Key: Yellow highlight = required component

We Have Liftoff

Subject Area(s) Chemistry

Associated Unit

Associated Lesson Rockets!

Activity Title **We Have Liftoff**

Header

Image 1 **Image file:** NASA-rocket-launch-237x300.jpg **ADA Description:** Image shows a NASA rocket launch *(Write as if describing the image to a blind person; do not repeat any caption content.)* **Source/Rights:** Copyright © The Green Optimistic **Caption:**

Grade Level 10 (9-12)

Activity Dependency

Time Required 120 minutes

Group Size 3-4

Expendable Cost per Group US $3

Summary
During the associated lesson, students receive a brief lesson in statics, free-body diagrams, combustion, and thermodynamics. This lesson helps students to understand that the energy required launch a rocket comes from the chemical energy stored in the rocket fuel. With their knowledge of stoichiometry, students are asked to design their own rocket engine using sugar and potassium nitrate. The performance of each engine is tested during a rocket launch. Finally, students asked to determine the reasons for the success or failure of their rockets.

Engineering Connection
Engineers rely on their knowledge of the sciences to successfully launch rockets into space. There are many factors at play in designing a rocket, including the shape of the body, the weight, and the type and amount of fuel needed to put a rocket into space. Additionally, the job of an engineer is to design a system based on theoretical measurements, test the design, analyze the results of the test, and loop back to the design stage until the system functions as intended. Students use this process to create their own rocket engine in this activity

Engineering Category = 2
Choose the category that best describes this activity's amount/depth of engineering content:
1. Relating science and/or math concept(s) to engineering
2. Engineering analysis or partial design
3. Engineering design process

Keywords
design, fuel, rocket, stoichiometry,

Educational Standards (List 2-4)
ITEEA 2000, grades 9-12, 16.J

Standard 16. Students will develop an understanding of and be able to select and use energy and power technologies.
J. In order to select, use, and understand energy and power technologies, students should learn that energy cannot be created nor destroyed; however, it can be converted from one form to another.

Texas: Science 2010, grades 9-10, C
Science Concepts. The student recognizes multiple forms of energy and knows the impact of energy transfer and energy conservation in everyday life. The student is expected to demonstrate common forms of potential energy, including gravitational, elastic, and chemical, such as a ball on an inclined plane, springs, and batteries

Texas: Science 2010, grades 9-10, C
Scientific processes. The student uses critical thinking, scientific reasoning, and problem solving to make informed decisions. The student is expected to in all fields of science, analyze, evaluate, and critique scientific explanations by using empirical evidence. Logical reasoning, and experimental and observational testing, including examining all sides of scientific evidence of those scientific explanations, so as to encourage critical thinking buy the student.

Pre-Requisite Knowledge

- Balancing chemical equations
- Stoichiometry

Learning Objectives

After this activity, students should be able to:

- Describe the engineering design process for creating any system or device
- Build a rocket engine prototype
- Determine the strengths and weaknesses of their design based on the success or failure of their rocket launch

Materials List

Each group needs:

- Cat litter
- Sugar
- Potassium Nitrate (found in Spectracide Stump Remover – Lowe's)
- 0.95 cm (3/8 inch) x 22.86 cm (9 inch) dowel
- 6.4 cm x 25.4 cm strip of kraft project paper
- fuse (~12 cm long)
- Two 1 cm straws
- Mortar and pestle
- Closed 80 mL-100 mL container

To share with the entire class:

- white glue
- ring stand
- skewer or 0.635 cm (1/4 inch) dowel with a spike at one end
- 0.3175 cm (1/8 inch) diameter drill bit or nail

Introduction / Motivation

Rocket science is an interdisciplinary field, requiring the expertise of engineers and scientists who specialize in different fields. Rockets are an engineering marvel. The ability to move a huge piece of machinery over 100 miles against gravity is quite the accomplishment. There are many things to consider when building a rocket, and because they are so expensive, efficiency and accuracy is of the utmost important.

