**Title of the Lesson:**

**Rocket Power**

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| **Estimated Time: 30-45 minutes** | |
| **Standards: S4P3, S5P1, S8P1, S8P3** | |
| **S4P3. Obtain, evaluate & communicate information about the relationship between balanced & unbalanced forces.**  a. Plan & carry out an investigation on the effects of balanced & unbalanced forces on an object & communicate the results.  b. Construct an argument to support the claim that gravitational force affects the motion of an object.  **S5P1. Obtain, evaluate, and, communicate information to explain the differences between a physical change & a chemical change.**  c. Plan & carry out an investigation to determine if a chemical change occurred based on observable evidence. (color, gas, temperature change, odor, new substance produced).  **S8P3. Obtain, evaluate, and communicate information about cause and effect relationships between force, mass, and the motion of objects.**  a. Analyze and interpret data to identify patterns in the relationships between speed and distance, and velocity and acceleration. (Clarification statement: Students should be able to analyze motion graphs, but students should not be expected to calculate velocity or acceleration.)  b. Construct an explanation using Newton’s Laws of Motion to describe the effects of balanced and unbalanced forces on the motion of an object.  c. Construct an argument from evidence to support the claim that the amount of force needed to accelerate an object is proportional to its mass (inertia).  **S8P1. Obtain, evaluate, and communicate information about the structure and properties of matter.**  c. Plan and carry out investigations to compare and contrast chemical (i.e., reactivity, combustibility) and physical (i.e., density, melting point, boiling point) properties of matter.  d. Construct an argument based on observational evidence to support the claim that when a change in a substance occurs, it can be classified as either chemical or physical.  f. Construct an explanation based on evidence to describe conservation of matter in a chemical reaction including the resulting differences between products and reactants. | |
| **Science and Engineering Practices:** | **Crosscutting Concepts:** |
| **Asking Questions and Defining Problems**  Ask and/or identify questions that can be answered by an investigation.  **Analyzing and Interpreting Data**  Record information (observations, thoughts, and ideas). Compare predictions (based on prior experiences) to what occurred (observable events).  **Using Math and Computational Thinking**  Describe, measure, and/or compare quantitative attributes of different objects and display the data using simple graphs.  **Planning and Carrying out an Investigation**  Make observations (firsthand or from media) and/or measurements to collect data that can be used to make comparisons.  Make predictions based on prior experiences. | **Cause and Effect**  Events have causes that generate observable patterns. |
| **Big Ideas/Enduring Understandings:** | **Vocabulary:** |
| **Film canister rockets are perfect for demonstrating Newton’s Laws of Motion. First the rocket lifts off because it is acted upon by an external force (Newton’s First Law) caused by the build up of gas produced inside the canister. This causes the lid to blow off, launching the film canister in the air.**  **The rocket travels upward with a force that is equal and opposite to the downword force propelling the water, gas, and lid (Newton’s Third Law).**  **The amount of force is directly proportional to the amount of water and gas released from the canister and how fast it accelerates (Newton’s Second Law)**  **Film canister rockets also can focus on the exploration of various chemical reactions.** | (should be embedded in lesson)  **Acceleration**  **Chemical Reaction**  **Force**  **Motion**  **Newton’s Laws of Motion**  **Newton’s First Law**  **Newton’s Second Law**  **Newton’s Third Law**  **Velocity** |
| **Essential Questions:** |
| **Which laws of motion are involved in the process of a rocket launch?**  **What processes cause a rocket to launch?**  **How does a rocket launch occur?** |
| **Materials:** | **Safety Considerations:** |
| Paper or index cards  Tape  Film canister  Scissors  Water  Paper Towels  Effervescing antacid tablet (Alka-Seltzer)  Watch or timer  Safety glasses | This experiment requires you to wear protective safety glasses. |
| **Technology Integration:** |
| Students can graph their data electronically and use it to evaluate their results. |
| **Phenomenon:** | |
| **A Rocket Launch video**  **Have students watch the following video**  [**https://pixabay.com/en/videos/rocket-launch-thrusters-nasa-236**](https://pixabay.com/en/videos/rocket-launch-thrusters-nasa-236) | |
| **5E Lesson:** | |
| **Engage:**  After watching the video of the Rocket Launch, the teacher and students will discuss rockets, how they launch, why they launch, and the difficulty of getting something into outer space. Conduct a Driving Question Board for the upcoming exploration. | |
