Shelby County Schools
Extended Learning Packet

Science

Grade 8

It's the Law

What is Newton's First Law of Motion?

Force and motion are related. In the 1680s, British scientist Sir Isaac Newton explained this relationship between force and motion with three laws of motion.

Newton's first law describes the motion of an object that has a net force of 0 N acting on it. The law states: *An object at rest stays at rest, and an object in motion stays in motion at the same speed and direction, unless it experiences an unbalanced force.* Let's look at the two parts of this law more closely.

An Object at Rest Stays at Rest

Active Reading **11 Identify** As you read, underline examples of objects affected by inertia.

Newton's first law is also called the law of inertia. **Inertia** (ih•NER•shuh) is the tendency of all objects to resist a change in motion. An object will not move until a force makes it move. So a chair will not slide across the floor unless a force pushes the chair, and a golf ball will not leave the tee until a force pushes it off.

Visualize It!

12 Explain In your own words, explain why the dishes remain in place when the magician pulls the cloth out from under them.

© Houghton Mifflin Harcourt Publishing Company • Image Credits: (bg) ©Stop/Photodisc/Getty Images

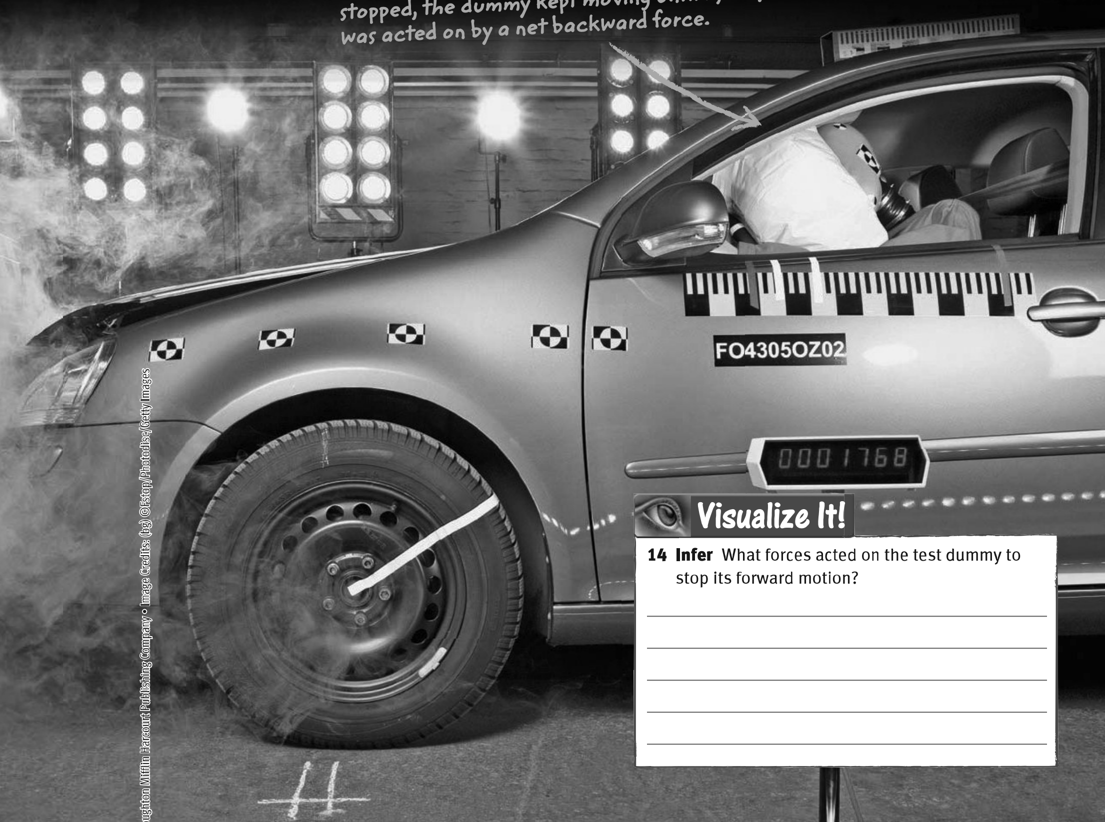
An Object in Motion Stays in Motion

Now let's look at the second part of Newton's first law of motion. It states that an object in motion stays in motion at the same speed and direction, or velocity, unless it experiences an unbalanced force. Think about coming to a sudden stop while riding in a car. The car stops because the brakes apply friction to the wheel, making the forces acting on the car unbalanced. You keep moving forward until your seat belt applies an unbalanced force on you. This force stops your forward motion.

