ROCKET FUEL LAB

CHABOT SPACE & SCIENCE CENTER

HOW IT WORKS

Watch the video included in your virtual package to learn about rockets and the different fuels used to launch them into space. The video is 45 minutes long without pause, and should take 60 to 90 minutes to complete when incorporating pauses for discussion and the activity. You may complete it all in one session, or split it up into multiple days according to the timecodes listed below.

Sample the video ahead of time to get familiar with the flow and decide how your students will engage with the show. Reference this guide and the instructions for the design challenge below as needed.

Discussion questions, additional resources, and related activities to extend the learning are listed on page 6 and 7.

VIDEO TIME CODES

0:00 – 3:56	Notable rockets
3:57 – 7:58	Rocket anatomy
7:59 – 14:36	Rockets and thrust!
14:37 – 21:42	Demos: solid fuel
21:43 – 33:41	Demos: liquid fuel
33:42 – 45:08	Activity: balloon rockets

In this activity, learners will design, construct, and test solutions for an air-powered balloon rocket. They will attempt to meet the criteria for a successful launch and discuss the strengths and weaknesses of their rocket using critical thinking, evaluation, and design skills.

ACTIVITY SET UP

1. Gather materials and make substitutions as needed (see list).
2. Determine where you are going to set up your "mission pathway string" for testing the rockets.
   a. You will need a wide, open area with 10 to 20 feet of space across.
   b. This can be set up indoors or outdoors.
3. OPTIONAL: set up your "mission pathway" string ahead of time.
   a. Tape one end of string to a wall. Unroll it while walking to the opposite side of the room.
   b. At the end point, cut the string and slide a straw over it.
   c. Place it aside for later.
   d. Repeat to make as many launch stations as you need.

OVERVIEW

- **Video length:** 45 minutes
- **Complete duration** (video, discussion, and activity): 60-90 minutes
- **Grade range:** K – 8^{th}
- **Skills:** Asking questions, Constructing explanations, Obtaining, evaluating, and communicating information
- **Concepts:** Cause and effect, Energy and matter, Structure and function

SUGGESTED MATERIALS*

- Balloons (different sizes and shapes optional)
- Straws
- Strings (10 to 20 feet long)
- Paper
- Scissors
- Tape
- Markers
- Small clips (binder, paper, clothespin, etc.)
- Air pump (optional)
- Timer (optional)

SUBSTITUTIONS

Substitute any of the materials listed above as needed based on what is available.

Suggestions for other ways to try this design challenge are listed on page 7 under "Think Different".

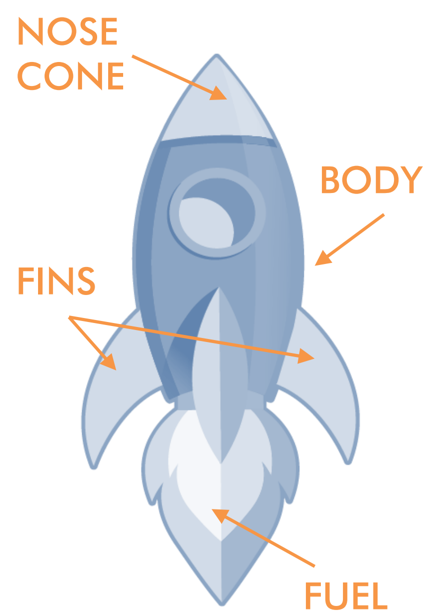
ACTIVITY INTRODUCTION

Congratulate the group on being rocket engineers! To practice their engineering skills, they will be completing a design challenge using balloon rockets!

1. Explain the challenge:
    a. Design and build an air-powered balloon rocket that can fly along a "mission pathway" string, from one end to the other, in one attempt.
        i. The longer the string, the more challenging the flight.
    b. They will have 10 minutes to design and build their rocket.
    c. They can use any of the materials available.
    d. They can work individually or in teams of 2 or 3, depending on your preference.
    e. When the time is up, they will be launching their rockets to determine if they are able to fly a successful mission and reach their destination.
2. Confirm that the group understands the goal of the challenge and take any questions.
3. If you did not set them up ahead of time, have your group set up the "mission pathway" strings now. These will be the pathway for the rockets to fly along during testing. You can set up as many as you'd like.
    a. To do this, tape one end of string to a wall. Unroll it while walking to the opposite side of the room.
    b. At the end point, cut the string and slide a straw over it.
    c. Place it aside for later.

