SPEED IT UP

Activity topic selected from NASA's KSNN™ 21st Century Explorer newsbreak "How can we travel faster in space?"

Educator Section

Introduction

NASA currently uses chemical propulsion systems for space travel; however, as we continue to explore space, we will need to travel faster so we can go further in space. Alternative propulsion systems such as nuclear thermal, magnetoplasma and hydrogen, will need to be studied and perfected in order to provide more efficient and faster space vehicles.

Lesson Objective

In this lesson, students simulate how different propellant systems affect the velocity, or speed, of a rocket by measuring the height the rocket is launched.

Problem

How can I determine if different propellants will make a rocket travel faster?

Learning Objectives

The students will

- gather data by measuring the height an object is launched.
- use data to describe the results of the different simulated propellant combinations.
- develop a conclusion based upon the results of this experiment.
- compare individual results to class results to look for patterns.

Materials

- NASA's KSNN™ 21st Century Explorer 30-second newsbreak, "How can we travel faster in space?" (Download the newsbreak at http://ksnn.larc.nasa.gov.)
- large room with high ceilings (at least 6 meters, or 20 feet) such as a cafeteria, or gym, or outside along the wall of a building
    - You will need enough wall-space for each group to work, about 2 meters (6-7 feet) of wall space for each group of students. (See Pre-Lesson Instructions.)
    - Conduct the rocket launches outside, only if it is not windy. The wind does not allow a

Grade Level: 3-5

Connections to Curriculum: Science

Science Process Skills: observing, predicting, measuring, inferring, communicating, using number relationship
(Association for the Advancement of Science)

Teacher Preparation Time: 30 minutes

Lesson Duration: 40 minutes

Prerequisite: none

National Education Standards addressed in this activity include Science (NSES). For an alignment to standards in this activity, see page 8.

Materials Required

empty film canisters (clear canister with inner sealing lid)
small zipper seal bags
effervescent antacid tablets
baking soda
water
vinegar
milliliter measuring spoons
tissues (facial tissue or toilet paper)
aluminum roasting pans, baking tins, or box lids
metric measuring tapes or meter sticks
wide masking tape
water bottles or plastic cups
permanent marker
safety glasses
paper towels
desks or small tables
large room with high ceilings - cafeteria, or gym, or outside along a wall

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NASA's KSNN™ 21st Century Explorer 30-second newsbreak – "How can we travel faster in space?"

straight launch, making it difficult for students to observe the height of the launch.

Per group (2 students working together)

- 1 small water bottle, or at least 100 milliliters (3 to 4 ounces) of water in a plastic cup
- vinegar in a plastic cup, approximately 100 milliliters (3 to 4 ounces)
- 1 small box of baking soda, or at least 5 milliliters (1 teaspoon) in a labeled zipper seal bag
- 1 milliliter (¼ teaspoon) measuring spoon
- 6-10 small sheets of facial tissue (single ply, cut into quarters) or, single ply toilet paper squares
- 1 aluminum roasting pan, baking tin, or box lid with high sides
- 1 metric measuring tape or meter stick
- paper towels for clean up

Per student

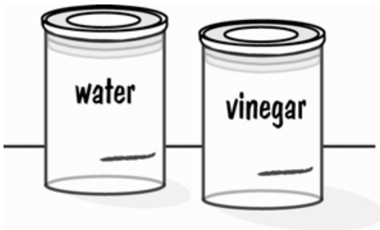
- 2 clear film canisters with inner sealing lids (See Pre-Lesson Instructions for how to label and mark the canisters.)
- 1/4 of an effervescent antacid tablet crushed into pieces in a labeled zipper seal bag (See Pre-Lesson Instructions.)
- 1 pair of safety glasses
- Speed It Up Student Section

Safety

Remind students about the importance of classroom and lab safety. Students should wear eye protection during this activity. Materials Safety Data Sheets (MSDS) are required for this experiment. http://www.msdssearch.com/msdssearch.htm. Use disposable latex-free gloves as necessary. This experiment will require proper clean up.

