Moon Rovers

DESCRIPTION
Students will design and build a rubber band-powered rover that can scramble across the room.

OBJECTIVES
Students will:
- Design and build a rover out of cardboard;
- Figure out how to use rubber bands to spin the wheels;
- Improve their designed system based on testing results.

NASA SUMMER OF INNOVATION

UNIT
Engineering: Exploration

GRADE LEVELS
7th – 9th

CONNECTION TO CURRICULUM
Newton's Second Law, Friction, Potential and Kinetic Energy, Measurement

TEACHER PREPARATION TIME
15-30 minutes

LESSON TIME NEEDED
60 Minutes *Level: Basic*

NATIONAL STANDARDS

National Science Education Standards (NSES)
Science as Inquiry
- Understanding of scientific concepts
- Understanding of the nature of science
- Skills necessary to become independent inquirers about the natural world
- The dispositions to use the skills, abilities, and attitudes associated with science

Physical Science Standards
- Motions and forces

Common Core State Standards for Mathematics (NCTM)
Expressions and Equations
- Solve real-life and mathematical problems using numerical and algebraic expressions and equations

ISTE NETS and Performance Indicators for Students (ISTE)
Creativity and Innovation
Students:
- apply existing knowledge to generate new ideas, products, or processes
- create original works as a means of personal or group expression
- use models and simulations to explore complex systems and issues
- identify trends and forecast possibilities

Critical Thinking, Problem Solving, and Decision Making
Students:
- identify and define authentic problems and significant questions for investigation
- plan and manage activities to develop a solution or complete a project
- collect and analyze data to identify solutions and/or make informed decisions
- use multiple processes and diverse perspectives to explore alternative solutions

MANAGEMENT

Read the challenge sheet and leader notes to become familiar with the activity. Gather the materials ahead of time and set them up in a central location for student access. Build a sample rover.

CONTENT RESEARCH

Friction—To move, rovers need friction between the wheels and ground. To be efficient, rovers need minimal friction between the axle and rover body.
Newton's 2nd Law (Force = Mass x Acceleration)—The more force the rubber band applies to the wheels and the less mass there is to move, the faster the rover will accelerate.
Potential and kinetic energy—When students wind up a rover's wheels, the rubber band stores energy as potential energy. As the wheels spin, the potential energy is changed to motion (kinetic) energy.
Measurement—Students measure how far their rovers traveled.

Misconceptions: The most common misconception of Newton's 2nd Law is the idea that sustaining motion requires a continued force. Students should have opportunities to investigate the effects of net forces on objects prior or after the challenge. A net force (an unbalanced force) causes an acceleration of an object; the acceleration is in the same direction as the net force. For example: Slide a book across a table and watch it slide to a rest position. The book in motion on the table top does not come to a rest position because of the *absence* of a force; rather it is the *presence* of a force - that force being the force of friction - that brings the book to a rest position. In the absence of a force of friction, the book would continue in motion with the same speed and direction - forever (or at least to the end of the table top)

MATERIALS
(per rover)

- *Corrugated cardboard body (6-inch/15-cm square)*
- *2 Corrugated cardboard wheels (5-inch/13-cm square)*
- *1 Sharpened round pencil*
- *2 Rubber bands*
- *Ruler*
- *Tape*
- *2 Round candies (the hard, white, mint ones with a hole in the middle)*
- *1 Plastic drinking straw*
- *Scissors*

LESSON ACTIVITIES

- Introduce the challenge: Tell kids how NASA astronauts will need moon cars—called rovers—to drive across the moon's surface, carry supplies, help build their outpost, and explore the area. (scripted in the Leader Notes.
- Brainstorm and design: Students should be working in cooperative groups to develop a group design and using individual journals to record their decisions, design sketches, test results, etc.
- Build, test, evaluate, and redesign: Test data, solutions, modifications, etc should all be recorded in their journals individually.
- Discuss what happened: Have the students show each other their rovers and talk about how they solved any problems that came up.
- Evaluation: Using the student's journaling, assess their mastery of content, skills, and the engineering design process.

http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/On_the_Moon_Guide.html

RELATED RESOURCES

Check out NASA's Exploration Mission Directorate at http://www.nasa.gov/exploration/home/index.html

