Launchpad

A STEM Enrichment Curriculum By Vivify

Middle School Version

Mission to the Moon

NASA Partner

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Thank You!

Thank you for downloading a Vivify product! If you have any questions, please email us at info@vivifystem.com.

About Vivify

Vivify is a team comprised of two Aerospace Engineer friends, Natasha and Claire, who live in Texas. We met as college classmates and roommates at Texas A&M University and later left engineering careers in the Department of Defense and Air Tractor to pursue our passion for STEM education. Learn more of our story here.

Our goal is to bring engineering to life—to vivify learning—for kids of all ages. Please connect with us so we can learn how to better serve your students!

- Natasha & Claire, The Vivify Team

Connect with us for free STEM resources!

Subscribe to our newsletter and receive access to a library of free STEM resources through www.vivifystem.com. Follow us on social media or listen to "The STEM Space" podcast for more resources and ideas. We also welcome you to join "The STEM Space" Facebook group to connect with other educators across the world.

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WANT MORE STEM?

For a complete list of all of Vivify STEM resources broken down by standards, topics, and grade levels, go here: http://bit.ly/VivifyResourceGuide

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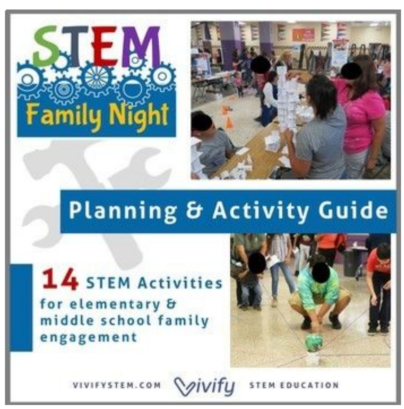

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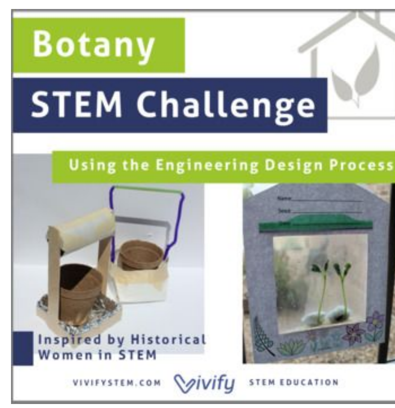

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Vivify's Overview of STEM Education

Successful STEM education is an empowering interdisciplinary approach that brings math and science concepts to life through problems that mimic the complexities and excitement of the real world. STEM revolves around the Engineering Design Process that embraces failure, relies on teamwork, and requires critical thinking and creativity. While exciting, educators often become intimidated as a search for curriculum leads to an overwhelming range of activities from index towers to robotics competitions. At Vivify, we believe that not all STEM is created equal. Educators should adopt a 3 Stages of STEM approach by progressively building towards more complex projects.

To learn more about the 3 Stages of STEM, go here: http://bit.ly/stemstages

Launchpad Mars

Want a Mars version of Launchpad. Read more here!
https://www.vivifystem.com/blog/2019/6/13/mission-to-mars-launch-kids-into-stem

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Mission to Moon Activities

Below is an activity overview of each Launchpad: Mission to Moon unit. Each mission is tied to a specific STEM career and has a 21st century skill focus.

Mission	Activity Overview	STEM Career Connection	21st Century Skill
1 **Meet the Crew**	Spark Mission Patch Helium Stick Icebreaker	Astronaut, STEM Careers	Teamwork
2 **Astronaut Training**	Moon and Earth Game Team Activity	Astronomer Scientist	Communication
3 **Get to Moon**	Straw Rocket Engineering Challenge	Aerospace Engineer, Engineer	Critical Thinking
4 **Welcome Tower**	Welcome Tower Engineering Challenge	Mechanical Engineer	Initiative
5 **Build Base**	UV Light Science Experiment Shelter Engineering Challenge	Material Scientist	Problem Solving
6 **Stay Alive**	Plant Device Engineering Challenge	Botanist/ Biology	Resilience
7 **Collect Samples**	Moon Grabber Engineering Challenge	Biomedical Engineer	Leadership
8 **Build Rover**	Energy Stick Science Experiment Rover Engineering Challenge	Electrical Engineer	Adaptability
9 **Entertainment**	Roller Coaster Engineering Challenge	Psychologist Civil Engineer	Creativity
10 **Mission Success**	STEM Careers BINGO Game Celebration Activity	Review	Review

Standards Alignment

Below is an activity overview of each Launchpad: Mission to Moon unit. Each mission is tied to a specific STEM career and has a 21st century skill focus.

