

Chapter 7 Newton’s Third Law of Motion—Action and Reaction

Exercises

7.1 Forces and Interactions (page 107)

1. A force is always part of a(n) mutual action that involves another force.
2. Define **interaction**. a mutual action between one thing and another
3. Describe the interaction forces between a nail and a hammer that hits it.
The hammer exerts a force on the nail, and the nail exerts a force on the hammer.

7.2 Newton’s Third Law (page 108)

4. State Newton’s third law.
Whenever one object exerts a force on a second object, the second object exerts an equal and opposite force on the first object.
5. Is the following sentence true or false? It doesn’t matter which force we call *action* and which we call *reaction*. true
6. Action and reaction forces are equal in strength and opposite in direction.
7. Is the following sentence true or false? In every interaction, the forces always occur in pairs. true
8. Complete the table by writing the reaction for each action.

| Action | Reaction |
|---|------------------------------------|
| When you walk, you push against the floor. | The floor pushes against you. |
| The tires of a car push against the road. | The road pushes back on the tires. |
| When swimming, you push the water backward. | The water pushes you forward. |
| A dog wags its tail. | The tail wags the dog. |
| You push on a wall. | The wall pushes on you. |
| When a batter swings, the bat exerts a force on the ball. | The ball pushes back on the bat. |

9. Use the idea of action and reaction forces to explain why a person trying to walk on ice may not have any forward motion.
Because there is minimal friction between the person and the ice, the person may not be able to exert an action force against the ice. Without an action force, there cannot be a reaction force to push the person forward.

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Chapter 7 Newton’s Third Law of Motion—Action and Reaction

7.3 Identifying Action and Reaction (pages 108–109)

10. What are the two steps you can take to identify a pair of action-reaction forces?
 - a. **First, identify the interacting objects A and B.** _____
 - b. **If the action is A on B, the reaction is B on A.** _____
11. Identify the action–reaction forces of a boulder falling off a cliff by answering the following questions.
 - a. What are the two interacting objects? **the boulder and Earth** _____
 - b. What is the action of A on B? **Earth exerts a force on the boulder.** _____
 - c. What is the action of B on A? **The boulder exerts a force on Earth.** _____
12. Complete the table by identifying the reaction forces. In each case, specify the direction of the reaction force.

| Action | Reaction |
|---|---|
| As a car moves along a road, the tires of the car push backward against the road. | The road pushes forward against the tires. |
| As a spaceship moves through space, it pushes gas out behind. | The gas pushes the rocket forward. |
| A ball rolls across a table and exerts a force against a second ball. | The second ball exerts a force in the opposite direction against the first ball. |

7.4 Action and Reaction on Different Masses (pages 110–111)

13. Is the following sentence true or false? If you drop a pencil, the pencil pulls Earth upward with a much smaller force than that with which Earth pulls the pencil downward. **false** _____
14. State Newton’s second law.
The acceleration of an object is proportional to the net force on the object and inversely proportional to the object’s mass. _____
15. When a boulder falls off a cliff toward the ground, Earth accelerates toward the boulder. Circle the letter that explains why we don’t sense this acceleration.
 - a. The boulder’s pull on Earth is much smaller than Earth’s pull on the boulder.
 - (b)** Earth’s huge mass causes its acceleration to be infinitesimally small.
 - c. Earth’s acceleration is in the same direction as the boulder’s acceleration.
 - d. The boulder’s acceleration is much smaller than the Earth’s acceleration.

Chapter 7 Newton’s Third Law of Motion—Action and Reaction

16. When a cannonball is fired from a cannon, the force the cannon exerts on the cannonball is exactly equal and opposite to the force the cannonball exerts on the cannon.
17. Name the three factors that you must consider in order to understand why a cannonball moves much faster than the cannon when the cannonball is shot from the cannon.
force, mass, and acceleration



18. The picture above shows a cannonball being shot from a cannon. Explain why the change in velocity of the cannonball is much greater than the change in velocity of the cannon.
The cannonball’s mass is much smaller than the cannon’s mass. Their forces on each other are equal but opposite. A given force exerted on a small mass produces a greater acceleration than the same force exerted on a large mass.
19. How is the acceleration of a rocket similar to the acceleration of a cannonball that is fired from a cannon?
Each molecule of a rocket’s exhaust gas acts like a tiny cannonball. The reaction force of a cannonball against a cannon causes the cannon to accelerate. Similarly, the reaction force of a molecule of exhaust gas against the rocket causes the rocket to accelerate.
20. Is the following sentence true or false? A rocket is propelled by the impact of exhaust gases against the atmosphere. false
21. The upward force that causes helicopters, birds, and airplanes to fly is called lift.
22. A helicopter has a lifting force because its blades are shaped to force air particles downward, and the air forces the blades upward.