Both parts of the law are really stating the same thing. After all, an object at rest has a velocity—its velocity is zero!

Think Outside the Book **Inquiry**

13 Apply Create a model that demonstrates the concept of inertia. Share your results with the class.



When this car was in motion, the test dummy was moving forward at the same velocity as the car. When the car hit the barrier and stopped, the dummy kept moving until it, too, was acted on by a net backward force.

Visualize It!

14 Infer What forces acted on the test dummy to stop its forward motion?

What is Newton's Second Law of Motion?

Active Reading

15 Identify As you read, underline Newton's second law of motion.

When an unbalanced force acts on an object, the object accelerates. Newton's second law describes this motion. The law states: *The acceleration of an object depends on the mass of the object and the amount of force applied.*

In other words, objects that have different masses will have different accelerations if the same amount of force is used. Also, a larger mass requires more force than a smaller mass to have the same acceleration. Imagine pushing a shopping cart. When the cart is empty, you need only a small force to accelerate it. But if the cart is full of groceries, the same amount of force causes a much smaller acceleration.

Force Equals Mass Times Acceleration

Newton's second law links force, mass, and acceleration. We can express this relationship using the equation $F = ma$, where F stands for applied force, m stands for mass, and a stands for acceleration. This equation tells us that a given force applied to a large mass will result in a small acceleration. When the same force is applied to a smaller mass, the acceleration will be greater.

Do the Math **Sample Problem**

These players train by pushing a massive object. If the players push with a force of 150 N, and the object has a mass of 75 kg, what is the object's acceleration? One newton is equal to 1 kg•m/s^2.

Use Newton's law:

$$F = ma$$
$$150\ \text{kg}\cdot\text{m/s}^2 = (75\ \text{kg})(a)$$
$$a = \frac{150}{75}\ \text{m/s}^2$$
$$a = 2.0\ \text{m/s}^2$$

You Try It

16 Calculate For a more difficult training session, the mass to be pushed is increased to 160 kg. If the players still push with a force of 150 N, what is the acceleration of the object?

Use Newton's law:

$$F = ma$$
$$150\ N =$$

Why It Matters

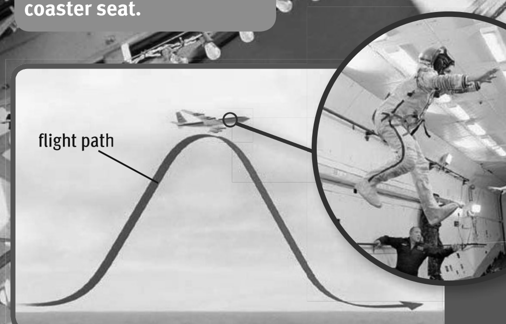
WEIRD SCIENCE

Newton's Second Law and You

Think about the last time you rode on a roller coaster or in a car on a hilly road. Did you feel like you were going to float out of your seat when you went over a big hill? Newton's second law can explain that feeling.

Going Up
When the roller coaster is going up a hill, you have two important forces acting on you—the force of gravity and the upward force exerted by the roller coaster seat.

Coming Down
Once the roller coaster starts down the other side, it accelerates downward, and your seat does not support your full weight.



Practicing for Space
Astronauts take special flights to train for space missions. The airplane's path looks like a roller coaster hill. As the plane accelerates downward, the astronauts lose contact with the plane and fall toward Earth. This condition is called free fall.

Extend Inquiry

17 Infer Suppose you were standing on a scale in an elevator in free fall. What would the scale read?

18 Synthesize Explain why the feeling of weightlessness in free fall is not the same as truly being weightless.

19 Compare In what ways are roller coaster rides similar to and different from training simulations in a NASA plane?

What is Newton's Third Law of Motion?

Newton also devised a third law of motion. The law states: *Whenever one object exerts a force on a second object, the second object exerts an equal and opposite force on the first.*

So when you push against a wall, Newton's law tells you that the wall is actually pushing back against you.

