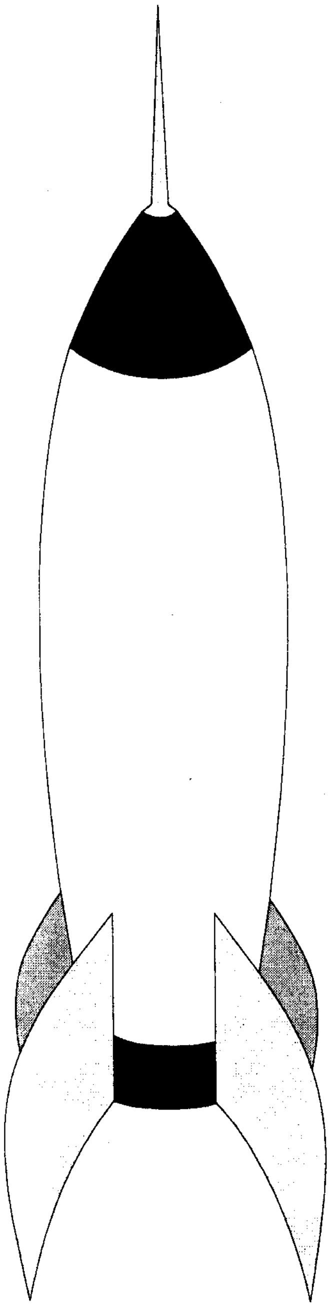
ROCKETS



History

Some of the earliest records of rockets date back to ancient China when black powder was invented. However, these devices were really no more than flying projectiles. Nevertheless, from this humble beginning the modern rocket has developed.

One of the earliest applications of the rocket was in battle. Shooting a noisy flaming projectile at enemy troops produced chaos and distress among their soldiers. Thus, early rockets were utilized as weapons of war.

Although the Chinese were the earliest known producers of black powder, the formula was not a secret. Many theories evolved on possible uses for this explosive. Some theorized that it would have a great impact on military applications such as propelling a rocket from a boat that would glide a few feet above the water and strike an enemy vessel. Although these applications existed only on paper as early as the 15th century, the rocket would attain such feats later in history.

An important early scientist whose research added in the advancement of the rocket was Konstantin Eduardovich Tsiolkovsky. Tsiolkovsky was born on September 17, 1857 in Izhevskoye, Russia and is considered to be the father of rocketry in that country. His theories helped to develop the former Soviet Unions space program into one of the greatest on earth.

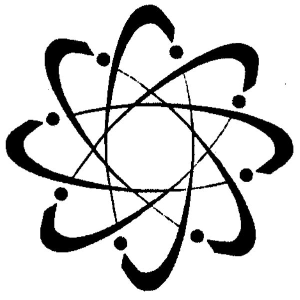
As a young boy Tsiolkovsky showed an interest in astronomy. Later as a young man he was sent to Moscow where he first studied science and mathematics. Tsiolkovsky then went on to become a teacher of physics and mathematics. He later turned his interest to rocketry. Intrigued by space travel he wrote many articles about the subject and the use of rocket engines and space travel. When he was twenty-six he explained how a throttled rocket engine would operate and a few years later completed a book predicting earth orbiting satellites. Tsiolkovsky was known for his visionary theories and his proven principles. He theorized that it would be possible to propel man and cargo into space if a light weight fuel was developed. He believed a hydrogen and oxygen fuel mixture could provide the needed power to send a rocket into orbital flight. It wasn't until 1963 that the first rocket empowered these principles, thus Tsiolkovsky proved to be a true visionary in the realm of rocketry.