Match each condition on the left to the result on the right.

| Condition | Result |
|--|-------------------------------------|
| <u>c</u> 23. Lift equals the helicopter’s weight. | a. The helicopter moves downward. |
| <u>b</u> 24. Lift is greater than the helicopter’s weight. | b. The helicopter moves upward. |
| <u>a</u> 25. Lift is less than the helicopter’s weight. | c. The helicopter hovers in midair. |

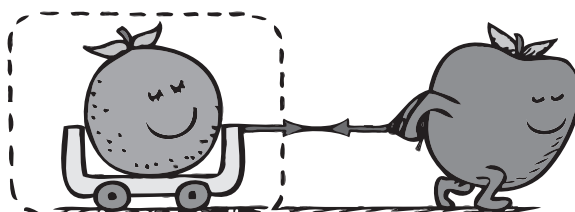
Chapter 7 Newton's Third Law of Motion—Action and Reaction

26. Describe the action and reaction forces that cause a bird to fly.
The shape of a bird's wings deflects air downward. The air pushes the bird upward.
-
27. Describe two action–reaction pairs that cause an airplane to move upward and forward.
- The wings deflect air downward, and the air pushes the wings upward.*
 - The engine pushes air backward, and the air pushes the plane forward.*

7.5 Defining Systems (pages 112–113)

28. In order to understand why action and reaction forces don't cancel to zero, you must consider the system involved.

For questions 29 and 30, refer to the figure below.



29. The figure shows a force exerted by an apple. The dashed line identifies the system that accelerates because of this force. Explain why the force that the orange exerts on the apple doesn't cancel the force that the apple exerts on the orange.
Action and reaction forces do not cancel each other when either of the forces is external to the system being considered.
-
30. Suppose the system includes both the orange and the apple. Explain why the force of the orange on the apple cancels the force of the apple on the orange.
Since this force pair is internal to the orange-apple system, these forces do cancel each other.
-
31. Is the following sentence true or false? The trillions and trillions of interatomic forces that hold a baseball together do play a role in accelerating the ball. false
32. Is the following sentence true or false? If the action–reaction forces are internal to a system, then the forces cancel and the system does not accelerate. true
33. When a football player kicks a ball, the player's foot exerts a force on the ball, and the ball exerts a force on the player's foot. Why does the ball accelerate, even though the forces are equal and opposite?
The forces act on different objects. Only one force acts on the ball.

Chapter 7 Newton's Third Law of Motion—Action and Reaction

7.6 The Horse–Cart Problem (pages 114–115)

34. Describe the horse–cart problem.

A horse pulls a farmer on a cart. The horse believes that its pull on the cart will be canceled by the opposite and equal pull of the cart on the horse, and acceleration will be impossible.

35. Name the three points of view from which you can consider the horse–cart problem.

a. the farmer

b. the horse

c. the horse and cart together

36. The farmer is only concerned with the force that is exerted on the cart system.

37. According to the farmer, the net force on the cart, divided by the mass of the cart, will produce a(n) acceleration.

38. The horse believes that the reaction force by the cart on the horse restrains the horse.

39. From the horse's point of view, the horse moves forward by interacting with the ground.

40. If the horse in the horse–cart system pushes the ground with a greater force than it pulls on the cart, then there is a net force on the horse, and the horse–cart system accelerates.

41. Consider the horse–cart system as a whole.

a. Which action–reaction pair contributes nothing to the acceleration of the system?

the pull of the horse on the cart and the reaction of the cart on the horse

b. Which interaction is responsible for moving the system?

the interaction between the horse–cart system and the ground

7.7 Action Equals Reaction (page 116)

42. Is the following sentence true or false? You cannot hit a wall any harder than the wall can hit you back. true

43. Explain why it is impossible to strike a sheet of paper that is held in midair with a force of 200 N.

The paper is not capable of exerting a reaction force of 200 N. You cannot have an action force without a reaction force.

44. For every interaction between things, there is always a pair of oppositely directed forces that are equal in strength.