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Sixth Step–
SENSATIONAL WORK!

LESSON 6
Science

Vocabulary to Know

Laws of Motion–One of the great advances in science occurred during the 1600s when Isaac Newton discovered natural laws that govern the motion of objects:

- **The Law of Inertia:** If no force is applied, an object at rest will remain at rest, and an object in motion will move in a straight line at constant speed.
- **The Law of Acceleration, Part I:** An object's speed increases in proportion to the amount of force applied.
- **The Law of Acceleration, Part 2:** For the same amount of applied force, a lighter object accelerates—changes its speed—at a greater rate than a heavier object.
- **The Law of Interaction:** For every action, there is an equal and opposite reaction.

Newton used his laws of motion to discover the Law of Universal Gravitation

Force, Work, and Machines

Scientists define **work** as the product of the units of force times the units of distance. For work to occur, there must be force applied to an object and the object must move:

Machines are devices that are designed to make work easier.

- A ***lever*** is a simple machine that consists of a bar that moves around a pivot point called a fulcrum. A lever changes a small prying force into a much larger one.
- A ***wheel and axle*** is a simple machine that changes a small turning force into a much larger one.

http://schoolworkhelper.net/sir-isaac-newton-the-universal-law-of-gravitation/

ASSIGNMENT 1

DIRECTIONS

Read the following passage.
Complete the assignment that follows.

Sir Isaac Newton: The Universal Law of Gravitation

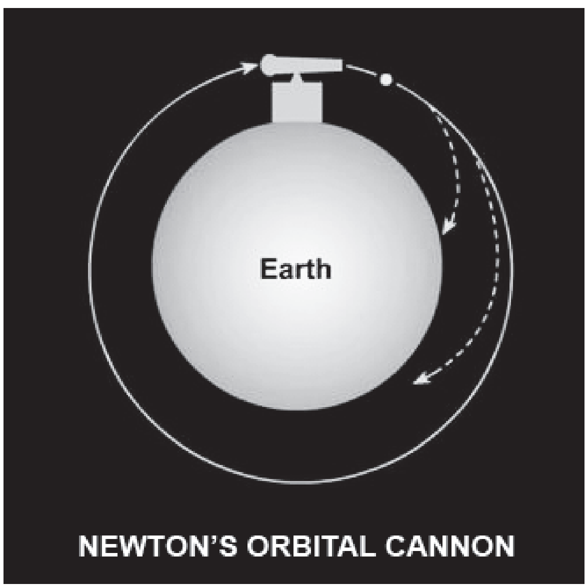
There is a popular story that Newton was sitting under an apple tree, an apple fell on his head, and he suddenly thought of the Universal Law of Gravitation. As in all such legends, this is almost certainly not true in its details, but the story contains elements of what actually happened.

What Really Happened with the Apple?

Probably the more correct version of the story is that Newton, upon observing an apple fall from a tree, began to think along the following lines: The apple is accelerated, since its velocity changes from zero as it is hanging on the tree and moves toward the ground. Thus, by Newton's 2nd Law there must be a force that acts on the apple to cause this acceleration. Let's call this force "gravity", and the associated acceleration the "acceleration due to gravity". Then imagine the apple tree is twice as high. Again, we expect the apple to be accelerated toward the ground, so this suggests that this force that we call gravity reaches to the top of the tallest apple tree.

Sir Isaac's Most Excellent Idea

Now came Newton's truly brilliant insight: if the force of gravity reaches to the top of the highest tree, might it not reach even further; in particular, might it not reach all the way to the orbit of the Moon! Then, the orbit of the Moon about the Earth could be a consequence of the gravitational force, because the acceleration due to gravity could change the velocity of the Moon in just such a way that it followed an orbit around the earth.