Pre-lesson Instructions

- Students should work in groups of 2.
- Note of Caution – any time a product is taken from its original labeled package or container, make sure the new container is clearly labeled. For instance, during the preparation for this activity, you will remove the effervescent tablets from the original labeled package and place into a zipper seal bag. Make sure to clearly label the zipper seal bag “effervescent tablet” so it will not be mistaken for something else. Use a permanent marker to label.
- Prepare the materials: It is recommended that the teacher prepare the materials (especially for the younger grade level students) to ensure consistency and a successful rocket launch and to save classroom time.
    - Break effervescent tablets into fourths. Then, break each fourth into small pieces and put into a labeled small zipper seal bag. (1/4 tablet broken into small pieces per bag, per student). Make sure that all tablets are the same brand as results may vary if brands are mixed. You may want to make a few extra bags incase some students do not have a successful launch with their first attempt.
    - Prepare the film canisters by measuring the length of the canister and dividing by 4. Mark a line with the permanent marker that is ¼ of the way from the bottom of the film canister. The students will pour liquids up to this line as they prepare their rockets. (See diagram below.)
    - Each student will need 2 film canisters. Using a permanent marker, one canister should be labeled “water” and the other should be labeled “vinegar”. (See diagram.)



- If you do not have enough boxes of baking soda for each group of students to have their own, you may want to divide the baking soda into labeled zipper seal bags. Each student will use 1 milliliter (¼ teaspoon) of baking soda.
- Cut the single ply facial tissues into fourths, or tear squares of single ply toilet paper. Cut enough for each student to have at least 2 small squares. You may want to prepare a few extra.

- Prepare the work space:

  Note – this can be prepared ahead of class to save time. Use caution when measuring and marking the walls.

  - Divide the room, cafeteria or gym, or outside along a wall, into sections where the groups will be working. Each group will need about 2 meters (6-7 feet) of working space along the wall. Make sure the groups have enough room to work safely without bumping into each other.
  - On the wall, in the center of each work space, measure and mark in centimeters and meters, the height of the wall by using the wide tape and the meter sticks or tape measures. Make sure to use a dark marker and write large enough, so that the numbers can be seen from ground level. The tape should be marked to the height of 6 to 8 meters (20-25 feet).
    - Instead of marking, you can also identify bricks, paint, paneling, or other features in the wall that are at known heights. Mark those heights. Students can “eyeball” and estimate using those identified items as reference points.
  - In the middle of each working space, push one desk up to the wall, directly along the measured tape. The students will launch their rockets from the top of the desk and will use the measured tape to see how high their rockets launch.

Lesson Development

To prepare for this activity, the following background information is recommended:

- Read NASA’s KSNN™ 21st Century Explorer Web Text Explanation titled “How can we travel faster in space?” at http://ksnn.larc.nasa.gov.
- Read the following text taken from the Observation Section of the Speed It Up Student Section.

Observation

The space shuttle uses a chemical propulsion system based upon both liquid and solid propellants. It combines the features of a rocket, aircraft, and glider and was designed to carry astronauts, satellites, and other cargo into Earth’s orbit. Traveling at approximately 29,000 km/h (18,000 miles per hour), the shuttle orbits Earth every 90 minutes.

By using current technology and a spacecraft powered by chemical rocket engines, a one-way trip to Mars could take between 6 to 9 months. The trip back to Earth would be another 6 to 9 months.

We need to find faster ways to travel to Mars and beyond. NASA is studying alternative propulsion systems. The new propulsion systems will need to be more efficient by providing a faster trip in order for humans to travel to distant planets like Mars. Shorter flight times lessen an astronaut's exposure time in reduced gravity and will also reduce the amount of exposure to space radiation.

