THE FRANKLIN INSTITUTE

Be a **Space Scientist!**

Be a **Rocket Engineer**

Educator Guide

Big Question: How can we design a rocket to fly as far as possible?

GSK Science in the Summer™

In collaboration with GSK

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Be a Space Scientist! Big Ideas

These are the themes you'll find running through all five *Be a Space Scientist!* activities.

- ***Space science is about exploring and traveling outside our planet. Space scientists study questions like:***
  - *What kinds of things are in the universe?*
  - *How can we learn more about them?*
  - *How might people (and other living things) travel or live in space?*

- ***Space is really big! Almost everything in space is too far away and hard to reach for space scientists to visit and study. Instead they:***
  - *Use tools and machines to **gather information** and send it back to Earth*
  - ***Compare** what they see in space to things they know about on Earth*
  - ***Use models** to represent things that are too big, too small, or too far away to study directly*

Core Four Strategies

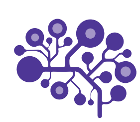
Use the Core Four Strategies as you guide your learners through this activity.

- **Ask questions** to spark curiosity and encourage new ideas
- **Encourage scientific thinking** with chances to observe, make predictions, and test ideas
- **Cultivate rich dialogue** with chances to talk together, share ideas, and use science words
- **Make connections** between learners' experiences, science careers, and this activity

Ask Questions

Encourage Scientific Thinking

Cultivate Rich Dialogue



Make Connections

Be a Rocket Engineer

Big Question: How can we design a rocket to fly as far as possible?

MATERIALS:

Per class:

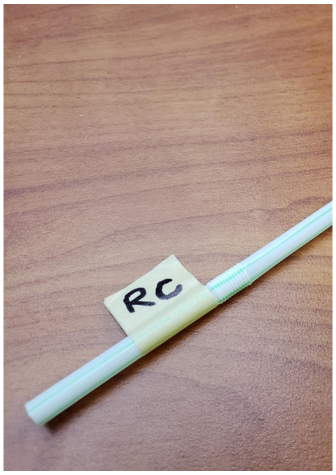
- Rocket engineer career card
- Masking tape rolls (6–8)
- Scissors (6-8)
- Playdough (6–8)
- Measuring tapes (2–3)
- Target images: International Space Station (ISS), Moon, Mars (2–3 each)
- Lab notebooks
- Pencils
- Science skills stickers

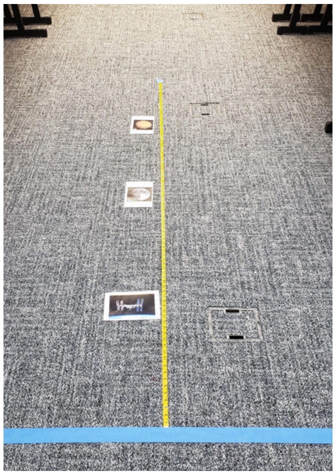
Per student:

- Straw with bendable neck
- 4″x6″ sheets of copy paper (at least 2)

Prepare

1. Put a piece of masking tape around each straw, just above the bend, to create a tag. Learners can label their straw with their initials or other mark so they can keep track of their own straw.
2. Pre-make a rocket model from a half-sheet of copy paper: roll the short side of the paper around a pencil to make a tube and tape the end of the paper down. Remove from the pencil. Pinch one end of the tube closed into a point and secure with tape to make the rocket nose.
3. Set up a test launch zone (or more than one zone, if your space allows):
    - Clear an area about 6 feet long and at least 3 feet wide (or wider to accommodate more learners at a time). Mark the boundaries with tape on the floor if possible.
    - Lay the measuring tape down the center of the space and secure with tape.
    - Tape the target images down on the floor: the ISS about 1 foot from the start, the Moon about 2 feet from the start and Mars about 3-4 feet from the start.





Engage

1. Introduce the rocket engineer career by showing the group the career card and asking questions to encourage students to think about what a rocket engineer might do:
    - *What do you notice about this picture? What do you think this person is doing?*
    - *What does the name rocket engineer make you think of?*
    - *What have you seen or heard about rockets? What do they do? What parts do they have?*
    - *What things do you think a rocket engineer might do as part of their job?*

2. Introduce the storyline like this:
    - We're part of a team that is designing a new rocket to use for different kinds of missions into space.
    - We need the rocket to be able to **travel as far as possible,** and **safely carry a payload** —that means whatever the rocket is delivering, like a satellite, or supplies, or even astronauts.
    - Another team is working on the engine part, and we're assigned to the body. Our job is to figure out how to help the rocket fly as far as it can with the fuel it has.
        - *Besides the engine and fuel, what do you think might be important for helping a rocket to fly a long distance?*
    - Rockets are big and expensive to build, so we're going to start with a **model**—a smaller or simpler version—to help us figure out what's important when we're building our rocket for real.