Objects Exert Force on Each Other

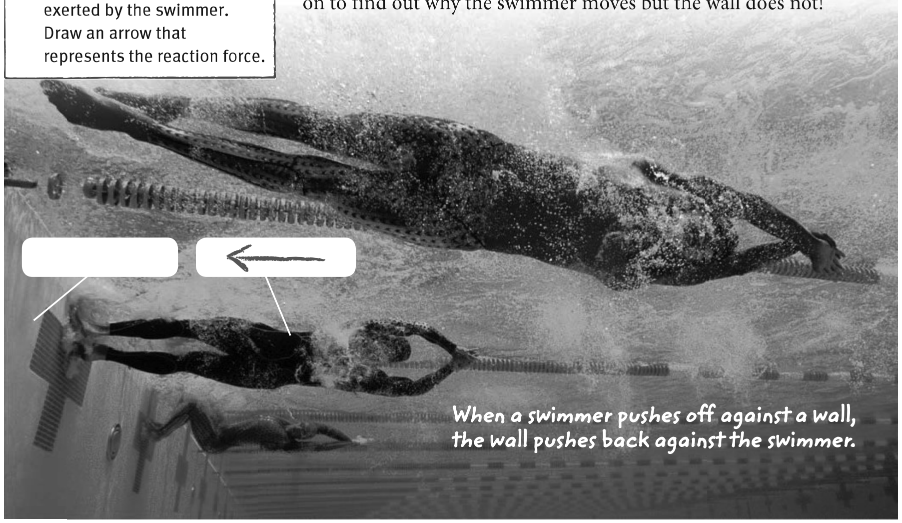
Newton's third law also can be stated as: All forces act in pairs. Whenever one object exerts a force on a second object, the second object exerts an equal and opposite force on the first. There are action forces and reaction forces. Action and reaction forces are present even when there is no motion. For example, you exert a force on a chair when you sit on it. Your weight pushing down on the chair is the action force. The reaction force is the force exerted by the chair that pushes up on your body.

Forces in Pairs Have Equal Size but Opposite Directions

When an object pushes against another object, the second object pushes back equally hard, in the opposite direction. In the pool below, the swimmer's feet push against the wall as he moves forward. This push is the action force. The wall also exerts a force on the swimmer. This is the reaction force, and it moves the swimmer forward. The forces do not act on the same object. Read on to find out why the swimmer moves but the wall does not!

Visualize It!

20 Apply The arrow below represents the action force exerted by the swimmer. Draw an arrow that represents the reaction force.



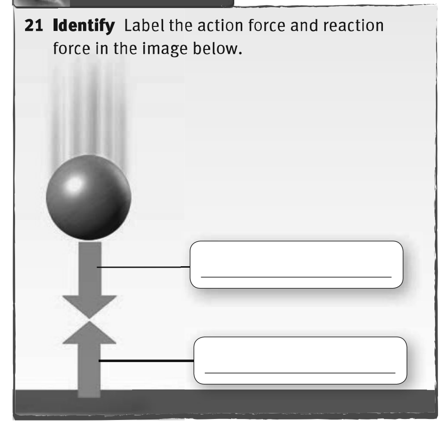
When a swimmer pushes off against a wall, the wall pushes back against the swimmer.

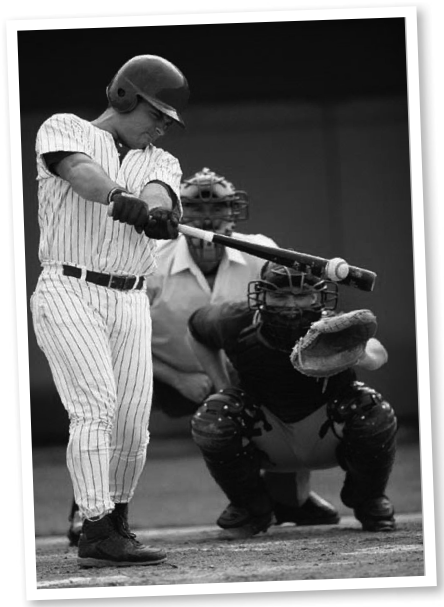
Forces Acting in Pairs Can Have Unequal Effects

Even though action and reaction forces are equal in size, their effects are often different. Gravitation is a force pair between two objects. If you drop a ball, gravity in an action force pulls the ball toward Earth. But the reaction force pulls Earth toward the ball! It's easy to see the effect of the action force. Why don't you see the effect of the reaction force—Earth being pulled upward? Newton's second law answers this question. The force on the ball is the same size as the force on Earth. However, Earth has much more mass than the ball. So Earth's acceleration is much smaller than that of the ball!

Visualize It!

21 Identify Label the action force and reaction force in the image below.





Forces Can Act in Multiple Pairs

An object can have multiple forces acting on it at once. When this happens, each force is part of a force pair. For example, when a baseball bat hits a baseball, the bat does not fly backward. A force is exerted on the ball by the bat. The bat does not fly backward, because the player's hands are exerting another force on the bat. What then keeps the player's hands from flying backward when the bat hits the ball? The bones and muscles in the player's arms exert a force on the hands. As you can see, a simple activity such as playing baseball involves the action of many forces at the same time.

