baseball in a straight line. Its momentum is 2.1 kg·m/s. What is the velocity of the ball?

$$v = p / m = (2.1 \text{ kg} \cdot \text{m/s}) / 0.14 \text{ kg}$$

17. If a 40 kg object has a momentum of 400 kg·m/s., what is its velocity?

$$v = p / m = (400 \text{ kg} \cdot \text{m/s}) / 40 \text{ kg}$$

18. If an object traveling at 20 m/s has a momentum of 800 kg·m/s., what is the object's mass?

$$m = p / v = (800 \text{ kg} \cdot \text{m/s}) / (20 \text{ m/s}) =$$

Conservation of **Momentum** Problems (Collision Problems)

19. A 12,000 kg railroad car is traveling at 2 m/s when it strikes another 10,000 kg railroad car that is at rest. If the cars lock together, what is the final speed of the two railroad cars?

$$p_i = p_f$$

$$m_i \times v_i = m_f \times v_f$$

$$\text{mass final is both cars} = 12,000 \text{ kg} \times 2 =$$

$$(12,000 \text{ kg}) \times (2 \text{ m/s}) = (24,000 \text{ kg}) \times v_f$$

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20. A 9,300 kg railroad car traveling at a velocity of 15 m/s strikes a second boxcar at rest. If the two cars stick together and move off with a velocity of 6 m/s, what is the mass of the second car?

$$p_i = p_f$$

$$m_i \times v_i = m_f \times v_f$$

mass final is both cars = 9,300 kg + mass of second boxcar =

$$(93,000 \text{ kg}) \times (15 \text{ m/s}) = (9,300 \text{ kg} + m_{\text{car \#2}}) \times 6 \text{ m/s}$$

21. A 25 gram bullet is fired from a gun with a speed of 230 m/s. If the gun has a mass of 0.900 kg. What is the recoil speed of the gun?

$$25 \text{ g} / 1000 = 0.025 \text{ kg}$$

$$p_i = p_f$$

$$m_i \times v_i = m_f \times v_f$$

$$(0.025 \text{ kg}) \times (230 \text{ m/s}) = (0.90 \text{ kg}) \times v_f$$

22. A 20 gram bullet traveling at 250 m/s strikes a block of wood that weighs 2 kg. With what velocity will the block and bullet move after the collision?

$$20 \text{ g} / 1000 = 0.020 \text{ kg}$$

$$p_i = p_f$$

$$m_i \times v_i = m_f \times v_f$$

mass final is both the block and bullet = 0.020 kg + 2 kg =

$$(0.020 \text{ kg}) \times (250 \text{ m/s}) = (2.02 \text{ kg}) \times v_f$$