Mission	NGSS	TEKS: Science
Process Skills for Engineering Challenges	MS-ETS1-1, 2,3,4	8.1B, 8.4A
1 Meet the Crew	MS-PS4-2, 3	
2 Astronaut Training	MS-ESS1-2	5.8D: M 6.11B: Gravity 7.9A: Elements for life, Atmosphere 7.12B: Circulatory system
3 Get to Moon	MS-PS3-1 MS-ESS1-2	6.11B: Gravity 8.6A: Unbalanced forces 8.6 C: Newton's 3rd Law, Rockets
4 Welcome Tower	MS-PS3-3 Energy	5.6D: Forces 6.9(C) 8.6A: Unbalanced forces
5 Build Base	MS-PS3-3 Energy	
6 Stay Alive	MS-LS2-3 Ecosystems	
7 Collect Samples		
8 Build a Rover	MS-PS2-3 Motion and Stability	5.6A/B: Electrical energy, Circuit 6.6A, 6.9(C)
9 Entertainment	MS-PS3-2 Energy	6.8(A)
10 Mission Success		

Mission to Moon Supplies

The following are supplies required to run all 10 Launchpad missions for a class of 24 students. Each item is hyperlinked to a recommended vendor. The total cost for all supplies if about $380. Materials for each mission are listed on the Mission Overview pages.

	Item	**Quantity Required** Class = 24 students	Ordering Amount	Total Cost
1	Batteries	1 per student	3 packs of 10	$17.97
2	Bendy Straws	300 per class	3 packs of 100	$5.98
3	Black Light (Needs AA batteries)	1 per class	1	$12.95
4	Cardstock	36 sheets per class	1 pack of 75	$6.99
5	Construction Paper	100 sheets per class	1 pack of 100	$3.18
6	Copy Paper	32 sheets per class	32	$7.62
7	Cotton Balls	1 pack per class	1 pack	$2.58
8	Craft Sticks	1 pack per class	1 pack of 1000	$7.81
9	Energy Stick	1 per class	1	$7.99
10	Foam Tape	1 inch per student	1 roll	$3.98
11	Index Cards	300 per class	3 packs	$8.67
12	LED Lights	1 per team	1 pack of 100 pcs	$4.99
13	Masking Tape	1 roll per 4 students	1 pack of 9 rolls	$12.98
14	Modeling Clay	6 rolls per class	1 pack of 24 rolls	$17.97
15	3V Motors	1 per student	2 pack of 15	$5.98

Mission to Moon Supplies Continued

	Item	**Quantity Required** Class = 24 students	Ordering Amount	Total Cost
16	Paper Bags	50 per class	1 pack of 50	$12.95
17	Paper Cups (5 oz)	120 per class	2 packs of 100	$6.99
18	Paper Plate (7 - 9")	150 per 24 students	1 pack	$3.18
19	Ping Pong Balls	6 per class	1 pack of 6	$7.62
20	Pinto Beans	2 beans per student	1 pack	$2.58
21	Pipecleaners	24 per class	1 pack of 100	$7.81
22	Pitsco Straws	2 per student	1 pack of 120	$7.99
23	Rocket Launcher	1 per class	1 launcher	$3.98
24	Rubberbands	50 per class	1 pack	$8.67
25	Solar Panels (2V)	1 per class to share or 1 per team	1	$5.95
26	Spoons	50 per 24 students	50 spoons	$12.98
27	UV Beads	10 per student	1 pack of 500	$6.99
28	Yarn	1 roll per class	1 roll	$3.44
29	Ziplock Bag (sandwich)	1 per student	24	$3.98

Launchpad Overview

Vivify STEM (www.vivifystem.com) presents Launchpad, an afterschool STEM (Science, Technology, Engineering, and Math) enrichment program that *launches* students into the world of STEM! Activities focus on **Stage 1 and 2 STEM** activities. Learn more about the stages of STEM at: http://bit.ly/stemstages.

Students will engage in hands-on activities that integrate standards-based science concepts with the engineering design process. Each week will focus on a different topic related to STEM such as robotics, space, and chemistry and include a real-world career connection to inspire an interest in STEM!

