

## Sir Isaac Newton and LeBron James



The English physicist and mathematician Sir Isaac Newton discovered three basic laws of motion. The First Law says that objects at rest and objects in motion will remain at rest or in motion, unless they are acted upon by an “unbalanced force.” The Second Law says that when a force acts on a mass, acceleration is produced. The greater an object’s mass is, the more force is needed to accelerate it.

But it’s Newton’s Third Law of Motion that everyone remembers. “For every action,” the famous law reads, “there is an equal and opposite reaction.” A simpler way of saying this might be: “When you push an object, it pushes back.” For every force, in other words, there is a reaction force equal in size.

There are many ways to describe how the Third Law of Motion works in the world of sports. One of the more interesting examples is the way that LeBron James dunks a basketball.

In order for LeBron James to score a slam-dunk, he must exert a certain amount of force against the surface of the basketball court. LeBron James is a big man. He is 6 feet, 8 inches tall. He weighs 245 pounds. When he is standing upright, with his arms raised above his head, his reach extends to 8 feet and 10  $\frac{1}{4}$  inches.

The rim of the basketball hoop is exactly 10 feet high. For LeBron James to slam the ball, he must propel himself high enough that he can force the basketball, which is approximately 9.39 inches in diameter, into the hoop. This requires that he reach well above the height of the rim,

which he does fairly often. In photographs and slow-motion replays of LeBron James dunking the basketball, his elbow is often equal to the height of the rim!

LeBron James may be tall, strong and fast. He may be extremely mobile and flexible. But it is no easy feat to dunk a basketball, especially when you weigh 245 pounds. His vertical leap—that is, the maximum height he can reach when he jumps—is around 44 inches. The average vertical leap in the National Basketball Association, or NBA, is about 27 inches. That means that LeBron James, despite his large size, can jump more than 10 inches higher than most players in the NBA! This is a serious benefit in basketball, a game of inches in which how high someone can jump often means the difference between scoring and missing the shot.

Why can LeBron James jump higher than other basketball players? The answer has to do with Newton's Third Law of Motion. When LeBron James jumps, he is driving force into the court. That force is created by the energy stored inside his muscles. And how high he jumps depends not just on how much energy he forces into the surface of the court, but also on how well he does it.

When LeBron James jumps, he is not unlike a rocket launching off the ground. The rocket uses its engines to push down on the surface of the Earth. This is the "action" that Newton mentions in his Third Law. The "reaction" comes when the ground pushes the rocket upwards using an equal amount of force.

It may seem strange to think of the ground exerting force on an object, especially a basketball player or a rocket ship. But this is what Sir Isaac Newton understood way back in 1687, when he published his most famous book, *Mathematical Principles of Natural Philosophy*.

Newton would have been fascinated by LeBron James's jumping ability. But he would also have understood that it is not simply the strength of James's legs that enables him to jump so high. The stability of his body, located in his core and his torso, also contributes to the energy that he forces into the ground. The energy and strength of LeBron James's *entire body* is what enables him to reach such fantastic heights.

Watching LeBron James dunk on television often causes people to think he is denying the forces of gravity, which seeks to pull us and other objects to the ground. In reality, no one can deny such forces. LeBron James just happens to be so strong and agile that, when he jumps into the air, he *appears* to be denying the force of gravity. He seems almost capable of flying.

Naturally, smaller basketball players require less force to dunk a basketball. Since they are lighter, they don't have to combat the same gravitational pull. On the other hand, the fact that they are lighter means they do not have as much mass to store energy. The more muscles you have, the more energy you can force into the ground, and the higher you can go.

This is why professional basketball players appear to have no fat on their bodies at all. Fat does not store energy as effectively as muscle, but it still contributes to one's body weight. Fat on a basketball player is equal to wearing lead weights around their hips during a game. Obviously, this would hinder a player's performance, especially his ability to dunk.

Physicists have spent time thinking about the physics of dunking. To remain in the air for one second, they say, one would have to have a vertical leap of 4 feet. Which is higher than pretty much any basketball player of all time. One exception is Michael Jordan, who is believed to have the highest vertical leap—48 inches, or 4 feet—of any professional basketball player. Michael Jordan was just 6 feet, 6 inches tall—average for an NBA player—but his vertical leap placed his head about 6 inches above the rim.

