Wizards of Wright

Lesson: Newton's Second Law of Motion

Use WOW! Lesson Intro to begin.

Background Info for Wizards:	Sir Isaac Newton was one of the greatest scientists and mathematicians that ever lived. He was born in England and lived from 1643 to 1727, and was raised by his grandmother. During his college studies he found an interest in math, physics, and astronomy. Newton's ideas have shaped our learning about motion, gravity, the diffraction of light, and forces. His accomplishments laid the foundations for modern science and revolutionized the world. If the students had the *WOW! Newton's First Law of Motion* Lesson they were introduced to Sir Isaac Newton, Aristotle and Galileo Galilei. They learned about and experimented with Newton's 1st Law of Motion, Gravity, Force and Inertia.
Materials:	Student Activity #1 – FMA strips (1 for each student) Wizard Demonstration – dolly, spring scale Student Activity #2 – wooden rulers, ping-pong balls, golf balls Student Activity #3 – string/twine (must be thin enough to slide easily through your straws), straight straws (bendy ones won't work) balloons, binder clips/clothes pins, balloon pumps, paperclips/popsicle sticks/small weighted objects, tape
Lesson Time: 60 minutes	Introduction: 5-7 minutes Guided Lesson #1: 5-7 minutes Student Activity #1: 5-7 minutes Guided Lesson #2: 2 minutes Wizard Demonstration: 5-7 minutes Student Activity #2: 10-15 minutes Student Activity #3: 10-15 minutes Conclusion: 5 minutes
Learning Targets:	
Introduction for Students: 5-7 minutes	**Ask students what they already know about Sir Isaac Newton.** **Ask students to explain Newton's 1st Law of Motion.** A still object will stay still unless a force pushes or pulls it. A moving object will stay moving unless a force pushes or pulls it. Or stated another way - an object at rest tends to stay at rest, and an object in

	motion tends to stay in motion, with the same direction and speed. This is called "the law of inertia". What does this mean? This means that there is a natural tendency of objects to keep on doing what they're doing. All objects resist changes in their state of motion. In the absence of a force, an object in motion will maintain this state of motion. Let's take this a step further. According to Newton's first law, when an object is in motion it will move in the same direction with the same speed unless a force acts on it. That means if you kick a ball it will fly forever unless some sort of force acts on it! Once kicked forces like resistance or friction start to act on the ball immediately. Gravity pulls the ball down to the ground and the air resistance slows it down. The second law teaches us that when an object has a greater mass, it will make more force to accelerate it. This also means that the harder you kick a ball the farther it will go. This seems kind of obvious to us, but having an equation to figure out the math and science is very helpful to scientists.
Guided Lesson #1: 5-7 minutes	Newton's 2nd Law of motion is best stated in the equation we just talked about that relates an object's mass and acceleration to the amount of force involved to cause motion. Force equals mass times acceleration. $F = m \times a$; $F = ma$. Let's define these words: <u>Force</u> – A force is anything that can change the state of motion of an object, like a push or a pull. You use force when you push a button on your phone or when you throw a ball. Forces are everywhere. Gravity acts as a constant force on us – it keeps us on the ground, not floating away. To describe a force we use direction and strength. For example when you kick a ball you are exerting force in a specific direction. That is the direction the ball will travel. Also, the harder you kick the ball the stronger the force you place on it and the farther it will go. <u>Mass</u> – Mass is a measurement of how much matter (i.e., electrons, protons and neutrons) an object contains. We can place a scale on the moon and weigh an object there. The weight will be different because the strength of gravity is different. But the mass will be the same.

	Let's think about different amounts of clay; as pieces of clay are removed the mass of the object decreases. The mass can be added to another ball of clay, increasing its mass. <u>Acceleration</u> – Acceleration is the rate of change in velocity of an object, or just a fancy word for speeding up. When you press down on the gas pedal in a car, the car surges forward going faster and faster. This change in velocity is acceleration. Newton's second law links these three terms together and is all about the effect that an unbalanced force has on the motion of an object. It states that the rate of change of speed (velocity) of an object is directly proportional to the force applied and takes place in the direction of the force. Think of it this way – how fast an object moves is based upon how much it weights and how hard it is being pushed. The harder you push a toy car, the faster it will move. When you're at school, if you couldn't go back to your homeroom or locker through the day, you would walk considerably slower if you had to carry all of your textbooks around.
Student Activity #1: 5-7 minutes	The force placed on an object is based on the objects mass and at what rate of speed it is traveling. Students will experiment with Newton's Second Law by using a variable strip that allows them to manipulate the three variables contained within Newton's 2nd Law. Give the students a premade variable sheet. (It will already have three holes cut into it. Each will be labeled as mass, force, and acceleration, in that order). They can work with a partner, so they can discuss what is happening. Students can then insert their finger into the hole representing the variable they wish to remain constant. By placing their finger in the other hole they can raise or lower that value and the third variable reacts accordingly (either high or lower).  What does it show us? If force remains constant, an increase in acceleration requires a decrease in mass. Etc.