Launchpad activities include

- Standards-based, hands-on engineering challenges
- Instructor guide and student handouts
- STEM career and real-world connections
- 21st Century skills such as collaboration and critical thinking

Launchpad Outcomes

The main goal of Launchpad is to connect academic subjects to a real-world problem through engaging, hands-on learning. The curriculum is not meant to replace math and science courses. Instead, Launchpad reinforces concepts taught in the classroom and provides an opportunity to practice skills. Below are additional outcomes for a STEM academic and enrichment program.

1. Increase academic confidence
2. Increase awareness of STEM careers
3. Increase interest in STEM careers
4. Increase persistence in STEM pathways

Launchpad Philosophy

- The main goal is to get students excited about science and engineering! Show them it can be fun through engaging hands-on demonstrations and activities.
- STEM activities have endless math and science extensions, and it can get overwhelming to try to cover everything. Do what is comfortable to you and your prior knowledge. Remember the overall goal of each week and use the activity guides to support you.
- Allow students to drive the group. Do they really like reflection? Do they really like building? Spend more time on what they enjoy.
- Ultimate rule: Make this a FUN experience. Students should leave loving STEM. Students should NOT be feeling intimidated, bored, or overwhelmed.
- Remember to use the word “STEM” often to help create a positive association with this term.
- Encourage students to “fail forward”. If one of their designs do not work the first time, this is not a stopping point, but a beginning point for a design.

Launchpad Mission Activities

Launchpad activities on the following pages are adaptable for grades 6 - 8. Differentiation for student level is provided throughout the teacher guide and student handouts.

Session Length

Launchpad is typically run as a daily or weekly program through sessions of 45 minutes to 90 minutes. However, missions that utilize the engineering design process may require longer to fully complete the design, test, and reflection phases. For these activities, plan for a 1.5 hour session or spending 2 session to complete the challenge. The engineering design process is discussed further in the next section along with guidelines on extending these missions even further.

Session Recommendations

- Have a clear transition to start the group. For afterschool, allow 15 minutes for snacks and socializing.
- Start the sessions with a hook to capture student interest. Video links are provided that are exciting ways to introduce the content and provide a real-world connection. Handouts also include a Mission Warm-up that can be used as students walk into the classroom.
- Do not release students until work area is clean.
- Try to spend a minimum of 5 minutes on reflection time. Wrap up the meeting with the message from Astronaut Alex and allow students to reflect on their work.

Weekly Prep

- ❑ Review Mission Overview, activity guide, and student handouts.
- ❑ Gather activity materials.
- ❑ Gather student handouts and pencils.
- ❑ Prepare laptop, speakers, and projector for videos.

Typical Launchpad Session: Shorter sessions will cut the engage and reflection times.

1. **Engage:** 15 minutes
   - Launchpad Oath
   - Play video related to mission
   - Read the message from Astronaut Alex.
   - STEM Connection Journal Prompt (coloring, drawing, or writing activity)

2. **Activity:** 60 minutes
   - Review activity instructions
   - Complete challenge individually or in teams

3. **Reflection:** 15 minutes
   - Clean-up
   - Read message from Astronaut Alex and group reflection.
   - Play video related to mission.
   - Receive mission sticker.