Print a picture of the Lunar Crater Observation and Sensing Satellite (LCROSS) from the LCROSS Web site (lcross.arc.nasa.gov).
Lunar Reconnaissance Orbiter (LRO) Mission Page: http://www.nasa.gov/mission_pages/LRO/main/

LCROSS Mission Page: http://www.nasa.gov/mission_pages/LCROSS/main/
Check out NASA's Moon missions at http://nssdc.gsfc.nasa.gov/planetary/planets/moonpage.html

DISCUSSION QUESTIONS

- What do you have to do to make the rover move? *Turn the wheels to wind up the rubber band. Place the rover on the floor. Then let go. NOTE: Depending on the direction you wind the wheels, the rover can move either forward or backward.*
- How can you make different kinds of wheels? *Students can make different-sized wheels by cutting larger or smaller squares or make different-shaped wheels by trimming the squares. NOTE: Square wheels offer two advantages: they're quick to make, and it's easy to find the exact center by drawing diagonal lines. The center is where the lines cross.*
- How do you think square wheels affect how the rover moves across the floor? *The points of the squares dig into soft surfaces, such as rugs, sand, or grass. This improves traction—the ability to grip a surface—and helps prevent the wheels from spinning out. Since the moon is covered in a thick layer of fine dust, good traction is essential, especially going up and down hills.*
- What are the different ways you can use rubber bands to power a rover? *You can change the number of rubber bands. Sometimes, a rubber-band chain works better than just one rubber band. Also, students can cut open a rubber band and use the single strand of elastic.*
- What kinds of Earth vehicles are similar to rovers? *Snowmobiles, tanks, dune buggies, and all-terrain vehicles are similar. They all have good traction, are very stable, have powerful engines, and don't require a roadway.*
- The challenge sheet gave you a rover prototype to get started with. How did starting with a prototype help you end up with a rover that worked really well? *With a prototype, we can quickly see what's working and what isn't. They then know where to make improvements.*
- How did friction affect your rover? *To be efficient, there needs to be minimal friction between the axle and the axle hole in the cardboard. To move, there needs to be lots of friction between the wheels and the ground.*
- How did the rover use potential and kinetic energy? *Potential energy is energy that is stored. Kinetic energy is the energy of motion. Winding the front wheels increased the amount of potential energy stored by the rubber band. When the wheels spin, this potential energy is turned into kinetic energy, and the axle and wheels turn.*
- How does the story about rover wheels on the back of the handout make you think about what it takes to design a wheel that can work on the moon? *Student should see that engineers face special design challenges when developing equipment to be used in space.*

ASSESSMENT ACTIVITIES

Journaling is a valuable tool for engineers as they prepare and test designs to solve complex problems and meet challenges. Students should record their brainstorming session ideas, labeled and annotated sketches of their prototype designs, test results, modifications to their designs with sketches, photos, and group solutions that allow them to meet the challenge in a journal. They should also record any science, math, engineering, or technology content that is connected to their work or that they used to meet the challenge. The journal should be used as a formative and summative assessment tool.

ENRICHMENT

- **Graph how increased potential energy affects distance traveled**: Kids can measure how far a rover travels as its rubber band is increasingly tightened. Have them turn the wheels 3, 6, 9, and 12 times and then measure the distance the rover travels each time. On a graph, have them plot the number of wheel rotations vs. the distance traveled. *Winding the wheels more increases the potential energy, which should increase the distance.*

- **Determine the effect of friction:** Have kids wind up the wheels a set number of times and measure the distance their rover travels. Then have them minimize friction in the wheel-axle system. For example, they can line the axle holes with a material such as aluminum foil, then wind up the wheels the same number of times and retest their rovers. Use the following formula to calculate the percent increase in distance traveled.

$$\text{Percent Increase} = \frac{\textit{(Distance modified rover traveled) – (Distance basic rover traveled)}}{\textit{Distance basic rover traveled}} \; \textit{X 100}$$

- **Test the effect of wheel shape:** Starting with square wheels, have kids measure how far their rovers travel. Then have them snip off the corners of their wheels and test again. Make sure they wind up the wheels the same number of turns. How did the distance change? Did the wheels spin out? Test square, octagonal, and round wheels.