Robert H. Goddard, another great contributor to rocket technology, was born on October 5, 1882 in Worchester, Massachusetts. Goddard was fascinated by science since his early childhood. He later turned this youthful fascination into advancements in science technology, dealing mostly with rocket engines. Along with Tsiolkovsky, Goddard believed that the secret to successful rockets lay in an engine that could bring light weight fuels together as a combustible mixture. Around 1914 he received several patents on devices that were related to rocket engines. During World War I he was hired by the U.S. Government to build military rockets for combat purposes. He successfully built rockets that could carry an explosive charge but before they were pressed into service, the war was over. On March 26, 1926 Goddard launched the first successful flight of a liquid propelled rocket. Goddard continued his advancements with rocket development until his death at the age of sixty two.

During World War II the Germans developed rockets as weapons of war. Perfecting previous designs, the V-2 rocket was constructed. The V-2, capable of reaching speeds of 2,480 miles per hour, stood 46 feet tall and could strike targets 186 miles away. Although it did not become operational until late in the war, it was a major accomplishment. If invented earlier, the Axis powers may have not been defeated.

The Japanese also were using the rocket to help in their struggle to defeat the allies. The Yokosuka MXY-7 Ohka Model II Kamikaze suicide bomber was basically a rocket airplane with an explosive charge. The concept was to carry the Ohka to within range of its target by an airplane, release it, and then have the pilot fire the rocket engine to fly the final distance to reach the target. The bomber was on a one way trip with the pilot sacrificing his life in delivering the explosive payload. Other developments made by various countries during World War II in rocketry included rocket assistance for aircraft takeoff and rockets used in air to ground missile attacks.

On September 11, 1956 the Soviet Union launched the first artificial satellite named Sputnik into orbit. American scientists were amazed that the Soviet Union had this capability, so the U.S. initiated efforts to win the space race and reach the moon. On July 29, 1958 President Eisenhower signed the National Aeronautics and Space Administration (NASA) into existence. Many technical problems required attention before NASA could send a man into orbit, a feat which the Soviet Union had already accomplished. The United States was trailing the Soviet Union in being the first at anything in the space race, and it wasn't until February 20, 1962 with John Glenn aboard the Friendship 7 that the United States finally sent a man to orbit the earth.



Laws of Motion

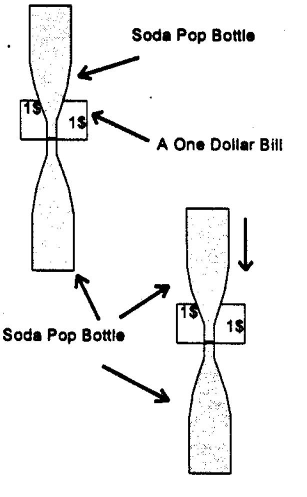
While discussing rocket development it is important to review the scientific laws of motion which explain why a rocket flies. Isaac Newton was born in Woolsthorpe, England on December 25, 1642. He discovered the following three laws of motion:

Newton's 1st Law of Motion: An object at rest will remain at rest and an object in motion will remain in motion until either is acted on by another force. In relation to a rocket a rocket set in motion will remain on course until met with a force that alters it's motion, such as wind or drag. In other words, an object resists any change in its status.

Exercise: Inertia - Pop Bottles

Theory: Newton's first law of motion states that: An object at rest tends to stay at rest; an object in motion tends to stay in motion unless acted on by an outside force. In plain language, an object resists any change in its status. If it is stationary, it wants to remain stationary. Trying to remove a dollar bill from between two pop bottles is a simple and exciting way to demonstrate inertia.

Materials:
- Two glass pop bottles
- A one dollar bill
- Food coloring



Procedure:
1. Fill one pop bottle with colored water.
2. Place it upside down atop another pop bottle with a dollar bill placed between them.
3. Challenge your students to remove the dollar bill without touching or disturbing the bottles in anyway.
4. A near foolproof method is to hold the dollar bill with one hand, presenting a slight amount of slack, while moving the other hand vertically and rapidly downward between the hand and the pop bottle.
5. The top pop bottle is at rest and wants to remain at rest. You moved the dollar bill.
6. The water will pour from the top bottle to the bottom bottle.

This experiment is provided courtesy of *Exciting Aerospace Activities* by Mr. Larry Scheckel.