Engineering Design Process

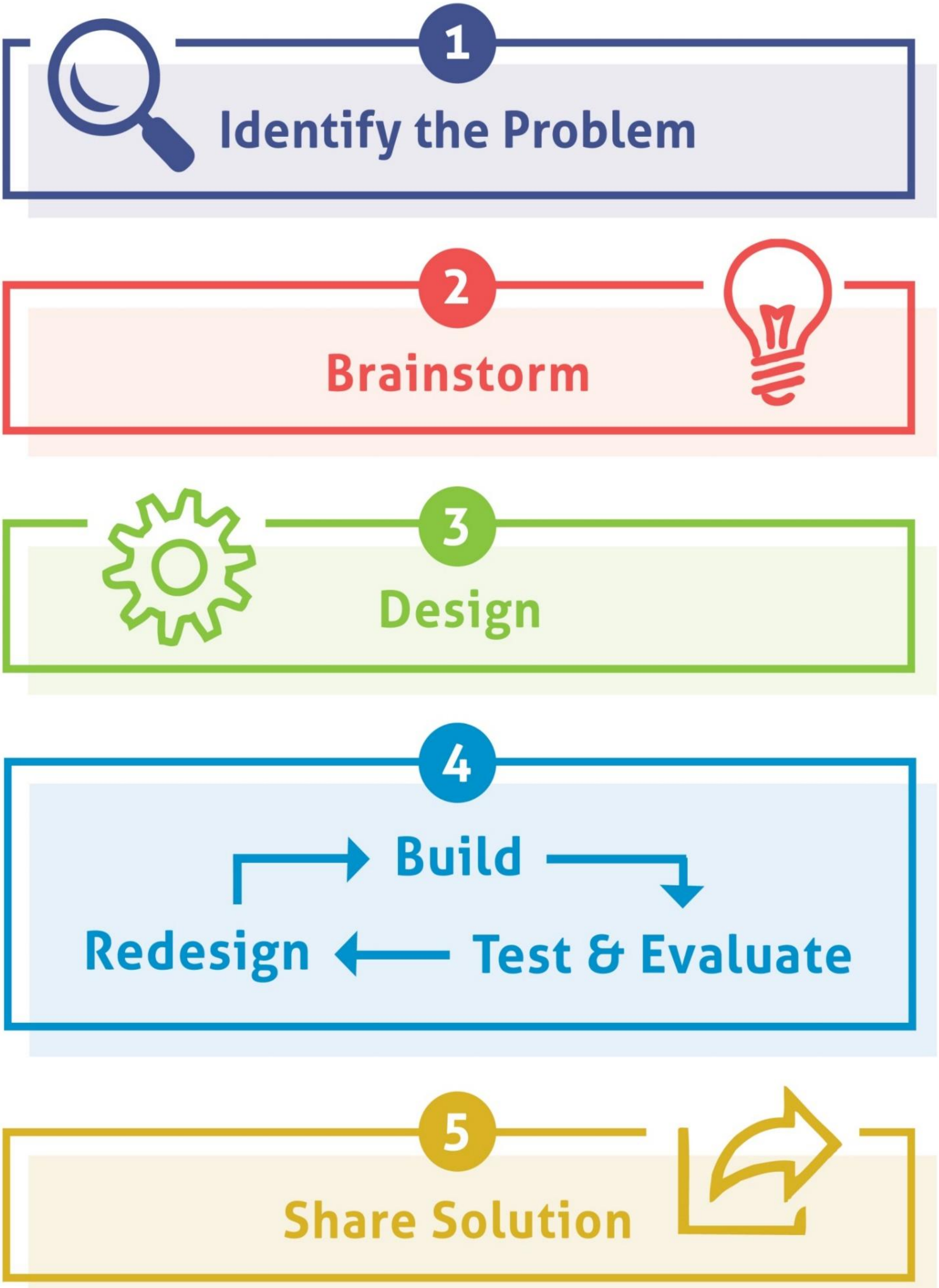
What is the engineering design process?

In STEM learning, students apply math and science concepts to solve an engineering problem using technology. Students tackle these problems with the engineering design process which helps them brainstorm, develop a design, test, and redesign for an optimal solution. However, the engineering design process should not be confused with the commonly used scientific method. The table below describes the differences between science and engineering. We recommend that instructors fully understand these differences and emphasize during the program.

	Science	Engineering
Goal	Seek to understand the world around us	Solve problems to make our lives easier, healthier, and more fun
Method to Reach Goal	***Scientific Method:*** Conduct experiments to collect data	***Engineering Design Process:*** Apply knowledge to solve a problem
Example Activity	Students discover what happens when Mentos are placed into Diet Coke. Students hypothesize that adding more Mentos will increase the height of the Diet Coke geyser.	Students are challenged to build a device to launch a ball to knock over a tower. Students must use the stored elastic potential energy of rubber bands to build a catapult to launch the ball. Through continual testing and re-design they optimize their product until successful.
Related STEM Careers	Biology, Physics, Astronomy, Chemistry	Biomedical Engineering Mechanical Engineering Aerospace Engineering

For Stage 2 STEM, students apply math and science concepts to problems using the engineering design process. This process can be visualized with the diagram on the next page. Instead of immediately building, students are systematically guided through a process of brainstorming, designing, building, testing, re-designing, and sharing their solutions. For example, in the catapult challenge, students apply knowledge of elastic potential energy to design a catapult device to either hit a target or maximize distance. During the testing phase, students analyze catapult designs to re-design and improve their results. This process enhances student critical thinking skills while integrating math and science skills into an engaging hands-on engineering project. Real-world connections further enhance the activity.