| **Explore: Allow students to make their own film canister rockets**  **What to do:**  Wrap and tape a tube of paper around the film canister. Invert the canister so that the lid lies flat on the table.  Cut fins from the index cards and tape them to the rocket.  Make a nose by cutting a circle out of paper. Cut out a pie shape from the circle and twist the paper into a cone. Tape the cone together then tape it on the open end of the paper tube.  Turn the rocket upside down and fill the canister 1/3 full with water.  Drop in a 1/2 tablet of Alka-Seltzer and snap the lid on tight.  Quickly stand the rocket upright (lid on the table) and stand back! CAUTION: Be careful when launching your rocket. Stand back and don’t point it at anyone.  Make sure you time how long it takes for your rocket to return to earth! This can help you a lot especially if you decide to try an experiment (See the ‘What would happen if’ ideas below). | |
| **Explain:**  As the antacid tablet fizzes, carbon dioxide is released inside the canister. Pressure from the gas builds and eventually pops the lid off. The thrust, or push, of your rocket is related to how much pressure built up inside the canister before the top popped off.  When you mix these effervescing tablets with water, a chemical reaction takes place between the citric acid and sodium bicarbonate contained in the tablet and the water. This chemical reaction creates many, many bubbles of carbon dioxide gas. Citric acid is a weak acid and is in the juice of most citrus fruits like lemons or limes. Sodium bicarbonate is, well, basically baking soda.  You already know what happens when you combine this chemical reaction with a film canister, when it pops, it goes up! | |
| **Elaborate:**  What would happen if…  You change the design of your rocket?  You use more or less fuel (effervescing tablets and water)?  You use hot or cold water?  You added weight to the canister?  Can you think of a way to measure the height reached by the rocket?  How many launches can you get from one tablet, by adding more water after each launch?  Would this happen with baking soda and vinegar?  **Why does your rocket go up?**  It goes up because gas is building and building in the closed film canister and since the lid is the weakest point of the canister, the lid pops off and all that gas comes rushing out of the end of the canister. This action can be explained using [Newton’s Laws of Motion](http://www.grc.nasa.gov/WWW/K-12/airplane/newton.html), more specifically it is an example of Newton’s Third Law of Motion – “Every action has an equal and opposite reaction”. The gas rushing out of one end of the canister (the action) causes your rocket to move in the opposite direction (the reaction). This is exactly how all rockets work whether you use an effervescing tablet as your fuel or a chemical rocket propellant like they do at NASA.  **How do the NASA rockets work?**  Quite simply, rockets are how NASA can get all those amazing missions off the ground. These rockets use a pressurized fuel and an oxidizer. The oxidizer is something that allows the fuel to burn without using outside air. (Can you think of a reason why this might be important? Write your answer in the comment box below!) The fuel, in a gaseous state, is pressurized because this forces it out the end of the rocket just like our Film Canister Rocket! However, there are a few more parts to an actual rocket.  The fuel used in the rockets like the ones that help the space shuttles enter space use liquid hydrogen as the fuel and liquid oxygen as the oxidizer. You may be saying to yourself, “I thought they just said that the fuel is in the gaseous state not liquid?”. You are right, the fuel and oxidizer are only in these liquid states when they are in the holding tanks and they can only stay in this liquid state at extremely low temperatures. The fuel and oxidizer are allowed to combine within the combustion chamber and as the burn they turn into a gas (gases take up about 1,000 times more space than a liquid) this causes the intense pressure. It is exactly like our Film Canister Rocket, the carbon dioxide builds up and puts intense pressure on the canister so the lid pops off. In the case of our shuttle rocket the fuel and oxidizer burn, are put under intense pressure and are released not by the popping off of a lid but through a tiny hole on the bottom of the combustion chamber called a nozzle. | |
| **Evaluate:**  Each student presents their calculations of the height of their rocket launch to their group and similarities and differences are discussed.  Each group explains their rocket launch showing how the forces interact to determine the rockets motion.  Students complete journal entries documenting | |
| **Differentiation:** | |
| **Rather than using paper to create the rocket, plastic tubing can also be used.**  **For a STEAM activity mix the water in the canister with food coloring and launch from white paper to create rocket launch artwork.**  **Launch multiple rockets simultaneously.**  **Rockets may be launched by individuals or by groups of students.** | |

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