A nuclear thermal propulsion system could cut down the time needed to travel to Mars and other places in our solar system. Nuclear fuel lasts longer and allows a spacecraft to travel faster by providing a more efficient and light weight system. A nuclear thermal propulsion system could potentially be over 100 times more powerful than chemical systems of comparable weight.

NASA is studying a plasma-based propulsion system called project VASIMR (Variable-Specific-Impulse Magnetoplasma Rocket). Franklin R. Chang-Diaz, PhD, the first Hispanic astronaut, is studying this system. According to NASA, a VASMIR flight to Mars could take a little over 3 months, compared to 6 to 9 months using current rocket engines.

In this activity you will simulate how different propellant systems affect the velocity, or speed, of a rocket by measuring the height the rocket is launched.

- During this activity, students will measure the height of their rocket launch. A simple projectile's maximum height is directly proportional to its initial velocity. We will measure maximum height since it is easier to measure than velocity.

- If needed, additional research can be done on the following science topics:
    - rocket engines and propulsion systems
    - velocity
    - Newton's Laws of Motion
    - VASIMR (http://www.nasa.gov/vision/space/travelinginspace/future_propulsion.html)
    - nuclear thermal propulsion
    - chemical reactions

Instructional Procedure

Throughout this lesson, emphasize the steps involved in the scientific method. These steps are identified in ***bold italic*** print throughout the Instructional Procedure Section.

1. Show NASA's KSNN™ 21st Century Explorer newsbreak "How can we travel faster in space?" to engage students and increase student knowledge about this topic.
2. Review the problem with the students.
   Problem: How can I determine if different propellants will make a rocket travel faster?
3. Have the students read the ***Observation*** Section in the Speed It Up Student Section and discuss in their groups.
4. Encourage your students to discuss and make ***observations*** about this topic by completing the first two columns in the KWL (KNOW/WANT TO KNOW/LEARNED) chart on the Speed It Up Student Section. Use the KWL chart to help students organize prior knowledge, identify interests, and make real-world connections. As students suggest information for the "KNOW" column, ask them to share "How they have come to know this information."
5. Ask your students if they have predictions relating to this activity and the "problem question". Help them refine their predictions into a ***hypothesis***. In their Student Section, they should restate the "problem question" as a statement based upon their observations and predictions. Encourage students to share their hypothesis with their group.
6. Students will ***test*** their hypothesis following this procedure.
   (The following steps are taken from the Student Section. Educator specific comments are in italics.)
    1. Put on your safety glasses.

Stress the importance of keeping eye protection on during this lesson.

2. Your group will be assigned a section along a wall where you will be launching the rockets. Each group will need at least 2 meters (6-7 feet) of working space along the wall so that you do not interfere with the other groups working beside your section.

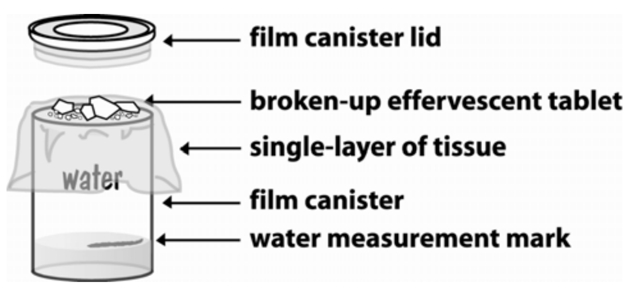
   Make sure the groups have enough room to work safely without bumping into each other. It is recommended that the students launch their rocket from the top of the desk to avoid leaning over the loaded rocket. If the walls were not marked as high 6 to 8 meters (20-25 feet), make students aware of other identified items of known heights that have already been labeled. Tell the students they can use these items as a reference point to know how high their rocket launched.

3. Measure the height of the top of the desks in centimeters. Record the measurement on the How High Did It Go Data Sheet. You and your partner will launch your rockets from the desk top.
4. Your first rocket launch will have a propulsion system of water and effervescent tablets. Predict how high your first rocket launch will go using the first propellant combination. Record the predicted height for Launch One on the How High Did It Go Data Sheet. Discuss your predictions with your group.
5. Before launching your first rocket, make sure to read and understand Steps 6-12 below.