Explore

Part 1: Build Model

1. Demonstrate the model: put the paper rocket on the end of the straw, hold the straw parallel to the floor (and pointing away from any learners!) and blow into the straw to launch the rocket. Ask students to make observations:
    - *What did you notice about how the rocket flew? How far did it go?*
    - *What do you think we could change to help it fly further?*
2. Ask students to make starter rockets like the one you modeled:
    - Roll the short side of the paper around a pencil to make a tube
    - Tape the end of the paper down to hold it shut
    - Slide the tube off the pencil
    - Pinch one end of the tube into a point and tape it closed
    - Write your name or draw something on it so you know it's yours
3. Introduce the test launch zone. Explain that they can test their rockets by standing at the line on the end of the zone and launching their rockets into the zone.

4. Remind the group that safety is important for engineers! Agree together on some launch safety rules, such as:
   - Launch rockets *only* in the test launch zone
   - Check before entering the test zone that no one is about to launch
   - Don't launch if anyone is in the test zone
5. Hand out straw launchers and ask students to put their name or initials on the tape tag of their straw.
6. Invite them to test their prototype rockets by standing at the edge of the launch zone, blowing to launch the rocket, and using the measuring tape and/or target images to note how far the rocket flew.

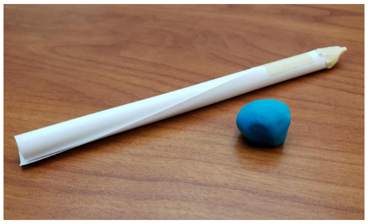
Part 2: Test Launch Angle

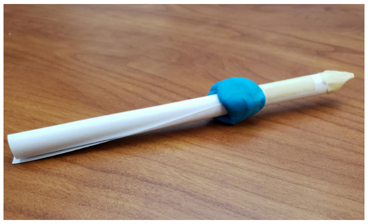
7. Ask learners what they noticed while testing their model rockets:
   - *Did everyone's rocket go the same distance every time?*
   - *What do you think could affect how far the rocket flies?*
8. Point out that the direction of launch is one thing they could change to see how it affects their rocket's flight. Demonstrate ways they can change the angle of the rocket's launch:
   - Use the bend in the straw to point the launcher (and the rocket) higher or lower.
   - Keep the straw straight but tilt your head to aim it higher or lower.
9. Invite learners to make predictions about how different angles will affect their rocket's flight and test their ideas in the launch zone. They can record their tests on page 17 of their notebooks.
   - *Which direction do you think will help it fly the farthest? What makes you think that?*
   - *What happened when you pointed it straight up? What else could you try?*

For younger learners, making the rockets and testing launch angles may be enough for one session. Skip Part 3 or save it for a later session and move directly into the Reflect section.

Part 3: Add Payload

10. Remind the group that the rocket needs to carry a payload, like people or equipment. Explain that for this model, they will use playdough to represent the weight of their payload.
11. Ask learners to start with a ball of playdough about the width of their finger (about ½ inch, or the size of a dime) as their payload. Invite them to add it to their rocket and test the rocket in the launch zone to see how it flies.
    - *What did you notice about how your rocket flew?*
    - *How did it fly differently with the payload attached?*
12. Ask learners to think about how they could change their designs so the rocket can fly farther while carrying a payload:





- *Where is the best place on the rocket to put the payload? Front? Back? Middle?*
- *What happens if it is all in one place, or if it is divided and spread out?*

13. Encourage learners to continue testing and revising their rocket designs. They can draw or write about their tests on page 18 of their notebooks. Suggest challenges for taking their designs even further:
    - *What if the rocket now needs to carry extra equipment? Add twice as much playdough and see if you can make it fly the same distance as before.*
    - *What is the most playdough you can add and still get it to fly to the Moon (in the launch zone)?*
    - *Could you change the shape or design of your rocket to help it carry a payload farther? What would you change? Build your new rocket and test it!*

Reflect

1. Bring the whole group together to discuss their results:
    - *What did you find out about the best ways to get a rocket to fly a long distance?*
    - *What did you try that didn't work? What did you learn from that?*
2. Discuss the results of the team's research:
    - *Are there similarities between everyone's best designs?*
    - *What shall we tell the rest of our team about building the new rocket?*
    - *What things should we keep in mind when we're designing it so that it can fly a long distance?*
3. Encourage the group to reflect on how they were like rocket engineers during the activity. Refer to the career card and the science skills stickers:
    - *What are some of the things we did today as rocket engineers?*
    - *How did we think like scientists? What science skills did we use?*
    - *What did you do today that made you feel like a scientist?*
4. Allow time for students to draw or write their reflections on page 19 of their lab notebooks. Invite them to choose a science skills sticker that reflects a skill they used and add it to their notebooks.