22 Describe In your own words, explain Newton's third law of motion.

Newton's Laws

Mark the correct letter for the Law of Motion being described in each example below.

A. 1st Law of Motion
B. 2nd Law of Motion
C. 3rd Law of Motion

1. __ A rocket blasting off.
2. __ The Law of Inertia.
3. __ A car accelerates faster than a truck.
4. __ A pencil on a table will stay there.
5. __ You push back, but you move forward while paddling a canoe.
6. __ It requires more force to lift a book than a sheet of paper.
7. __ The Law of Action-Reaction.
8. __ A ball will continue to roll until gravity and friction stop it.
9. __ An empty grocery cart requires less force to push than a full grocery cart.
10. ____A picture hanging on the wall.
11. ____The air is let out of a balloon and it flies around the room.
12. ____The Law of Acceleration.

Brainstorm a list of ways that Newton's Laws of Motion are seen in school on a daily basis.

Newton's 1st Law	**Newton's 2nd Law**	**Newton's 3rd Law**
<u>Examples</u>:	**<u>Examples</u>:**	**<u>Examples</u>:**

Sir Isaac Newton and LeBron James

by ReadWorks

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.

Newton's laws of motion have become known throughout the world, including his Third Law of Motion. It reads: "For every action, 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 ¼ 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 pushes down on the surface of the court. This is the "action" that Newton mentions in his Third Law. The "reaction" comes when the floor pushes back using an equal amount of force.

It may seem strange to think of the floor exerting force on an object, especially a basketball player. But this concept 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 surface of the court. 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 defying the force of gravity, which pulls us and other objects to the ground. In reality, no one can defy such force. LeBron James just happens to be so strong and agile that, when he jumps into the air, he *appears* to be defying 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 one of the best basketball players 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.

From basketball players like LeBron James to Michael Jordan, it may seem like they are bending the rules of physics and gravity when they dunk a basketball. On the contrary, they are able to perform crowd-rousing dunks because of these rules.

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 pushes down on the surface of the court. This is the 'action' that Newton mentions in his Third Law."

Based on this information, LeBron James jumping is an example 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.

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. According to the passage, in order for LeBron James to score a slam-dunk, what must he exert?

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

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.

How Soccer Can Help Us Understand Physics

by ReadWorks

Sports provide a great way to understand some concepts in physics. Physics, after all, is the study of matter, motion, force, and energy. And since sports like soccer, swimming and cycling involve bodies moving through space, they can help us understand how the principles of physics work.

Imagine that you're looking at a soccer ball on a grassy field. If you do nothing to the ball, it will stay motionless on the grass. If you kick the ball, it will roll along the grass before coming to rest again. Pretty simple, right?

For thousands of years, though, people thought that objects like this soccer ball come to rest because they have a natural tendency to stop. It took a famous physicist by the name of Sir Isaac Newton, who lived in the 1600s, to prove that this was not exactly correct.

Newton suggested that objects like the soccer ball have a natural tendency to keep moving. The only reason they stop, he believed, is because an unbalanced force acts on them. By an unbalanced force, Newton meant the force applied to the soccer ball by its environment. When kicked, the surface of the ball travels over the grass, creating friction. The taller the grass, and the rougher the surface of the ball, the more friction is created. And the more friction that exists between the ball and the grass, the less it will travel after being kicked.

Now, imagine that there is no grass. Instead, the ball is resting on a frozen lake. When you kick the ball on the ice, the ball will go much farther than it would have on the grass. This is because ice provides a lot less friction than the grass.

Even so, ice does cause some friction. The ball's interaction with the frozen water crystals on the surface of the lake eventually causes it to come to rest again. But now imagine that instead of ice, the ball is in a place where there's no friction at all. The ball is floating in a vacuum. If you remove friction entirely, kicking the soccer ball would cause it to keep going and going at the same speed, until some force caused it to slow down and stop.

To paraphrase Sir Isaac Newton, a soccer ball on the grass will stay where it is unless acted on by a force. Similarly, once you kick the ball, it will remain in motion unless acted on by force. This, in so many words, is known as Newton's First Law of Motion.

The same principles apply for other sports. Take swimming. Olympic swimmers are in a constant battle with the force of water. Water slows them down. To increase their speed, swimmers often shave their entire bodies, reducing the amount of friction caused by hair. Since a swimming contest can be won or lost by a tenth of a second, anything they can do to remove friction will help-even if it means ridding their bodies of hair.