That the best basketball player in history also has the highest vertical leap is no coincidence. Michael Jordan's body was strong, stable and proportioned in such a way that the force he pushed onto the ground placed him above the rest. He was one of the best overall athletes in the game, and his slam-dunking ability was an indication of his prowess.

Still, Michael Jordan often tucked his legs beneath him when he jumped, to make it seem as if he was flying through the air. Even athletes with 48-inch vertical leaps, in other words, wish they could jump even higher.

Name: \_\_\_\_\_ Date: \_\_\_\_\_

1. What is Sir Isaac Newton's Third Law of Motion?

- A Objects at rest and objects in motion will remain at rest or in motion, unless they are acted upon by an unbalanced force.
- B For every action there is an equal and opposite reaction.
- C When a force acts on a mass, acceleration is produced.
- D When a force acts on a mass, the mass increases.

2. What does the author describe in the passage?

- A Sir Isaac Newton's most famous book, *Mathematical Principles of Natural Philosophy*
- B how LeBron James developed his basketball dunking skills
- C how Sir Isaac Newton came up with the three basic laws of motion
- D how the way that LeBron James dunks a basketball illustrates Newton's Third Law of Motion

3. Read the following sentences from the passage: "When LeBron James jumps, he is not unlike a rocket launching off the ground. The rocket uses its engines to push down on the surface of the Earth. This is the 'action' that Newton mentions in his Third Law."

Based on this information, LeBron James jumping and the rocket using its engine to push down on the surface of the Earth are examples of which part of Newton's Third Law?

- A both the action and the equal and opposite reaction
- B the equal and opposite reaction of an action
- C the action which causes an equal and opposite reaction
- D neither the action nor the equal and opposite reaction

4. The force created when the court pushes LeBron James upwards is equal to which force?

- A the force LeBron James used to dunk the ball
- B the force LeBron James drives into the court when he jumps
- C the force LeBron James uses to throw the ball
- D the force LeBron James drives into the court when he lands after jumping

5. What is the main idea of this passage?

- A LeBron James and Michael Jordan are two of the best players in the history of professional basketball.
- B Basketball players must have high vertical leaps in order to dunk basketballs.
- C Newton's Third Law of Motion is related to the First and Second Laws of Motion.
- D Newton's Third Law of Motion can be examined using the examples of basketball players jumping and rockets launching.

6. Read the following paragraph from the passage:

"LeBron James is a big man. He is 6 feet, 8 inches tall. He weighs 245 pounds. When he is standing upright, with his arms raised above his head, his reach extends to 8 feet and 10¼ inches."

How can the tone of the author best be described in this paragraph?

- A humorous
- B angry
- C disinterested
- D factual

7. Choose the answer that best completes the sentence below.

\_\_\_\_\_ LeBron James has an impressive vertical leap of 44 inches, Michael Jordan holds the record with a vertical leap of 48 inches.

- A In contrast
- B For example
- C Although
- D Initially

8. Describe how a rocket launches off the ground by using information from the passage.

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9. When LeBron James jumps, he is driving force into the court. How is this force created?

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10. How does the example of LeBron James jumping to dunk a basketball illustrate Newton's Third Law of Motion? Use information from the passage to support your answer.

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## Teacher Guide &amp; Answers

Passage Reading Level: Lexile 1050

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8. Describe how a rocket launches off the ground by using information from the passage.

**Suggested answer:** The rocket uses its engines to push down on the surface of the Earth. Then the ground pushes the rocket upwards using an equal amount of force.

9. When LeBron James jumps, he is driving force into the court. How is this force created?

**Suggested answer:** This force is created by the energy stored inside his muscles.

10. How does the example of LeBron James jumping to dunk a basketball illustrate Newton's Third Law of Motion? Use information from the passage to support your answer.

**Suggested answer:** When LeBron James jumps to dunk a basketball, he is using energy to drive force into the court. This force is the "action" that Newton mentioned in his Third Law. The "reaction" comes from the ground pushing LeBron James upwards with an opposite and equal amount of force.