

So, You Want to Be a Rocket Scientist?

Purpose: The purpose of these activities is to learn more about rockets.

Students will be able to

1. Demonstrate an understanding of Newton's Laws of Motion, especially as they relate to rocketry.
2. Become familiar with and define terms related to rockets.
3. Identify the main parts of a rocket.
4. Use research skills to produce a written report and oral presentation regarding some aspect(s) of rocketry.
5. Design and build simple rockets.

Important Vocabulary

rocket	motion	force	action	reaction
Sir Isaac Newton	drag	thrust	propellant	velocity
combustion chamber	payload	nozzle	canards	fins
nose cone	case	controls	igniter	throat
pump	insulation	injectors	stages	rest
solid rocket motor	ion rocket	liquid rocket engine	arcjet	

Space Shuttle Commander

Students read an excerpt from a website called "Lloyd Rieber's Gallery of Neat Stuff," at <http://www.nowhereroad.com/gallery/index.html>, as an introduction to Newton's Laws of Motion as they apply to space. (** Note: Students should have some basic knowledge of the Laws of Motion prior to completing the following activities.)

(** See below for printable activity sheets.)

Blast Off! Paper Rockets

Students make their own rockets, using paper and straws, and complete a data record sheet.

(** See below for printable activity sheets.)

Stomp Rockets

Students can work in small groups of approximately four students each, to make a different version of a paper rocket along with a rocket launcher made from a 2-liter soda bottle. (Instructions for these activities can be found in THE MATH EXPLORER: GAMES AND ACTIVITIES FOR MIDDLE SCHOOL YOUTH GROUPS, published by The Exploratorium, a museum in San Francisco. These activities also can be accessed online in PDF format at the museum's official website:

http://www.exploratorium.edu/math_explorer/index.html.)

Sprockets and Springs: Parts of a Rocket

Students draw and label the main parts of a rocket. Alternatively, students can label an image or diagram taken from an online source or a textbook.

So, You Want to Be a Rocket Scientist?

Students research varying aspects of rocketry, to produce a written report and an oral presentation with PowerPoint slides. Students must use between five and ten sources, of which one to three must be non-web-based. Students must also include at least one image/picture and one diagram/chart in the PowerPoint presentation. Some aspects of rocketry that might be explored include the history of rocketry, significant figures in the history and/or development of rockets and rocket science, principles of rocketry/rocket theory, types of rockets, uses of rockets, etc.

Helpful Resources

The following resources can be used before or in conjunction with these activities, for greater understanding and extension of learning.

1. <http://www.grc.nasa.gov/WWW/K-12/airplane/newton.html> (A NASA website about Newton's Laws of Motion; includes basic explanations and activities.)
2. <http://www.thespace.com/space/history/dawn3.php> ("An online community dedicated to space exploration;" includes background on Sir Isaac Newton and his work.)
3. <http://www.fi.edu/pieces/knox/automaton/students.htm> (Provides links to some online and some offline activities re: motion.)
4. http://wings.avkids.com/Curriculums/Forces_Motion/ (Activities that demonstrate Newton's Laws of Motion)
5. <http://www.glenbrook.k12.il.us/gbssci/phys/Class/newtlaws/newtltoc.html> (A website geared towards high school physics students, but very informative in an informal way; includes some interactive 'checks for understanding' re: Newton's Laws of Motion.)
6. <http://www.iit.edu/%7esmile/ph9408.html> (A lesson plan with activities demonstrating Newton's Third Law of Motion.)
7. <http://www.woodmansee.com/science/rocket/rocket-science.html> (Provides some good basic background information on rockets.)
8. http://www.nasa.gov/pdf/58269main_Rockets.pdf (NASA's Educator Guide on Rockets, including background reading and several activities.)
9. <http://nmwg.cap.gov/santafe/Activities/> (Patterns for some basic rockets made from cardstock.)
10. <http://www.apogeerockets.com/education/index.asp> (Great website of Apogee Components, a rocketry supply retailer; provides rocketry supplies, design tips, education-/curriculum-related ideas, and links to other helpful sites.)

**** NOTE:** *These activities will take approximately between one and four weeks of 45-minute daily class sessions to complete.*

BLAST OFF!

PAPER ROCKETS

This rocket is one way to show the famous Third Law of Motion - for every action there is an equal and opposite reaction. This very important law was first discussed by Newton and remains as a foundation for modern physics. The law can be demonstrated in many ways. Here's one that's simple and familiar. A common occurrence at any fast food restaurant when families receive their drinks is blowing paper wrappers off straws. This activity relates this common experience to the launching of a rocket. You can design rockets, launch them, and compare flight distances as well as in flight directions. Wow! What a blast!

Language with science

rocket, force, blow, reaction, flight, distance, launch

Things you will need

- large plastic drinking straws
- cellophane tape
- paper
- scissors

What to do

1. Cut 4 strips from a 8 1/2 X 11 inch sheet of paper.
2. Fold in half.
3. Tape, leaving 1 inch untaped at the bottom.
4. Fold and tape to a point at the top.
5. Tear paper on untaped end to make fins.
6. Put the straw in the end that is not taped.
7. Now have the children blow on the straw, and their rockets will fly.
8. How far can your rocket fly? Compare flight distances.
9. Where did the power to make your rocket come from?

Want to do more?

Try to get your rocket to land in a designated recovery zone. Place boxes at various distances. Have the children aim and try to land their rockets in a designated box. Encourage children to create their own rocket designs.