ROCKET BUILD

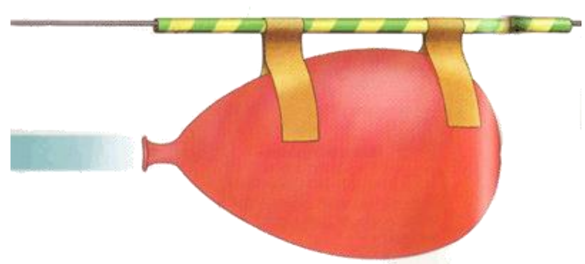
1. Begin a 10-minute timer.
2. Each engineer or team will need to select a balloon.
    a. The balloon acts as the body of the rocket. They can experiment with different shapes and sizes, depending on the balloons available to them at home.
3. Next, they should fill their balloons with air.
    a. The air acts as fuel to power the rockets. They can decide how much or how little fuel to add.
    b. Use a clip to keep the balloon shut and store the air inside.
4. Lastly, they can customize, design, and attach the other parts of their rocket to increase its aerodynamics.
    a. Paper can be cut to make fins, nose cones, and other rocket features.
    b. Use tape to attach to the rocket body.
5. Check in with your students during the build. Ask how it is going and provide facilitation or feedback using questions such as:



How many fins are you going to add? What shape will they be?
Are you adding a nose cone? What shape will it be?
Does your rocket need more than one stage on its body? How could you add another stage?
What is the name of your rocket?
How did you come up with your rocket design?

ROCKET LAUNCH

1. When the timer goes off, gather your group and determine the order in which you will be testing the rockets.
    a. You can test more than one at a time if you prefer.
2. Prepare the rockets for launch:
    a. To do this, have the group gently lay a few pieces of tape over their mission pathway straw and lightly press their balloon against it to stick (see image below).
3. Launch the rockets!
    a. Pull the mission pathway string tight for flight.
    b. Remove the clip from the balloon.
    c. Release the air to watch it fly!
4. Determine whether they had a successful flight or not.
    a. If it reached the end of its mission pathway string, it was a success!
    b. If it did not fly all the way, it could use some improvements!



5. Once all rockets have been launched, discuss the results of their designs using questions such as:

What parts of your design worked well?
What parts could be improved?
What would you do differently if you could do it again?
Is there anything you wish you could add to your design?
Is there anything you wish to take away?
How does your design look similar or different from a real rocket?

6. Explain to the group that testing their design is a great way to figure out what works and what doesn't. It helps reveals ways to improve something, whether the goal is to make it stronger, faster, or tougher.
7. Now, they will have a chance to improve their rockets in a second round of building!

SECOND ROUND INTRODUCTION

Explain that your group now has an opportunity to re-design and re-test their rockets for improvements!

1. Explain the second part of the challenge:
    a. They will improve their rockets to fly along a mission pathway string, from one end to the other, in one attempt. If they already met this challenge in the first round, they can try to fly the path even faster in the second round.
    b. They will have 10 minutes to re-design and improve their rockets.
    c. They can use any of the same materials as before.
    d. If they worked in teams, they will remain in the same teams for the second round.
    e. When the time is up, they will be launching their rockets to determine if they are aerodynamic enough to fly a successful mission.
2. Confirm that the group understands the goal of the second round and take any questions.

ROCKET BUILD ROUND TWO

1. Begin a 10-minute timer. Give more or less time as needed.
2. The group can adjust any parts of their rocket that needed improvement, or they may start over from scratch. Remind them of the different rocket parts and encourage them to think about making them all as aerodynamic as possible:
    a. The balloon is the rocket's body.
    b. The air is the rocket's fuel.
    c. The paper can be shaped to be the rocket's fins and nose cone.
3. Check in with your students during the build. Ask how it is going and provide facilitation or feedback using questions such as:

What are you doing differently this time around to improve your rocket?
Is there a different style balloon that will fly through the air faster?
Is there a way to add more fuel into the rocket so it can create more thrust?
Is there a way you can change the shape, size, or placement of your fins and nose cone to slice through the air easier?
What are you doing to increase your rocket's speed and aerodynamics?

ROCKET LAUNCH ROUND TWO

1. When the timer goes off, gather their attention and launch the rockets again, like before.
2. Determine if they were successful flights, or if they could use another round of improvements.
3. Discuss the results and compare how it went to the first round using the questions below:

Which improvements worked? Which didn't work?
What would they do differently If they could do another round of testing?
How did they feel in the second round compared to the first?
Are there other materials they wish they had?
What were the biggest challenges of this activity and were they able to overcome them?