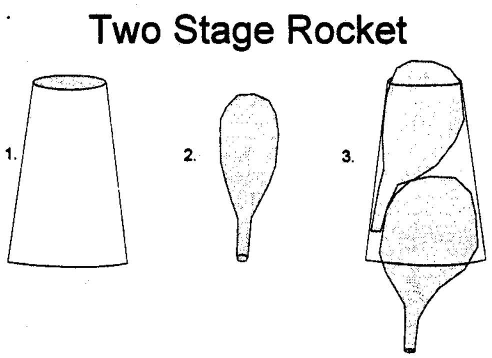
Newton's 2^{nd} Law of Motion: A force acting on an object will cause it to accelerate in the same direction as the force, and the value of the acceleration will be proportional to the force and inversely proportional to the mass of the object. This law is used in calculating the thrust necessary for a rocket to climb to a predetermined altitude.

Exercise: Two Stage Rocket

Theory : The two stage rocket is an excellent method to illustrate Newton's 2nd Law of motion: $F = ma$ (F = Force, m = Mass and a = Acceleration). The acceleration is inversely proportional to the mass. As the mass decreases, the acceleration increases. When the fuel from the first stage is exhausted, it drops away and the second stage is ignited. This reduces the overall mass of the rocket allowing it to travel farther and faster using less force.

Materials:

- Styrofoam cup
- Long balloons



Procedure:

1. Cut the bottom from a styrofoam coffee cup as shown in step 1.

2. Grasp the neck of one of the balloon as shown in step 2.

3. Insert the nozzle through the inter-stage connector (styrofoam cup) so that it protrudes through the wider end of the cup as shown in step 3.

4. Hold these together with one hand while inserting the first stage balloon well into the inter-stage connector (cup) and start filling it with air (fuel).

5. As the first or lower stage is filled with air (fuel), it will seal the nozzle of the upper (second) stage rocket against the side of the inter-stage connector.

6. Have a countdown and release the rocket. When the first stage runs out of fuel (air), the second stage will ignite carrying your rocket higher and faster.

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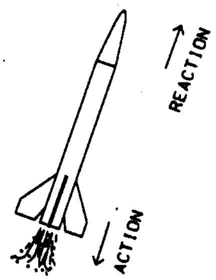
Newton's 3rd Law of Motion: For every action there is an equal and opposite reaction. For rockets thrust is the action and liftoff is the reaction.

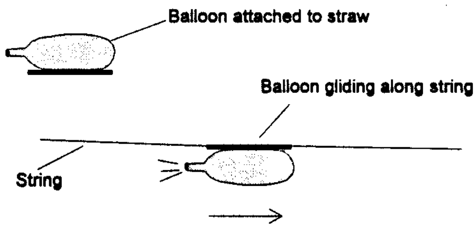


Exercise: Explaining Sir Isaac Newton's Third Law of Motion

Materials: Balloon, drinking straw, measuring device, paper, pencil, string, tape.

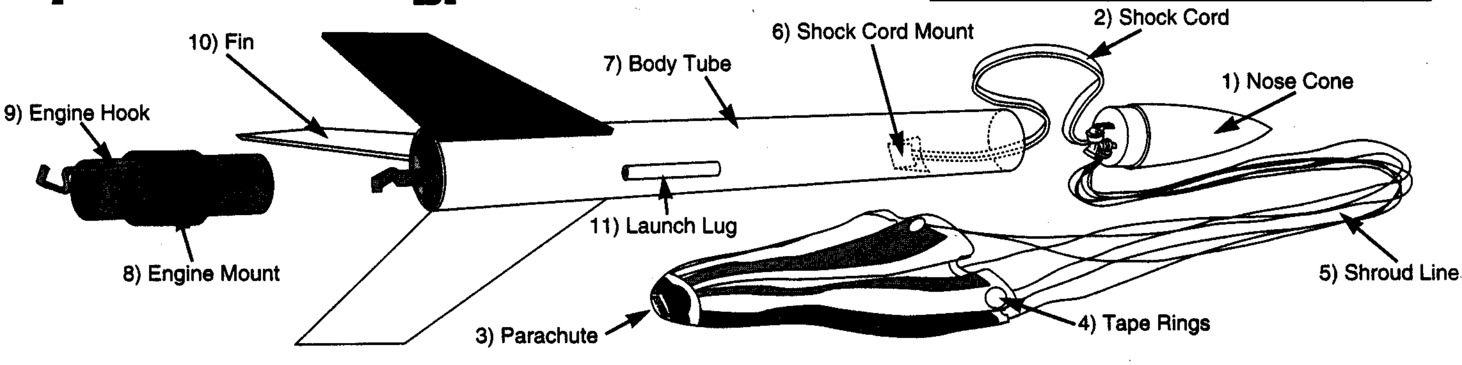
Directions: Tape drinking straw to the balloon and then take string through the straw and attach both ends of the string to stationary objects approximately four feet off the ground between ten and twenty feet apart.

