Lesson Focus

Lesson focuses on aerospace engineering and how space flight has been achieved from an engineering vantage point. Students build and launch a model rocket and consider the forces on a rocket, Newton's Laws, and other principles and challenges of actual space vehicle launch. They design their structure on paper, learn about aerospace engineering, launch their rocket, and share observations with their class. *Note: Teachers and students should be aware that most commercially available rockets generate considerable heat. Great care should be exercised to follow the manufacturer's instructions closely. Supplementary safety instructions are given at the end of this lesson plan.*

Lesson Synopsis

The "Blast Off" lesson explores rocketry, and the principals of space flight. Students work in teams with teacher supervision and construct and launch a rocket from an inexpensive kit. They observe their own achievements and challenges, as well as those of other student teams, complete a reflection sheet, and present their experiences to the class.

Age Levels

14-18.

Objectives

- Learn about aerospace engineering.
- Learn about engineering design and redesign.
- Learn about space flight.
- Learn how engineering can help solve society's challenges.
- Learn about teamwork and problem solving.

Anticipated Learner Outcomes

As a result of this activity, students should develop an understanding of:

- aerospace engineering
- engineering design
- space flight
- teamwork

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Lesson Activities

Students explore how engineers have developed rocketships over the years, and learn about the principals of rocketry. They work in teams to construct and launch a model rocket from a kit under teacher supervision. The students compare their accomplishments and challenges with those of other student teams, complete a reflection sheet, and present to the class.

Resources/Materials

- Teacher Resource Documents (attached)
- Student Resource Sheet (attached)
- Student Worksheet (attached)
- NASA Beginner Guide to Rocketry (www.grc.nasa.gov/www/k-12/rocket/)

Alignment to Curriculum Frameworks

See curriculum alignment sheet at end of lesson.

Internet Connections

- TryEngineering (www.tryengineering.org)
- Timeline of Rocket History (http://history.msfc.nasa.gov/rocketry/)
- NASA Beginners Guide to Rockets (www.grc.nasa.gov/WWW/K-12/rocket/bgmr.html)
- Virgin Galactic Human Space Flight (www.virgingalactic.com/human-spaceflight)
- NASA Parker Solar Probe (www.nasa.gov/content/goddard/parker-solar-probe-humanity-s-first-visit-to-a-star)

Recommended Reading

- Make: Rockets: Down-to-Earth Rocket Science (ISBN: 978-1457182921)
- Handbook of Model Rocketry (ISBN: 978-0471472421)
- "A Pictorial History of Rockets" (www.nasa.gov/pdf/153410main_Rockets_History.pdf)

Optional Writing Activity

- Write an essay or a paragraph describing an example of rockets might be used to help society in peaceful times.

Extension Activity

- Have older or more advanced students use an altimeter to measure acceleration as part of this lesson and incorporate g-force discussions.

Safety Notes

- Please read and follow safety recommendations on page 15.
- For younger students TryEngineering.org offers a water pressure rocket lesson, called "Water Rocket Launch"

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For Teachers: Teacher Resource

Lesson Goal

The "Blast Off!" lesson focuses on aerospace engineering and how space flight has been achieved from an engineering vantage point. Students build and launch a model rocket and consider the forces on a rocket, Newton's Laws, and other principles and challenges of actual space vehicle launch. They design their structure on paper, learn about aerospace engineering, launch their rocket, and share observations with their class.

Lesson Objectives

- Learn about aerospace engineering.
- Learn about engineering design and redesign.
- Learn about space flight.
- Learn how engineering can help solve society's challenges.
- Learn about teamwork and problem solving.

Materials

- Student Resource Sheets
- Student Worksheets
- Student Team Materials: paper, pen, pencil; model rocket kit.
- Suggested resources for model rocket kits:
  - Estes (www.estesrockets.com)
  - Model Rockets (www.modelrockets.co.uk)
  - Local or national rocket competitions
- Internet access (optional) to explore www.grc.nasa.gov/WWW/K-12/rocket/ for research and to use online rocket simulator

Procedure

1. Show students the student reference sheets and the NASA Beginner Guide to Rocketry (www.grc.nasa.gov/www/k-12/rocket/). These may be read in class or provided as reading material for the prior night's homework.
2. To introduce the lesson, consider asking the students how they think a rocket can fly and how engineers have to consider payload, weather, and the shape and weight of a rocket when developing a new or re-engineered rocket design.
3. Teams of 3-4 students will consider their challenge, read about rocketry, and explore the online rocket simulator (if internet access is available)
4. Teams next build and launch their rocket as a team, and observe the flight patterns of other rockets that are launched.
5. Teams reflect on the experience, and present to the class.

Safety Note

This lesson is intended for older and mature students, under continual supervision of a responsible teacher or teacher team with prior experience with rocket launch kits. Be sure to follow your school's safety guidelines at all times.

Time Needed

Two to four 45 minute sessions.

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Student Worksheet:

◆ Engineering Teamwork and Planning

You are part of a team of engineers given the challenge of building a model rocket from a kit that can rise the highest and straightest compared with other student teams in your class. You'll research ideas online (if you have internet access), learn about rocket design and flight, and work as a team to construct and test your rocket. You'll consider the results of other teams, complete a reflection sheet, and share your experiences with the class.