Procedure

Background

IMAGE Insert Image 2 here, align left, wrap text

Image 2

Image file:
cartoon rocket.jpg

ADA Description: Image shows a cartoon rocket flying in a right-diagonal direction

Source/Rights: CoadePoint Ltd, Shift Technology Ltd

We won't be too concerned about the level of engineering for the miniature rockets we will be building in this class. The purpose of this activity is to give you a basic understanding of rocket design.
You will be building your rockets out of crafting supplies and other household items. The fuel used for your rockets will be a mixture of potassium nitrate (found in stump remover and gun powder) and household sugar. The unbalanced combustion reaction equation for the fuel is:

$$C_{12}H_{22}O_{11} + KNO_3 + O_2 \rightarrow CO_2 + H_2O + K_2CO_3 + N_2 + KOH$$

With the Students

1. Spread white glue evenly on one side of the kraft paper. Wrap it tightly around the 0.95 cm (3/8 inch) dowel, such the dowel is not glued to the paper, to form the shape of a cylindrical

rocket motor casing. The casing should be 6.4 cm long. Remove the dowel and let the glue dry.

2. Using a mortar and pestle, finely ground some cat litter. When the paper cylinder has dried, place one of the open ends onto the tabletop or a flat surface and pour the litter into the cylinder. Use the dowel to pack it down. The packed litter layer should be about 0.85 cm thick and will act as a plug. If the litter powder is fine enough, packing it down will, in a sense, make it into a solid. If you are having trouble packing the litter, mix it with some water so that it begins to clump, then retry packing.
3. Weigh out 6 grams of powder sugar and pour it into the mixing container.
4. Balance the combustion equation above and determine the appropriate amount of KNO_3 needed for the fuel, given you are using 6 grams of sugar. Complete the attached table. DO NOT CONTINUE ONTO THE NEXT STEP UNTIL YOU HAVE CONFIRMED YOUR ANSWERS WITH YOUR INSTRUCTOR.

    Teacher Note: The recommended amount of sugar to potassium nitrate is 1:2, but different answers will arise when balancing the equation. For safety, I would recommend no more than a 1:2.5 ratio.
5. Weigh out the appropriate amount of KNO_3 determined from your calculations. Using a CLEAN mortar and pestle, ground the crystals into a fine powder.
6. Add the KNO_3 powder to the mixing container. Shake to create an evenly mixed powder.
7. Pour the fuel powder into the open end of the rocket body and compress it with the dowel until there is about 1 cm of space left at the top of the cylinder.
8. Pour more cat litter into the top of the body, packing it down, until the litter layer is flush with the end of the rocket body.
9. Using the drill bit or nail, slowly and carefully bore a hole down the middle of the rocket. Be sure that your borehole does not puncture the cat litter-plug at the other end of the rocket.
10. Glue the two 1 cm straw bits to the side of the rocket body in a vertical direction. These will act as a guide during the launch; they will be placed over the skewer or dowel used for the launch. That being said, make sure that the straws are aligned when gluing.
11. Insert the fuse into the borehole. Bend the top of the fuse, if necessary, to make sure that it fits snuggly.
12. Launch the rockets in an open and safe area. Using the ring stand and skewer or thin dowel, set up a launch pad in such a way that the bottom of the rocket rests on the stand and the straws along the rocket body slide over the skewer. Wearing safety glasses, light the fuse and back away immediately.

    Note: Because these rockets do not have fins, they will fly in an unpredictable pattern.

Attachments

We Have Liftoff (doc)

We Have Liftoff (pdf)

Safety Issues

- Have students wear gloves when handling the sugar and/or potassium nitrate.
- Eye protection is necessary for the individual launching the rocket.

Troubleshooting Tips

If rocket does not ignite, stay away from it for 5 minutes. Using thick gloves or tongs, pick it up carefully with the fuse-end pointing away from you. Soak it in water until it disintegrates and discard the pieces in an outdoor trash can.

Some rockets will have good rocket engines and fly, some will have good engines and not fly, and some rockets will be duds. The factors contributing to the success or failure of the rockets are total weight, moisture content, and the homogeneity of the fuel mixture. Students will be asked to consider why or why not their launch was successful in the post-activity assessment.

Assessment

Pre-Activity Assessment
Descriptive Title: ___?