Engineering Design Process



Mission 1

Meet the Crew

Mission: Meet the Crew

1

Mission Overview

Objective: Introduce Launchpad and build student relationships.

Mission to Moon: Meet the crew

STEM Career: Astronaut, STEM

Theme: Teamwork
Activities center around how astronauts need to work together as a team to accomplish the mission. Everyone must participate to succeed!

Activities:

1. Pass out Launchpad student folders. We recommend using folders with brads or a binder. Mission 1 handout includes a Launchpad cover page (large circle on the page). This can be taped to the front of the folder.

2. (Handout pg 1) Review the Launchpad Oath on the front cover. Talk about classroom rules, and ask students to write these rules on the front cover. Examples include: cleaning up, talking with inside voices, being kind, etc.

3. (Handout page 2) Introduce Launchpad by reading the message from Astronaut Alex. We recommend showing: We are NASA (3 min) and NASA Astronaut Welcome Class of 2017 (3:20)

    - We recommend checking out this NASA playlist for the latest Mission to Moon videos.

4. (Handout page 2) Complete the "Mission Warm-up" box. In the future, this can be completed as students walk into the classroom.

5. (Handout page 3 - Team Challenge) Complete ***Helium Stick Activity***. Ask students to complete the "Mission Log" box about teamwork. A great video extension is: NASA Mission Control (14:00)

6. (Handout page 4) Complete the "Spark Quiz." Sparks are something you are passionate about, makes you excited, and is unique to you! We recommend instructors sharing their personal sparks with students. Learn more about sparks from the Search Institute.

7. (Handout page 5) Complete ***Sparks Mission Patch***. Students will create their personal mission patch on the Launchpad cover page. Watch: Our World: Mission Patches (5:22)

8. *Optional:* On a Launchpad group poster, add each student name and spark. This can be displayed throughout the Launchpad sessions. Create a class name or mascot to add to the poster.

9. (Handout page 5) Reflect with "Mission Reflection" and Alex message. Each week, NASA releases a "This Week @NASA" video that you can show. Some can be very technical so you may want to watch ahead of time. But they will give you the latest current events on space travel!

Short on time?
Break this intro mission into 2 sessions.
- Session 1: Complete the team challenge and spark quiz
- Session 2: Review sparks and complete mission patch

Activity: Helium Stick

1

Learn how to communicate and work in a team.

Group Size: 3 - 4 students

Prior to Activity

1. Gather materials listed.
2. Build a long stick with straws and tape using at least 1 straw per student in the group.

Materials Per Group
❑ Straight straws (1 per person) ❑ Clear tape

Activity Instructions

1. Students form 2 lines facing each other.
2. Everyone holds arms out and points index fingers.
3. Lay straw stick across everyone's fingers. Adjust finger heights until stick is horizontal and everyone's fingers are touching the stick.

The challenge: Lower the stick to the ground! Rules include:

- Everyone's fingers must be in contact with the stick AT ALL TIMES. Must restart from the beginning if someone loses contact.
- No pinching or grabbing the stick

4. You will notice that instead of the stick going down, it will "magically" start to move upward! And of course the stick does not contain helium. The secret is that the collective upward pressure created by everyone's fingers tends to be greater than the weight of the stick. As a result, the more a group tries, the more the stick tends to 'float' upwards

Activity: Sparks Mission Patch

1

Students create their own personal mission patch.

Group Size: Individual

Materials	
❑	Launchpad Cover page or copy paper
❑	Pencil
❑	Colored pencils / Markers

Activity Instructions

1. A spark is something you are passionate about, makes you excited, and is unique to you! Sparks can be something you like to do or an interest you have. Sparks are a great way to build relationships with students and help them feel connected to Launchpad.

2. Ask students to think about their interests. Use the student handouts to brainstorm ideas and narrow down to one spark. You may need to help students get beyond the silly phase and select something they are actually passionate about.