Guided Lesson #2: 2 minutes	Newton's Second Law states that acceleration (a) is based upon force (F) applied to the object and the mass (m) of the object. A change in force or mass will change the object's acceleration F=ma (Force = mass X acceleration).
Wizard Demonstration: 5-7 minutes	1) Have one student sit on a dolly/scooter at the front of the class and hold one end of the spring scale. 2) Another student should pull the first student at a constant force of 10 N. 3) Observe the speed of the students as they keep the force constant. Discuss with students that this shows the relationship between force and acceleration. Have different volunteers (safely!) repeat at different N values.
Student Activity #2: 10-15 minutes	Students will compare the acceleration of a ping pong ball to the acceleration of a golf ball when a constant force is applied. The large mass (golf ball) should show a lower acceleration then the small mass (ping pong ball). Have students work in small groups. This may be best done on the floor. Each group will get: 1 ping-pong ball, 1 golf ball, 1 wooden ruler, and a worksheet We want students to show the connection between force (F), mass (m), and acceleration (a). There are two sets of directions to experience Newton's 2nd Law: 1) Constant Force, and 2) Constant Acceleration. **To test constant force:** 1) Place a ping-pong ball in front of the wooden ruler. 2) Carefully bend the ruler back and release it. 3) Discuss your observations. 4) Place a golf ball in front of the wooden ruler. 5) Carefully bend the ruler back and release it. Be sure to bend the ruler back to the same spot. ***The force needs to be constant***. 6) Discuss your observations. **To test constant acceleration:** 1) Place a ping-pong ball in front of the wooden ruler. 2) Carefully bend the ruler back and release it. 3) Discuss your observations. 4) Place a golf ball in front of the wooden ruler.

	5) Carefully bend the ruler back and release it. Be sure to bend the ruler back to achieve the same acceleration as the ping-pong ball. ***The acceleration needs to be constant*.**
	6) Discuss your observations.
	
	Wizards: This second test will take more experimentation because the students will not be pulling the ruler back to the same spot. They will need to test several spots to achieve the same acceleration. (With the golf ball they will have to pull the ruler back further.)
	
	Observations:
	If all goes well – with constant force, the ping-pong ball should move faster.
	If all goes well – with constant acceleration, the ping-pong ball needed to be hit more softly, while the golf ball needed to be hit with greater force.
	
	Questions for discussion:
	
	1. How does this show Newton's 2nd Law?
	    a. Acceleration is based on mass and force.
	2. When the ruler was bent to the same spot (constant force) which ball accelerated faster? WHY?
	    a. The ping-pong ball; because it had less mass.
	    b. The large mass (golf ball) should show a lower acceleration then the small mass (ping pong ball).
	3. When the ruler was bent to achieve similar acceleration (constant acceleration) which ball went faster? WHY? (Trick question.)
	    a. Neither. Both had the same acceleration, the force was different.
	4. Explain the relationship between mass and acceleration.
	    a. More mass and acceleration require a greater force.
	5. Which ball had more inertia?
	    a. The golf ball. It has more mass so it has more inertia. Mass and Inertia are directly related.

Student Activity #3: 10-15 minutes	Students will race balloons across a suspended string, showing that the balloon with the lower mass will travel faster than a weighted balloon. Each group (same small group as before) receives four balloons, two for each race. (For first race – one small and one large, for second race – two of the same size.) BEWARE of popping balloons!

	(Using a balloon pump helps the students inflate the balloons to the proper and consistent size. Discuss consistency of pumps with them. Binder clips help the students keep the balloon inflated until ready to race.) Have students tie one end of the string to one chair, thread your straw onto the string, then tie off the other end on the other chair. Pull the chairs apart until the string is taut. Repeat for each track. (Make sure to tie the ends of the string to something sturdy – desk to desk, chair to chair.) I've heard that these balloons go pretty fast. Aim for a long track. (8 feet long may be too short. Aim for 10-15 feet or longer if you have the space.) TIP! Make sure your string is level. Test #1: 1. Inflate two balloons of unequal size (one small and one large). Use a clip to secure the end of the balloon. 2. Tape each balloon to the straws. 3. Release each balloon at the same time. 4. Discuss your observations. 5. Test several times.  Test #2: 1. Inflate two balloons of equal size (same size). 2. Tape 5 large paper clips to one balloon. 3. Tape one small paper clip (or other items of small weight) to the other balloon. 4. Release each balloon at the same time. 5. Discuss your observations. 6. Test several times. What does this show us? When a constant force is applied (inflated balloon), the object with the least mass will have the greatest acceleration.
Conclusion: 5 minutes	Review what Newton's 2nd Law of Motion is. Review force, mass, and acceleration.

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