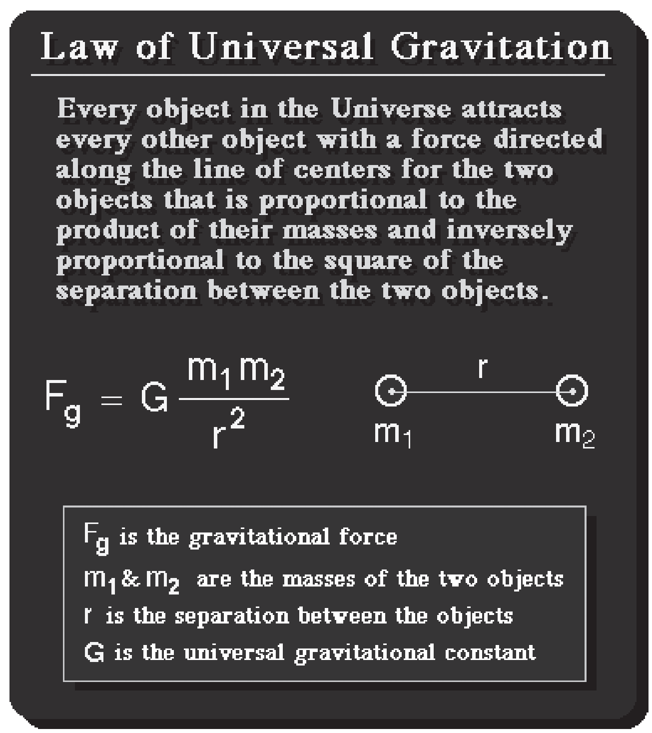
NEWTON'S ORBITAL CANNON

This can be illustrated with the thought experiment shown in the figure above. Suppose we fire a cannon horizontally from a high mountain; the projectile will eventually fall to earth, as indicated by the shortest trajectory in the figure, because of the gravitational force directed toward the center of the Earth and the associated acceleration. (Remember that acceleration is a change in velocity and that velocity is a vector, so it has both a magnitude and a direction. Thus, acceleration occurs if either or both the magnitude and the direction of the velocity change.)

But as we increase the muzzle velocity for our imaginary cannon, the projectile will travel further and further before returning to earth. Finally, Newton reasoned that if the cannon projected the cannon ball with exactly the right velocity, the projectile would travel completely around the Earth, always falling in the gravitational field but never reaching the Earth, which is curving away at the same rate that the projectile falls. That is, *the cannon ball would have been put into orbit around the Earth*. Newton concluded that the orbit of the Moon was of exactly the same nature: the Moon continuously "fell" in its path around the Earth because of the acceleration due to gravity, thus producing its orbit.

By such reasoning, Newton came to the conclusion that any two objects in the Universe exert gravitational attraction on each other, with the force having a universal form:

The constant of proportionality G is known as



the ***universal gravitational constant***. It is termed a "universal constant" because it is thought to be the same at all places and all times, and thus universally characterizes the intrinsic strength of the gravitational force.

http://csep10.phys.utk.edu/astr161/lect/history/newtongrav.html

LESSON 6
Science

Write a Summary

When you summarize, you express the ***main idea(s)*** of the passage in your own words. Look at the **RAP Summary Strategy**. Use these steps to complete the following assignment.

RAP Summary Strategy

1. **R**=Read a passage by paragraphs.
2. **A**=Ask questions:
   What is the topic? (circle key words)
   What is the most important thing it tells me about the topic?
   What are the important details?
3. **P**=Paraphrase (put in own words), **aim for about 10 words per sentence.**

DIRECTIONS

Summarize each paragraph in the article *"Sir Isaac Newton: The Universal Law of Gravitation."* Remember to summarize each paragraph and aim for 10 words per sentence. You should have 5-6 sentences when you finish. *Complete this assignment on a separate sheet of paper.*

ASSIGNMENT 2

DIRECTIONS

Answer the following multiple choice questions.

Newton's second law of motion states that the acceleration of an object is dependent on the object's mass and the amount of force applied to the object. The table shows data from an investigation of Newton's second law.

Net Force (N)	Mass (kg)	Acceleration (m/s^2)
8	2	4
8	4	2
16	2	8
16	4	4

1. **Which statement describes the pattern established in the data included in the chart?**
   A. A doubling of the net force increased acceleration 4 times when the object's mass is constant.
   B. A doubling of the net force decreases acceleration 2 times when the object's mass is constant.
   C. A doubling of the mass decreases the acceleration of the object by half when the net force is constant.
   D. A doubling of the mass increases the acceleration of the object 2 times when the net force is constant.

LESSON 6
Science

The following information refers to question 2

An object at rest with a mass of 4 kilograms (kg) is acted on by a force causing the object to move. The table shows measurements of the object's motion.

Time(s)	Velocity(m/s)
0	0
1	2
2	4
3	6
4	8
5	10

The relationship between the force acting on an object and the object's mass and acceleration (change in object's velocity over time) is defined by the formula:

$$\textit{Force} = \textit{mass} \times \textit{acceleration}$$

2. Based on the data, which equation correctly calculates the amount of force, in Newton's (N) Second Low of Motion, that acted on the object?