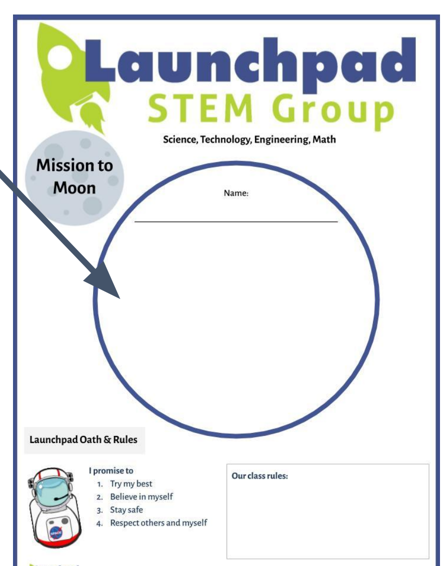
3. Once every student has a selected spark, time to create a personal mission patch! The purpose is to have a way to display their spark and keep it as a reminder during Launchpad. Teachers should also use this spark as a way to get to know students and connect lessons to personal interests.

4. Students will use the Launchpad cover page to create their mission patch.

5. The mission patch should include: student name, name of spark (i.e. “football”), and decoration to represent that spark. Students that don’t like to draw can be provided stickers, magazines, or other materials to add to their mission patch. You can also have students create digital artwork to print and add to their mission patch.

Create mission patch here.

For the Space Colony Competition, each team has an astronaut mascot who wears the mission patches!



Mission 2

Astronaut Training

Mission: Astronaut Training

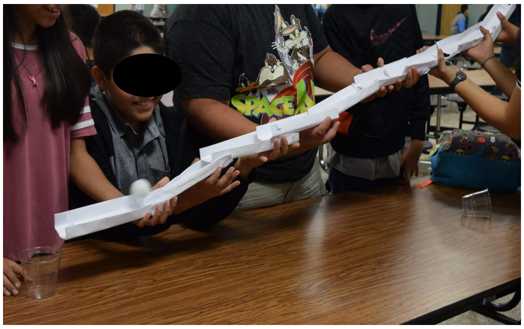
2

Mission Overview

Objective: Learn about the Moon and how to work as a team.

Mission to Moon: Astronaut Training

STEM Career: Astronomer, Scientist



Theme: Communication
Ideas only come to life if you can clearly communicate them! As a team, you must be able to communicate effectively to work together and complete the mission.

Activities:

1. (Handout page 6) Read the message from Astronaut Alex and complete the "Mission Warm-up." We recommend showing: Apollo 11: Landing on the Moon (2:30 min) and We are Going (3:50 min)

2. Discuss scientist. Show I am a Scientist (2 min). Discuss astronomer and show Size of Stars (3 min)

3. Test the students knowledge of the Moon by completing the ***Moon-Earth Game***.

4. (Handout page 7) Show Living on the Moon (3 min) and if more time: Moon Crash Course (10 min) Work as a group to complete the two tables to think about the challenges of living on the Moon. Answer key on the next page.

5. (Handout page 8) Complete the mental challenges in "Astronaut Mental Training." They can also be completed individually at a later time. Explain that astronauts have to do similar mental training to test their skills during the astronaut selection process. Just like a weightlifter needs to workout to gain more strength, we need to challenge our brains to get better at problem solving.This page also includes information on the astronaut space suit. You can show: NASA #SuitUp Video (1 min)

6. (Handout page 9) Complete ***Pipeline Challenge***. Focus on teamwork and communication skills. There is also an additional maze activity related to moving supplies to the launchpad.

7. (Handout page 9) Reflect with "Mission Reflection" and Alex message. You can show: We Go Together (2:50 min)

Short on time?
Break this mission into 2 sessions.

- Session 1: Moon-Earth Game
- Session 2: Mental Training Activities and Pipeline Challenge

2

Science Background Answer Key

Handout page 7

Moon Facts	
Temperature Range	**-280℉ (173℃) to 260℉ (127℃)** *Temperature extremes on Earth: -96℉ (-71℃) to 134℉ (56℃)*
Length of Day	**29.5 Earth Days** The length of day is defined as how long it takes the Sun to move all the way across the sky and return to its original position again. *Earth day = 24 hours*
Atmosphere	**Extremely thin.** The Moon's atmosphere is so thin that it is almost the same as being in the vacuum of outer space with no pressure. Humans must wear a pressurized space suit to survive on the surface. The atmosphere provides no protection from radiation or asteroids.
Gravity compared to Earth	**17% or about ⅙ of Earth's gravity** Anything that has mass also has gravity. Objects with more mass have more gravity. Since the Moon has less mass than Earth, you will experience less of a gravitational pull on the Moon. You can jump 6 times higher on the Moon! But gravity still exists on the Moon so nothing is floating away.