   You should demonstrate the following steps of this activity before the groups begin their own rocket launches. Make sure the students carefully read and understand Steps 6-12 before continuing. Emphasize caution and careful work.

6. Your first rocket propulsion system will be of water and effervescent tablets. Open your film canister. Carefully and slowly, pour water into the film canister up to the marked line.
7. The film canister should stay on the desk top. Place one tissue (single ply) square loosely on top of the canister opening.
8. Hold the tissue around the top of the canister. Carefully place the broken pieces of a ¼ of an effervescent tablet into the center of the tissue. (Your zipper seal bag should already contain a ¼ of an effervescent tablet.) Make sure the tissue does not fall into the water. (See diagram.)

   If you have not prepared the zipper seal bags with the effervescent tablets in advance, make sure the students break up their ¼ of a tablet into small pieces. This will help ensure a successful launch.



9. KEEP THE CANISTER LEVEL and on the desk top. Without letting the tissue fall into the canister, close the lid on the tissue so that the tissue and effervescent tablet pieces are suspended above the water. Make sure the lid snaps on and closes tightly – if it does not close properly, call your teacher for help. The simulated rocket is now loaded with propellants.

Tell students to ask for help closing the lid if it does not close properly. If the lid does not close properly, the rocket may not launch or it may launch prematurely.

10. One student will launch the rocket. The other will step back at least 3 meters (about 10 feet away) in order to see the height that the rocket travels along the measured tape on the wall. Make sure that the student measuring the maximum height the rocket travels always stands in the same place for each launch.
11. To launch the rocket, follow these steps:
    - Place the aluminum pan on the desk top. This will catch any liquid that will come from the launch.
    - Keeping the rocket level, hold the canister (with the lid up) above the aluminum pan, at arms length from the body, keeping the rocket away from your face and away from other students.
    - Quickly and carefully, turn the canister over so the lid lays flat inside the aluminum pan. Steady the rocket and then let go of the canister. The rocket will take several seconds to launch, so work quickly but do not rush.
    - Step back and wait for the launch.

      Stress this step for safety.

    - If your rocket does not launch in approximately 30 seconds, call your teacher over to the launch site for a quick check of the rocket.

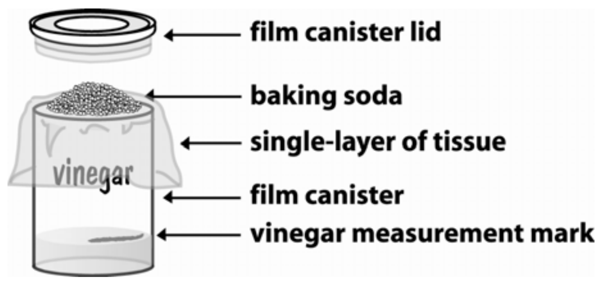
      For teachers checking the rockets, always make sure the lid of the rocket stays pointed at the baking pan when holding it. Use your thumb to snap off the lid into the pan. Never point the rocket at anyone.

12. Using the tape measure or other markers on the wall, ***collect and record data*** by measuring how high the rocket traveled on the How High Did It Go Data Sheet.
13. Calculate the actual distance your rocket traveled by subtracting the desk height from the height of the rocket launch and record on the How High Did It Go Data Sheet.
14. Use paper towels to clean the rocket and test area. Make sure to clean the inside of the canister and the lid. Properly dispose of the paper towels.
15. Repeat steps 3-14 for your partners' first rocket.

16. You will now run the test again, this time using a different propellant combination of baking soda and vinegar. Predict how high the second rocket will travel. Record your predicted height for Launch Two on the How High Did It Go Data Sheet. Discuss your prediction with your group.