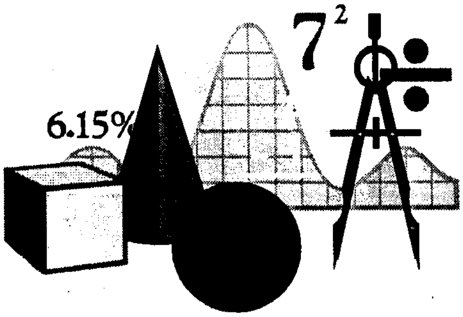
Next, inflate the balloon. Release the balloon and let it freely glide on the string. Measure the distance between the starting point and were the balloon stops and record it. Now inflate the balloon half full and turn it loose. Record the distance again.



Discussion: After conducting the experiment explain the third law again to the students. Then explain that the air that was blown into the balloon propels the balloon the same as the fuel in a rocket. When the air is released in the balloon it pushes out and pushes the balloon forward like a rocket.

Components of a Typical Model Rocket





MATH EXERCISE - Rockets

ADDITION

1. You are the captain of the Saturn V moon rocket heading for the moon. Your cargo weighs 1,200 pounds and the crew weighs 525 pounds. How much would the total weight of the crew and cargo be?
2. NASA needs to purchase a new computer costing $12,345 with software that cost $24,990 dollars. What is the total cost of the entire purchase?
3. After landing the lunar module on the moon, NASA instructs you to pick up 23 pounds of rocks and 12 pounds of dust to bring back to earth. What is the total weight of the cargo you will bring home?

SUBTRACTION

1. The space shuttle is being launched at 2:00 a.m. It is currently 11:00 p.m. How many more hours will it be until liftoff?
2. If a rocket weighs 300 pounds on the launch pad, and it burns 25 pounds of fuel per minute, how much will it weigh in one minute?
3. A rocket is launched to orbit the earth at 250,000 feet. One minute after liftoff the rocket has reached 30,000 feet. How many more feet must it climb before it reaches its destination altitude?

MULTIPLICATION

1. If three astronauts aboard the Saturn V rocket were traveling towards the moon at 22,535 miles per hour, how many miles would they travel in 3 hours?
2. If the weight of a rock on the moon is 2 pounds and the gravity on the moon is 1/6th what it is on the earth, how much would that same rock weigh on the earth?
3. If one gallon of rocket fuel weighs 7 pounds, how much would 234 gallons weigh?

DIVISION

1. An astronaut aboard the Command and Service Module orbiting the moon is instructed by mission control to dock with the lunar Module in 10 minutes. The docking is to take place 3,000 miles from his present location. How fast must he travel if he wants to arrive on schedule?
2. If the total circumference of the moon is 2,160 miles, how many hours would it take to drive a lunar roving vehicle around the moon going 10 miles per hour?
3. As captain of the shuttle crew, NASA informs you that the shuttle is 60,000 feet above the earth just 3 minutes after liftoff. How many feet per minute has the shuttle been traveling?