Title of Lesson: Rocket Power
Estimated Time: 1 class period

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. **Scale, Proportion, and Quantity** Relative scales allow objects and events to be compared and described (e.g., bigger and smaller; hotter and colder; faster and slower).
Big Ideas/Enduring Understandings:	**Vocabulary:**
A **force** is simply a push or pull (usually on an object). In this activity the force to push the rocket is provided by the gases pushing off on the inside of the cannister. This force generated must overcome the force of gravity for it to launch into space. While this force is sufficient to launch the rocket, gravity – the force that attracts any object toward the center of the earth – quickly pulls it back to the ground again. Film canister rockets also can focus on the exploration of various chemical reactions.	(should be embedded in lesson) **Force** **Push** **Pull** **Motion** **Chemical Reaction**
Essential Questions:	
Which kind of forces 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:**
Film canister (with caps that attach inside) Cup and Water Paper Towels Effervescing antacid tablets (Alka-Seltzer) Watch or timer (optional) 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:

Getting something into outer space is an amazing phenomenon because the object must overcome the mighty force of gravity that tries to pull it back down again. In this exploration, students begin by observing a NASA rocket launching into space. They then construct a simple a model rocket using a film canister for the rocket and Alka-Seltzer and water for the fuel. Along the way, they explore and discuss the forces and obstacles that must be overcome to successfully get a rocket into outer space.

5E Lesson:

Engage:

Have students watch the following video of the recent SpaceX/NASA rocket launch
https://www.youtube.com/watch?v=zAtjTawE5KA
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. If time permits, conduct a Driving Question Board for the upcoming exploration.

Explore:
The Challenge:
In this exploration, your job is to simulate the launch of a real NASA rocket. Your challenge is to find what combination of fuel (Alka-Seltzer and water) produces the most effective launch. In order to do so, you will be given the following materials:
Film canister , ruler, cup and water, 2 Alka-Seltzer tablets, rocket launcher (canister and launchers can be purchased from www.stevespangler.com

Explain:
After completing the lab, have student discuss their results and describe how they think forces were able to propel the rocket. Also, discuss how their rocket could be changed to improve its performance.
Here is an overview of key concepts for this lesson:

1. A **force** is simply a push or pull (usually on an object). In this activity the force to push the rocket is provided by the gases being produced in the canister. As the antacid tablet fizzes, gases are 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.
2. Forces cannot be seen but their effects can be felt. The harder you push or pull on object, the more its motion will change.
3. The larger the mass(weight) of an object , the more force that is needed to move it. When you double the mass of the rocket, students should see that the rocket won't move as far – it takes more force to move a bigger rocket.
4. **If appropriate:** 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.

Elaborate:

What would happen if…

You change the design of your rocket?

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?

Would this happen with baking soda and vinegar?

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:

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.

Teacher Notes:

Have students bring in Alka-Seltzer so you have enough for the lab. If they know it is for shooting off rockets, they will bring it in. Film canisters with caps that lock on inside are much better to use in this activity and they are getting harder to find now that camera film is quickly becoming extinct. You can buy a set of canisters and launchers cheaply from www.stevespangler.com and they will las forever.



For 8th graders, film canister rockets are also 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 downward 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)

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. 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 rockets like the ones that helped 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) producing the intense pressure. It is much like our Film Canister Rocket - the carbon dioxide builds up and puts intense pressure on the canister until the lid pops off. But in a rocket, the pressure created by the burning of the fuel and oxidizer is released through tiny holes on the bottom of the combustion chamber called nozzles. The push from these expanding gases propels the rocket into space.