    Make sure the students predict the next launch height before launching the rocket.

17. Open your clean and dry film canister. Carefully and slowly, pour vinegar into the film canister up to the marked line.
18. The film canister should stay on the desk top. Place one tissue (single ply) square loosely on top of the canister opening.
19. Hold the tissue around the top of the canister and carefully place 1 milliliter (1/4 teaspoon) of the baking soda into the center of the tissue. The tissue will need to sink into the canister a little bit so that the baking soda will not fall off. Make sure the tissue does not fall into the vinegar. (See diagram.)



20. KEEP THE CANISTER LEVEL and on the desktop. Without letting the tissue fall into the canister, close the lid on the tissue so that the tissue and baking soda are suspended above the vinegar. Make sure the lid snaps on and closes tightly. The simulated rocket is now loaded with propellants.

    Tell students to ask for help closing the lid, if it does not close properly. If the lid does not close properly, the rocket may not launch or it may launch prematurely.

21. One student will launch the rocket. The other student will step back to the same spot as before (about 3 meters or 10 feet away) in order to see the height that the rocket travels along the measured tape on the wall.
22. To launch the rocket, follow these steps:
    - Place the aluminum pan on the desk top. This will catch any liquid that will come from the launch.
    - Keeping the rocket level, hold the canister (with the lid up) above the aluminum pan, at arms length from the body keeping the rocket away from your face and away from other students.
    - Quickly and carefully, turn the canister over so the lid lays flat and inside the aluminum pan. Steady the rocket and then let go of the canister. The rocket will take several seconds to launch, so work quickly but do not rush.
    - Step back and wait for the launch.

      Stress this step for safety.
    - If your rocket does not launch in approximately 30 seconds, call your teacher over to the launch site for a quick check of the rocket.

      For teachers checking the rockets, always make sure the lid of the rocket stays pointed at the baking pan when holding it. Use your thumb to snap off the lid into the pan. Never point the rocket at anyone.

23. Using the tape measure or other markers on the wall, ***collect and record data*** by measuring how high the second rocket traveled on the How High Did It Go Data Sheet.
24. Calculate the actual distance your rocket traveled by subtracting the desk height from the height of the rocket launch and record on the How High Did It Go Data Sheet.
25. Use paper towels to clean the rocket and test area. Make sure to clean the inside of the canister and the lid. Properly dispose of the paper towels.
26. Repeat steps 16-25 for your partners' rocket.
27. After taking all measurements, ***study the data*** and ***draw conclusions*** by answering the questions following the How High Did It Go Data Sheet.

    Using this information, ask students to determine if the data supports or refutes their hypothesis.

Conclusion

- Discuss the answers to the Speed It Up Student Section questions.
- Have the students update the LEARNED column in their KWL chart.
- Ask students to compare their individual data to the class data. What patterns can be found?
- Ask students "what they wonder now?" Encourage students to design their own experiments.

Assessment

- Assess student knowledge through questioning.
- Observe and assess student performance throughout the activity using the attached Scientific Investigation Rubric.

Activity Alignment to National Education Standards

National Science Education Standards (NSES):
Content Standard A: Science as Inquiry
- Abilities necessary to do scientific inquiry (K-8)
- Understandings about scientific inquiry (K-8)

Content Standard B: Physical Science Standards
- Properties of objects and materials (K-4)
- Position and motion of objects (K-4)
- Motions and forces (5-8)
- Transfer of energy (5-8)

Content Standard E: Science and Technology Standards
- Abilities of technological design (K-8)
- Understanding about science and technology (K-8)

Content Standard G: Science as a Human Endeavor Standard
- Science as a human endeavor (K-8)
- History of science (5-8)

National Mathematics Education Standards (NCTM):
Number and Operations Standards:
- Compute fluently and make reasonable estimates
  - develop fluency in adding, subtracting, multiplying, and dividing whole numbers;

Algebra Standards:

- Use mathematical models to represent and understand quantitative relationships
  - develop model problem situations with objects and use representations such as graphs, tables, and equations to draw conclusions.