BLAST OFF!

PAPER ROCKETS

DATA RECORD

Make three separate paper rockets. Sketch and briefly describe each one, noting details such as size of fins, length of tape used, etc.

Launch three separate paper rockets. Record the distance traveled between a pre-set launch site and the point of landing; and place a check in the box if the rocket reaches a pre-set target.

	Rocket #1	Rocket #2	Rocket #3
Distance from launch site			
Reached target landing site?			

What conclusions can you draw about your rockets? What role, if any, do you think the design differences played in the flight of each rocket? Can you think of any other alterations that could be made to the rockets? Do you think the results would have differed with these alterations?

Space Shuttle Commander

Understanding Newton's Laws of Motion

High above the earth in orbit...

Space Station Flight Controller: "Space Shuttle Columbia, you are clear for docking."

Shuttle Commander: "Roger that, Space Station Hopeful, we are coming in."

Shuttle Commander: "Easy as it goes. Reducing speed by firing forward thrusters."

Just then, a small piece of space debris rams into the shuttle!

Shuttle Commander: "Did you feel that! I think we've been hit by something. Space Station Hopeful, please report!"

Space Station Flight Controller: "I saw what happened, Columbia. A small object, about 2 feet square, hit your forward compartment. It just came out of nowhere. It looked like a toolbox -- probably came from the construction activity going on in the Alpha section. I don't see any damage."

Shuttle Commander: "But it looks like the collision has nudged us out of position for the docking."

Space Station Flight Controller: "Yes, our sensors confirm that. You are about 6 inches off center. I suggest you abort the dock. If you are not accurate to within 1 centimeter, you will damage the docking station!"

Shuttle Commander: "Don't worry, I have it. Firing left thruster -- correcting trajectory."

Shuttle Commander: "Steady... steady...I have it! Docking complete!"

Space Station Flight Controller: "Outstanding, Columbia. We'll meet you in the debriefing room."

Understanding the motion of objects

You probably take for granted that you and the things around you can move. However, scientists have tried to understand the motion of objects for thousands of years. One of the most brilliant scientists of all time was Isaac Newton who was born in England in 1642. Many of his ideas were built on the work of Galileo who, interestingly, died in 1642. Newton discovered many important laws of nature, but he is most famous for his 3 laws of motion. Here is Newton's first law stated in everyday language:

"An object at rest tends to remain at rest and an object in motion tends to remain in motion unless acted upon by an outside force."

On one hand this law is easy to understand for objects that are not moving. A book sits on a table and obviously doesn't go anywhere. However, we tend to forget about the influence of many strong forces, such as friction and gravity. What do you think would happen if we

could magically take away the forces of gravity and friction? According to Newton's first law, even a little push on the book would make it move forever.

Newton's second law describes how fast and in what direction objects will move if we give them pushes and tugs. Scientists have a special word to describe things like pushes, tugs, kicks, and nudges -- force. Here is Newton's second law also stated in everyday language:

"The speed and direction in which an object moves depends on the mass of the object and the amount of force that is applied to it and the direction of the force."

This second law is usually summarized by one of the most famous equations in all of science:

"Force equals mass times acceleration" or "F=ma" for short.

Examples of this law can be found everywhere. If you kick a soccer ball with a 'medium sized' kick, it will quickly roll across a field. But if you give the same size kick to a bowling ball, its initial speed will be much less. Of course, the friction of the both balls caused by their touching of the ground as they roll will result in both balls coming to a stop eventually. But remember Newton's first law. If there was no other forces acting on the balls, each would roll forever -- the soccer ball going fast and the bowling ball going slow. Finally, here is Newton's third law:

"For every action, there is an equal and opposite reaction."

In other words, when you give something a push, it also pushes back. If you have ever fired a gun, you know that the "kick back" is a force to be reckoned with. Some forces act as impulses, or short bursts, such as kicking a soccer ball, hitting a baseball with a bat, or the "kick back" you feel when you fire a gun. Other forces are continuous, such as the wind produced by a ceiling fan, the push of a person behind a wheelbarrow, or the tug of gravity pulling a bicycle down a hill.

Newton's third law is especially important in helping to understand how machines like the Space Shuttle operate. But first, try to imagine yourself sitting in the middle of a frozen lake on a wagon while holding a shotgun. Every time you fire the gun, the kick back makes you move in the opposite direction. If there is little friction between the ice and the wagon's wheels, you will move very far before stopping. If you keep firing the gun in the same direction, you move faster and faster. The only way to stop would be to turn around and fire the gun in exactly the opposite direction. The Space Shuttle is kind of like the wagon and its engines are kind of like the shotgun. But instead of an impulse force produced by the firing of a gun, the shuttle's engines provide continuous thrust.

Newton's Laws of Motion

Newton's First Law describes motion produced by balanced forces.

- **An object at rest will remain at rest, and a moving object will remain at a constant velocity unless unbalanced forces act on it.**
- Newton was first to use the term **inertia** to describe the tendency of objects to remain in motion or stay at rest. Inertia comes from the Latin word *iners*, which means "lazy".

Newton's Second Law describes motion produced by unbalanced forces.

- **This law is best stated using the equation:**

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

- Acceleration is always in the direction of the unbalanced force.
- The units of force are "Newtons".
- $1 \text{ N} = 1 \text{ kg} \times 1 \text{ m/s/s}$

Newton's Third Law explains why forces act in pairs.

- **For every action, there is an equal and opposite reaction.**
- Forces always act in pairs.