Background

- Rockets are **vehicles that carry other things, like people, supplies, or satellites, into space.** They use powerful engines and fuel to push themselves and their payload, or cargo, upward against the force of gravity, through Earth's atmosphere, and out into space.
- Rocket engineers consider many different factors to design a rocket that can safely carry cargo long distances into space:
    - **Mass:** The heavier the rocket is, the more fuel it takes to move it. (And the rocket must carry that extra fuel, too, which makes it even heavier!)
    - **Air resistance:** Until the rocket leaves Earth's atmosphere, air pushes on it as it flies and slows it down. Features like a pointed nose and a long cylinder shape help minimize air resistance.
    - **Stability:** Wobbling or tumbling as it flies can slow the rocket down or send it off course. Balancing where the engines, fuel, and payload are placed on the rocket helps it stay stable as it flies. The fins on the end of a rocket also help with stability by controlling air turbulence in Earth's atmosphere.
- **A rocket's path, or trajectory, depends on the different forces that are pushing or pulling it.** Rocket engineers carefully plan how the different forces will interact to get the rocket where it needs to go. At first, the rocket's engines have to push hard enough to overcome Earth's gravity pulling it down.

As the rocket gets further away, the effect of Earth's gravity becomes less. When the rocket approaches another planet or moon, it will start to be affected by that planet's gravity instead.

- In this activity, **learners used air from the straw as the "fuel" to push the rocket** into motion. That push combines with the pull of gravity to send the rocket in an arc toward the ground. In real life, rockets can keep firing their engines after launch to adjust their speed and direction—as long as the engineers have planned the right amount of fuel to do it!

Acknowledgments

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Rocket Engineer Quick Guide

EDUCATORS DO:	EDUCATORS ASK:	LEARNERS DO:
ENGAGE		
Introduce Career • Use career card • Ask discussion question • Explain what robotics engineers do	*What do you notice about this picture?* *What have you seen/heard about rockets?* *What things do you think a rocket engineer might do as part of their job?*	• Make observations about the image • Make connections to their own experience • Share their ideas
Introduce Story • We're building a new rocket • We need it to travel as far as possible, and carry a payload	*Besides the engine and fuel, what else do you think might be important for helping a rocket to fly a long distance?*	• Imagine being rocket engineers • Brainstorm ideas about what affects a rocket's flight
EXPLORE		
Part 1: Build Model • Demonstrate rocket • Give rocket-building procedure • Introduce launch zone • Review safety rules	*What did you notice about how the rocket flew? How far did it go?* *What do you think we could change to help it fly further?*	• Build rocket model • Test launch rocket • Make observations
Part 2: Test Launch Angle • Demonstrate changing straw angle • Encourage testing & observation	*What do you think could affect how far the rocket flies?* *Which direction do you think will help it fly the farthest? What makes you think that?* *What happened when you pointed it straight up? What else could you try?*	• Make predictions • Test launch angles • Draw conclusions

***Quick Guide continues on the following page.*

Rocket Engineer Quick Guide

EDUCATORS DO:	EDUCATORS ASK:	LEARNERS DO:
Part 3: Add Payload • Distribute playdough • Encourage predictions & testing ideas • Add challenges	*How did it fly differently with the payload attached?* *Where is the best place on the rocket to put the payload?* *What is the most playdough you can add and still get it to fly to the Moon?*	• Add playdough payload • Test rocket flight • Redesign & retest
REFLECT		
Share Group Results	*What did you find out about the best ways to get a rocket to fly a long distance?* *What did you try that didn't work? What did you learn from that?* *What shall we tell the rest of our team about building the new rocket?*	• Draw conclusions • Make recommendations
Make Career Connections	*What did you do today that made you feel like a rocket engineer?* *How did we think like scientists? What science skills did we use?*	• Use skill stickers • Draw/write reflections

Notes

Notes