Measurement Standard:

- Apply appropriate techniques, tools, and formulas to determine measurements
  - select and use benchmarks to estimate measurements;

Data Analysis and Probability Standard:

- Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them
  - collect data using observations, surveys, and experiments;
  - represent data using tables and graphs such as line plots, bar graphs, and line graphs;

Reasoning and Proof Standard:

- recognize reasoning and proof as fundamental aspects of mathematics;
- develop and evaluate mathematical arguments and proofs;

Curriculum Explorations

To extend the concepts in this activity, the following explorations can be conducted:

Mathematics

Have each student create a double-bar graph to compare the data from their rocket launches. Students should title and label their graphs. Compare the graphs with the rest of the class.

Ask students to display their data in other ways. Ask them to explain why they have chosen to display their data in this format.

Analyze the data, looking for patterns and trends.

National Mathematics Education Standards (NCTM) (3-5):

Data Analysis and Probability Standard:

- Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them
  - collect data using observations, surveys, and experiments
  - represent data using tables and graphs such as line plots, bar graphs, and line graphs
- Develop and evaluate inferences and predictions that are based on data
  - propose and justify conclusions and predictions that are based on data and design studies to further investigate the conclusions or predictions

Language Arts

Ask students to explain the experiment. How might students improve this experiment? Where might there have been mistakes made? How might these mistakes have affected the results?

National Council of Teachers of English Standards (NCTE):

- Students conduct research on issues and interests by generating ideas and questions, and by posing problems. They gather, evaluate, and synthesize data from a variety of sources (e.g., print and non-print texts, artifacts, people) to communicate their discoveries in ways that suit their purpose and audience.

Engineering and Technology

Ask students to design a nose cone and fins for the rocket. Ask students to test their new rocket to see what effect the new design has on the rocket height and ask them to explain why.

National Science Education Standards (NSES):
Content Standard E: Science and Technology
- Abilities of technological design (K-8)

Sources and Career Links

Thanks to subject matter experts Dan Woodard, Victoria Friedensen and Joseph Trevathan for their contributions to KSNN™ and Noticiencias NASA™ on the development of this education material.

Dan Woodard is the Physical Science Research Outreach and Education Department lead at NASA's Marshall Space Flight Center. You can find out more at http://www.nasa.gov/centers/marshall/home/index.html.

Victoria Friedensen is Policy and Communications Manager for Project Prometheus, Office of Space Science, NASA. To find out more, visit: http://ses.gsfc.nasa.gov/ses_data_2003/030506_Friedensen_Abstract.htm.

Joseph Trevathan is a mechanical engineer at the NASA Johnson Space Center (JSC) where he worked in the Propulsion Division for 14 years. He is currently with the Biomedical Systems Engineering division at JSC.

For a related career profile, learn about Franklin R. Chang-Diaz, PhD, the first Hispanic astronaut. Find out more by visiting http://www.jsc.nasa.gov/Bios/htmlbios/chang.html.

This activity was adapted from NASA educational products.

Lesson development by the NASA Johnson Space Center Human Health and Performance Education Outreach team.

Scientific Investigation Rubric

Experiment: SPEED IT UP

Student Name ___________________________________ Date ____________________

Performance Indicator	**0**	**1**	**2**	**3**	**4**
The student developed a clear and complete hypothesis.					
The student followed all lab safety rules and directions.					
The student followed the scientific method.					
The student recorded all data on the data sheet and drew a conclusion based on the data.					
The student asked engaging questions related to the study.					
The student described at least one recommendation for NASA in the area of propulsion.					
Point Total					

Point total from above: _________ / (24 possible)

Grade for this investigation _________________

Grading Scale:

A = 22 - 24 points

B = 19 - 21 points

C = 16 - 18 points

D = 13 - 15 points

F = 0 - 12 points