CONCLUSION

4. Explain that this activity reflects the importance of the engineering process:
    a. Defining a problem, designing a solution, optimizing the design solution, and repeating it over again and again.
5. Engineers must go through this process multiple times and test for multiple factors before they can be confident that their design will survive all of the potential challenges that space has to offer. And failure is almost always part of the process!
6. Once you are finished with the activity, check out some of the resources and extension activities, listed on page 7 to learn more about rockets!

STANDARDS, CONCEPTS, AND PRACTICES (NGSS)

NEXT GENERATION SCIENCE STANDARDS (NGSS)

Completing these activities and experiments will satisfy the following NGSS standards:

- **K-PS2-1:** Investigate the effects of different strength or directions of pushes on the motion of an object.
- **K-PS2-2:** Analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push.
- **3-5-ETS1-1**. Define a simple design problem reflecting a need or a want that includes the specified criteria for success and constraints on materials, time, or cost.
- **3-5-ETS1-2.** Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- **MS-ETS1-2.** Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

NGSS: CROSS CUTTING CONCEPTS

Completing these experiments and activities will help children understand the following about cross cutting concepts:

- **Cause and Effect:** cause and effect relationships are routinely identified and used to explain change and that events have causes that generate observable patterns.
- **Energy and Matter:** energy is tracked into, out of, and within a system to help understand the systems' possibilities and limitations.
- **Structure and Function:** the shape of designed objects are related to their function within a system.

NGSS: PRACTICES FOR K-12 CLASSROOMS

Throughout these activities, learners of all ages will practice skills such as:

- Asking questions and defining problems
- Developing and using models
- Constructing explanations and designing solutions
- Obtaining, evaluating, and communicating information

DISCUSSION QUESTIONS

Use the discussion questions listed below to guide conversation with your students before, during, and after completing the Rocket Fuel Lab Science Show. Discuss them as a group or assign them as a journal prompt or writing exercise.

PRE-SHOW

What do you know about rockets?

Have you ever seen a rocket launch before?

What do you think is needed to launch a rocket into space?

What do you think are some of the challenges to launching a rocket?

MID-SHOW

What else do you want to learn about rockets?

Which rocket did you find the most interesting and why?

What did you learn about rocket fuel in the video?

What do you think is the most important element to safely launching rockets into space?

What are some of the similarities and differences between balloon rockets and real rockets?

POST-SHOW

Do you think it is important to send rockets into space? Why or why not?

Is there anything you would invent to improve rockets to make them safer/faster/more efficient?

Do you consider yourself an engineer? Why or why not?

What skills or strengths do you think are important for an engineer to have?

Which of those skills or strengths did you use during the design challenge?

ADDITIONAL RESOURCES

FROM CHABOT

What goes up, must come down… especially astronauts! Check out Chabot's Splashdown activity from the Learning Launchpad. Learners will design and build a model capsule that protects the astronauts inside during a water-based return to Earth.

Rockets are a necessary technology for sending people, equipment, and technology into space. Learn more about rocket aerodynamics and build your own with Chabot's Aerospace Engineering activity from the Learning Launchpad.

FROM NASA

Discover more rocket lessons and activities on NASA Jet Propulsion Laboratory's Education Resource Page. Activities cover a wide range of grade appropriate content, from straw rockets, to robotic design challenges!

Find information on upcoming rocket launches with NASA's launch schedule. Then, tune in to NASA TV for live coverage and watch liftoff happen in real time!

Check out NASA's video series, "Rocket Science in 60 Seconds." Hear directly from engineers and scientists involved in the research, production, and launch of NASA's newest deep space rocket, named the Space Launch System!

EXTENSION ACTIVITIES

KEEP IT GOING

Add more rounds onto this design challenge until you successfully meet all criteria. Or add some extra challenges into the activity with ideas listed below:

- Increase the length of the mission pathway string.
- Set up more than one string and race two rocket balloons against each other for speed.
- Try creating a multi-stage rocket by adding more than one balloon onto its body.

THINK DIFFERENT

Encourage your students to think differently about this challenge. If you do **not** have the materials needed to complete this activity, how else can you determine whether a rocket launch is successful or not? Is there a different air-powered rocket you can test? Come up with your own design challenge and parameters for success. Some ideas listed below:

- Release balloons freely in the air, without the mission pathway string. Determine how to measure success based on distance traveled, or height reached. Or come up with your own measurement.
- Build a rocket out of different materials, such as a film canister filled with water and an effervescent tablet. Use the buildup of air pressure inside of the canister to pop the lid off and launch it from the ground!

WRITE A STORY

Imagine you are an astronaut, sitting inside of the balloon rocket as it races towards its destination in outer space. Write a short story about your experience. Where are you headed in space? What is your mission there? What do you think, see, or feel?