A. $4\text{ kg} \times 0.5\text{ s}^2/\text{m} = 2\text{ N}$

B. $4\text{ kg} \times 2\text{ m/s}^2 = 8\text{ N}$

C. $4\text{ kg} \times 5\text{ s} = 20\text{ N}$

D. $4\text{ kg} \times 10\text{ m/s} = 40\text{ N}$

The following passage refers to question 3.

When a moving object, such as a car, experiences a collision that causes the object to stop moving, the amount of force experienced by the object can be determined using the following formula:

$$\text{FORCE} \times \text{CHANGE IN TIME} = \text{MASS} \times \text{CHANGE IN VELOCITY}$$

During the collision, the object's velocity (speed) slows down over a period of time until the object stops, reaching a velocity of zero. If the force experienced by the object during the collision is too high, the force can damage the object. For example, the force of a collision can damage a car and injure passengers in the car.

One way to reduce the amount of force experienced during a collision is to reduce the velocity of the object before the collision occurs. An object that is moving slower will experience less force during a collision. An object that is moving faster will experience more force during a collision.

Another way to reduce the amount of force experienced during a collision is to increase the amount of time that it takes the velocity to slow down and reach zero. An object that comes to a stop more slowly will experience less force. An object that comes to a stop more quickly will experience more force.

3. Which of these is an example of a safety feature that reduces the amount of force experienced during a collision involving a car?

A. A concrete barrier on a road helps prevents cars from driving into a ditch.

B. An engine helps supply power to the wheels to increase the velocity of a car.

C. A car windshield is constructed from reinforced layers to help prevent shattering.

D. An air bag in a car helps increase the amount of time that a person takes to slow down.

4. One of Newton's laws indicates that an object moves in a straight line unless acted upon by an outside force. A recently discovered planet has been observed for the last five years. Observations indicate that the planet travels in a curved path.

What conclusion can be made?

A. The planet has a liquid centre.

B. A change in the planet's rotational speed has altered the planet's course.

C. The planet is influenced by the gravitational pull of a different body with mass.

D. A cosmic wind has altered the planet's course.

E. It only appears that the planet is traveling a curved path from earth's reference point.

LANGUAGE ARTS ASSIGNMENT 3

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 10¼ 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.

LESSON 6
Reasoning through Language Arts

DIRECTIONS
Based on the passage, choose the best answer in the following questions.

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. the way in which 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 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

DIRECTIONS

Use a separate sheet of paper to answer questions 8-10.

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

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.

ASSIGNMENT 4

Using Cellphones and Computers to Transmit Information

by Alissa Fleck

Modern technology can do some pretty incredible things. It's possible, with current technological capabilities, to transmit digital information over long distances using coding and decoding processes without losing the contents of the original information. The best part is we don't have to do anything besides send the message and wait for it to be received.

Consider, for instance, the cellular phone. It wasn't until the early 1980s that this mobile variation on the standard telephone was even available for people to use. Now, it seems like everyone has a cellphone, sending and receiving information in speedy ways invisible to the human eye.

LESSON 6
Reasoning through Language Arts

There's so much going on below the surface of what we can see when we use our cellphones. One difference between a mobile phone and a traditional landline telephone is you can move the cellphone just about anywhere geographically and still use it to talk to other phone users. No matter how far away you are from someone you call, you can usually still understand each other's voices over the phone, thanks to radio waves and something called a cellular network.

It took many evolutions in phone technology to get where we are today, but the current cellphone wirelessly transmits information by connecting to a cellular network. Mobile phone operators provide these cellular networks, which function with the help of cellphone towers, and then calls are made over what is known as a radio link. Through this process, information—in this case, voice input—is broken down and reassembled over the radio link, so the person on the other end instantaneously hears what is said.

In other words, as you speak into the phone, your voice is converted into an electrical signal, transmitted in the form of a radio wave by these towers, and then converted back into the sound of your voice by the phone on the receiving end. All this happens in the blink of an eye while you chat over the phone without any distortion.

The process of transmitting digital information is not exclusive to telephones. Computers are another instrument that can receive, decode and convert information, though typically this information is not a person's voice, but written content.

We may take for granted the ease with which we can pass along information with computers and the Internet, but many forces are hard at work processing information to make computers easier for us to use and communication more reliable.