Recently, Olympic swimmers took to wearing full-body suits in the water, which made swimmers sleeker and reduced underwater friction. Swimmers wearing these suits began to break world records. They started winning all the races. Soon enough, Olympic officials, realizing that these suits posed an unfair advantage, banned the use of suits in Olympic competition. Swimmers had to fall back on their own, hairless skin.

The situation for professional cyclists is slightly different. Unlike the swimmer, who battles the water, the cyclist is confronted with forces from other sources that seek to slow him or her down: the force of the road and the force of the air. Like professional swimmers, pro cyclists are known to shave their body hair, to reduce the amount of friction caused by the wind. But the loss of body hair represents only a tiny reduction in surface friction compared to, say, wearing spandex shorts instead of baggy shorts with pockets that fill up with air as you ride.

To reduce friction and increase speed, cyclists adopt all kinds of techniques. They wear aerodynamic helmets. They crouch low over their bikes. They wear shirts and shorts that cling closely to their skin, preventing air from slipping inside and slowing them down. However, little can be done about the tires' interaction with the pavement. As in the case of the soccer ball, a bicycle wheel will eventually stop spinning if no force acts upon it to keep it moving. The rougher the road, the sooner that bike wheels will come to a stop.

For this reason, cyclists tend to have large, bulging thigh muscles. These muscles allow the cyclist to continue exerting force on the bicycle pedals, which cause the wheels to keep spinning despite their constant interaction with the road. Of course, other factors come into play, too. The heavier you are, the more work you have to do to keep the bike moving-that is, unless you're moving down a hill, in which case the gravitational force of your weight acts to your advantage.

Also, your ability to keep your legs pushing the pedals depends on how fit you are, not just how strong your legs are. Many people who are out of shape would run out of breath before they complete a mile-long bike ride, whereas a person who is fit and has a lot of stamina could travel two miles without much difficulty.

Whether you are in shape or not, what really matters when trying to kick a ball, swim a lap, or bicycle a 5 mile race are the forces of physics. Without them, every time you kicked a soccer ball, the ball would keep going, forever.

Name: ________________________________ **Date:** ______________

1. Once it is in motion, what does an object like a soccer ball have a natural tendency to do?

A. It has a natural tendency to keep moving.

B. It has a natural tendency to stop.

C. It has a natural tendency to change direction.

D. It has a natural tendency to slow down.

2. What does the author explain in this passage?

A. The author explains the force of friction, using different kinds of music as examples.

B. The author explains the sport of soccer, using examples of current teams and players.

C. The author explains the idea of motion, using different sports as examples.

D. The author explains the importance of bike safety, using helmets as an example.

3. Swimmers wearing full-body suits that reduced underwater friction were able to swim faster than other swimmers.

What evidence from the passage supports this statement?

A. Some swimmers shaved their entire bodies to reduce friction caused by hair and increase their speed.

B. After losing contests by a tenth of a second, some swimmers started ridding their bodies of hair to reduce friction.

C. Swimmers wearing full-body suits swam at the same speed as swimmers wearing shirts and shorts that clung closely to their skin.

D. Swimmers wearing full-body suits began to break world records and started winning all the races.

4. Based on the information in the passage, how can friction be described?

A. Friction can be described as a force that acts on an object in motion and can cause the object to stop.

B. Friction can be described as a force that acts on an object in motion and can cause the object to speed up.

C. Friction can be described as the path an object takes after a force acts on it and causes it to move.

D. Friction can be described as the path an object takes when a force acts on it inside a vacuum.

5. What is the passage mainly about?

A. why swimmers and cyclists move at different speeds

B. the motion of bodies and objects

C. the movement of an object inside a vacuum

D. the scientific discoveries of Sir Isaac Newton

6. Read the following sentence: "Newton suggested that objects like the soccer ball have a natural **tendency** to keep moving. The only reason they stop, he believed, is because an unbalanced force acts on them."

What does the word **tendency** mean?

A. a very small chance of something happening

B. a fifty-fifty chance of something happening

C. the fear of doing something or acting in a certain way

D. the way something normally behaves or acts

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

Newton suggested that a ball has a natural tendency to keep moving _______ others believed that a ball has a natural tendency to stop.

A. although

B. because

C. before

D. later on

8. What are some things cyclists do to reduce friction?

9. According to Newton's First Law of Motion, what will happen to a soccer ball that is kicked?

10. The end of the passage states that without the forces of physics, every time you kicked a soccer ball or jumped on a bike, the ball and the bike would keep going, forever. Explain why the ball and bike would keep going, using evidence from the passage.