Activity Embedded Assessment
Design Process:

1) What factors must be considered in order to have a successful launch?
2) Is it advantageous to use fine powders in the rocket fuel mixture? Why or why not?
3) What is the significance/purpose of the borehole through the rocket fuel?

Post-Activity Assessment
Project Reflection & Discussion: This can be done as a class or students can discuss these questions in their groups.

4) Why was your rocket launch a success or failure?
5) If you could redesign your rocket, using the same procedure, what would you do differently to improve your rocket's flight?
6) How would changing the compactness of the powders affect how the fuel burns?
7) What could you do to make your rocket fly straight?

Activity Extensions

Have students discuss the post-activity questions as a class to improve the rocket design. Another rocket may be built to see if flight it improved.

Students could also add extra design elements (fins, nose, nozzle, etc.) to improve the direction and height of the flight.

Additional Multimedia Support

none

References

Gurstelle, W. (2013, September 10). Homemade Sugar Rocket. Retrieved November 29, 2014, from http://makezine.com/projects/make-35/homemade-sugar-rocket/

Other

Redirect URL

Contributors

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Supporting Program

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Acknowledgements

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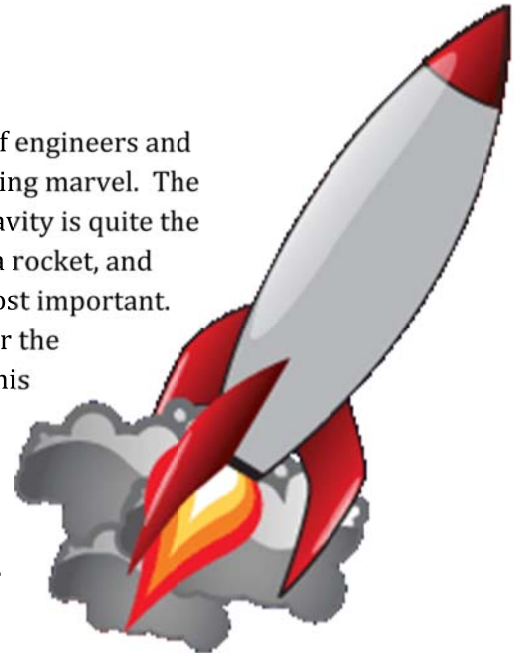
Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Classroom Testing Information

We Have Liftoff



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- Mortar and pestle
- Closed 80 mL-100 mL container

To share with the entire class:

- white glue
- ring stand
- skewer or 0.635 cm (1/4 inch) dowel with a spike at one end
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Procedure:

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$$\_\_\_\_C_{12}H_{22}O_{11} + \_\_\_\_KNO_3 + \_\_\_\_O_2 \rightarrow \_\_\_\_CO_2 + \_\_\_\_H_2O + \_\_\_\_K_2CO_3 + \_\_\_\_N_2 + \_\_\_\_KOH$$

Substance	Weight (g)	Molecular Weight (g/mol)	Moles
$C12H_{22}O_{11}$	6	342.3	
KNO_3		101.103	
O_2		32	
CO_2		44.01	
H_2O		18	
K_2CO_3		138.205	
N_2		28	
KOH		56.106	

5. Weigh out the appropriate amount of KNO_3 determined from your calculations. Using a CLEAN mortar and pestle, ground the crystals into a fine powder.
   **Is it better to have fine powder or course powder for combustion?* ____________________
   **Why?* ____
   ____
6. Add the KNO_3 powder to the mixing container. Shake to create an evenly mixed powder.
7. Pour the fuel powder into the open end of the rocket body and compress it with the dowel until there is about 1 cm of space left at the top of the cylinder.

8. Pour more cat litter into the top of the body, packing it down, until the litter layer is flush with the end of the rocket body.
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Questions:

What factors contributed to the success or failure of your rocket launch? ______________________________

____

If you could redesign your rocket, using the same procedure, what would you do differently to improve your rocket's flight? ____

____

____

How would changing the compactness of the powders affect how the fuel burns? ___________________

____

What is the significance of the borehole through the rocket fuel/what does the hole do? ____________

____

____

What could be done/added to make your rocket fly straight? ____________________________________

____