◆ Research Phase

Read the materials provided to you by your teacher. If you have access to the internet, also visit www.grc.nasa.gov/WWW/K-12/rocket/ for additional research and to use the online rocket simulator, RocketModeler III.

◆ Planning and Design Phase

On a separate piece of paper draw a detailed diagram of how your rocket will look when completed and estimate how high you believe your rocket with travel. Is there anything you can do to encourage your rocket to go higher and straighter?

◆ Build and Launch

As a team, build your rocket -- but always under the supervision of your teacher! You'll then test the rocket. Be sure to observe how high and how straight the rockets built by other teams go.

◆ Reflection/Presentation Phase

Complete the attached student reflection sheet and present your experiences with this activity to the class.

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Student Worksheet:

◆ Reflection

Complete the reflection questions below:

1. How did the height you estimated your rocket would reach compare with the actual estimated height?

2. What do you think might have caused any differences in the height you achieved?

3. Did your rocket launch straight up? If not, why do you think it veered off course?

4. Do you think that this activity was more rewarding to do as a team, or would you have preferred to work alone on it? Why?

5. Did you adjust your model rocket at all? How? Do you think this helped or hindered your results?

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Student Worksheet:

◆ Reflection (continued)

Complete the reflection questions below:

6. How do you think the rocket would have behaved differently if it were launched in a weightless atmosphere?

7. What safety measures do you think engineers consider when launching a real rocket? Consider the location of most launch sites as part of your answer.

8. When engineers are designing a rocket which will carry people in addition to cargo, how do you think the rocket will change in terms of structural design, functionality, and features?

9. Do you think rocket designs will change a great deal over the next ten years? How?

10. What tradeoffs do engineers have to make when considering the space/weight of fuel vs. the weight of cargo?

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For Teachers: Alignment to Curriculum Frameworks

Note: Lesson plans in this series are aligned to one or more of the following sets of standards:

- U.S. Science Education Standards (http://www.nap.edu/catalog.php?record_id=4962)
- U.S. Next Generation Science Standards (http://www.nextgenscience.org/)
- International Technology Education Association's Standards for Technological Literacy (http://www.iteea.org/TAA/PDFs/xstnd.pdf)
- U.S. National Council of Teachers of Mathematics' Principles and Standards for School Mathematics (http://www.nctm.org/standards/content.aspx?id=16909)
- U.S. Common Core State Standards for Mathematics (http://www.corestandards.org/Math)
- Computer Science Teachers Association K-12 Computer Science Standards (http://csta.acm.org/Curriculum/sub/K12Standards.html)

◆National Science Education Standards Grades 9-12 (ages 14-18)

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop

- Abilities necessary to do scientific inquiry

CONTENT STANDARD B: Physical Science

As a result of their activities, all students should develop understanding of

- Chemical reactions
- Motions and forces

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop

- Abilities of technological design
- Understandings about science and technology

CONTENT STANDARD F: Science in Personal and Social Perspectives

As a result of activities, all students should develop understanding of

- Science and technology in local, national, and global challenges

CONTENT STANDARD G: History and Nature of Science

As a result of activities, all students should develop understanding of

- Science as a human endeavor
- Nature of scientific knowledge
- Historical perspectives

◆Next Generation Science Standards - Grades 6-8 (Ages 11-14)

Matter and its Interactions

Students who demonstrate understanding can:

- MS-PS1-6. Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.

Engineering Design

Students who demonstrate understanding can:

- MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

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- MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

For Teachers: Alignment to Curriculum Frameworks

◆Next Generation Science Standards – Grades 9-12 (Ages 14-18)

- HS-ETS1-4. Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

◆Standards for Technological Literacy - All Ages

The Nature of Technology

- Standard 1: Students will develop an understanding of the characteristics and scope of technology.

Technology and Society

- Standard 6: Students will develop an understanding of the role of society in the development and use of technology.
- Standard 7: Students will develop an understanding of the influence of technology on history.

Design

- Standard 8: Students will develop an understanding of the attributes of design.
- Standard 9: Students will develop an understanding of engineering design.
- Standard 10: Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Abilities for a Technological World

- Standard 11: Students will develop abilities to apply the design process.

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For Teachers: Supplementary Safety Considerations

- Students and the teacher in charge should read and follow the rocket manufacturer's instructions CAREFULLY.
- Teachers who have never supervised a rocket launch may want to team with a teacher who has for their first launch.
- Be sure to follow your school's safety policies.
- Launching can, of course, only be done out of doors.
- Students and others who are not actively involved in launching the rocket should be kept well back. 250 ft is a safe figure.
- All members of the launch team should wear protective eye shields.
- Rockets of the type illustrated are ignited electrically by a pair of wires about 20 ft long. Launch team should stand behind an automobile or other protective barrier. They could even sit inside the car if necessary.
- Note that an alternate to rocket launch kits would be to use a foot pump and launch an air rocket (using an empty soda bottle or other container for the rocket).

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