The first computer showed up around 1941, but it was much more limited in its capabilities than computers now. In fact, computers are everywhere—sometimes they are so small we do not think of them as computers at all, though they serve the same function as the computers we have at home, the office or school.

Much like cellular telephones, computers were actually first used to transmit sensitive information across geographical spaces by the military at a point when government officials worried it would be possible to knock out a country's entire telephone grid.

Computer engineers began finding ways to link their computers together in order to share information among them. This linking began with just a couple of computers and grew to the millions which connect regularly today. Ultimately, that's how what we know as the Internet was developed.

Wireless computer networking is also similar to cellular phone use in that computers use the same networks our mobile phones use.

LESSON 6
Reasoning through Language Arts

While you speak into the telephone using your voice, you typically insert data into your computer by typing on the keyboard. You may decide to share information through an email or access information on a website by typing in or visiting what is known as a hyperlink.

When you use the Internet to share and access information, you connect to the relevant network. You can send a message from your computer to another computer anywhere in the world and it will arrive almost immediately, going through many different networks in the process.

Still, the information you send does not travel in a single piece as it might through the standard mail service; instead, it is broken down into smaller digital information. As with a cellphone, the information you send is fragmented into tiny pieces and then reconstructed once it's reached its destination. Along with your message comes other information, for instance about ordering, or how the message should be restructured to make sense to the reader. Your message will also include more basic data about where it came from and where it is supposed to go.

Computers and the Internet require many high-tech and complicated pieces to run properly, but something known as a router is a key instrument that keeps information being sent from one computer to another going along the correct pathway. The Internet also relies on telephone wires and satellite links for wireless information sharing.

It's important to note that for the Internet to work as it does, many companies have to agree to work with one another. The Internet is really a collection of networks working together toward a common goal of allowing information to be shared.

DIRECTIONS
Based on the passage, choose the best answer in the following questions.

1. **What are two examples of technology that send information over long distances?**
   A. the human eye and computers
   B. government officials and computers
   C. cellphones and the human eye
   D. cellphones and computers

2. **What does the author compare to cellphones in this passage?**
   A. The author compares companies to cellphones.
   B. The author compares engineers to cellphones.
   C. The author compares computers to cellphones.
   D. The author compares cellular networks to cellphones.

3. A cellphone sends and receives information in a speedy way invisible to the human eye.

What evidence from the passage supports this statement?

A. When a person speaks into a cellphone, his or her voice is broken down and reassembled over a radio link, so the person on the other end instantaneously hears what is said.

B. When computers first showed up around 1941, they were used to transmit sensitive information across geographical spaces by the military because of worries government officials had.

C. Although people may take for granted the ease with which they can pass along information through computers, many forces are at work to make computer communication more reliable.

D. Like cellphones, computers can receive, decode, and convert information, though typically this information is written content rather than someone's voice.

4. What is one way that computer use has changed over time?

A. Computers were first used in homes, schools, and offices to send different kinds of information, but now they are used only by the military to send sensitive information.

B. Computers were first used by the military to send sensitive information, but now they are used in homes, schools, and offices to send different kinds of information.

C. Computers used to send a person's voice from one place to another, but now they send only written content.

D. Computers used to send a person's voice from one place to another, but they have been gradually replaced by landline telephones.

5. What is this passage mostly about?

A. computers, the Internet, and how the military uses technology to protect people

B. cellphones, landline telephones, and the reasons people have trouble hearing each other over the phone

C. mobile phone operators, government officials, and companies that work with one another

D. cellphones, computers, and how they send information from one place to another

6. Read the following sentence: "It's possible, with current technological capabilities, to *transmit* digital information over long distances using coding and decoding processes without losing the contents of the original information."

What does the word *transmit* mean in the sentence above?

A. harm

B. fold

C. hear

C. send

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

Information is transmitted by different kinds of modern technology, ________ cellphones and computers.

A. in conclusion

B. instead

C. especially

D. never

LESSON 6
Reasoning through Language Arts

DIRECTIONS
Use a separate sheet of paper to answer questions 8-10.

8. According to the passage, what are cellphones used for?

9. How does a cellphone transmit information using cellular networks?

10. At the end of the passage, the author writes, “The Internet is really a collection of networks working together toward a common goal of allowing information to be shared.” Could cellphones be described in the same way? Explain your answer using evidence from the passage.

References

www.readworks.org