	How do we get this on Earth?	What challenges will we have on the Moon? *Includes possible solutions for discussion.*
Oxygen	Our atmosphere contains oxygen. Plants produce oxygen during photosynthesis	There is no oxygen and the very thin atmosphere and lack of nutrient rich soil prohibit plant growth. You will need to find ways to create or bring oxygen to breathe.
Water	Plentiful bodies of water. 71% of the Earth is covered in water.	No evidence of liquid water. Liquid water can not remain on the surface of the Moon due to the thin atmosphere and extreme temperatures. You will need to find ways to create or bring water. Scientists have found evidence of ice deposits.
Food	A wide variety of agriculture and livestock	Plants and animals can not survive in the lunar environment. How will your grow or bring food to survive? What food is most important?
Power	Fossil fuels and renewable energy sources (sun, wind, water) are turned into electricity	We need to find resources to create power. What renewable resources exist on the Moon?
Communication	Phones and internet are available because of satellites, communication towers, and cables.	Construction of satellites, towers, cables will be expensive and have to withstand the harsh environment.

Astronaut Mental Training Answer Key

Handout page 8

The answers to the mental challenges are as follows:

1. (a) 43 hours. Divide distance by speed to get the time.
2. (87) Turn the page upside down to see the numbers ordered from (87) to 91. There is no “up” in space! There are currently 4,987 satellites orbiting the Earth right now (as of 2019)
3. (b) The pattern mirrors adjacent shapes but in the opposite color.

More puzzles like these can be found in Astronaut Tim Peake’s book, *The Astronaut Selection Test Book: Do You Have What it Takes?*

Activity: Earth-Moon Corners Game

2

Students will discover information about the Moon through a comparison game with Earth facts by moving around the classroom to different signs.

Group Size: Class

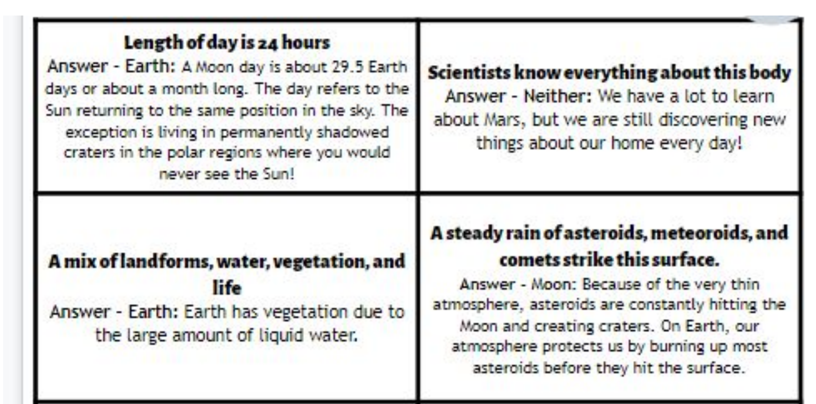
Materials
❑ Tape ❑ Moon - Earth Facts ❑ Moon -Earth Signs

Prior to Activity

1. Print and cut out the Earth - Moon signs. You need 4 signs that read: Moon, Earth, Neither, Both. Tape one to each corner in the room.
2. Read over the Moon-Earth facts.

Activity Instructions

1. Gather students into the center of the room.
2. Read the first fact. Students will decide on the answer by moving to the corner that they think is correct. For example, “Length of day is 24 hours.” Students move to either the Moon, Earth, Neigher, or Both sign.
3. Read the correct answer and discuss.
4. If you get questions you are unable to answer, write them down! This is a great opportunity to continue the learning through researching the answers. You can reference these facts later in the missions.



Length of day is 24 hours Answer - Earth: A Moon day is about 29.5 Earth days or about a month long. The day refers to the Sun returning to the same position in the sky. The exception is living in permanently shadowed craters in the polar regions where you would never see the Sun!	**Scientists know everything about this body** Answer - Neither: We have a lot to learn about Mars, but we are still discovering new things about our home every day!
A mix of landforms, water, vegetation, and life Answer - Earth: Earth has vegetation due to the large amount of liquid water.	**A steady rain of asteroids, meteoroids, and comets strike this surface.** Answer - Moon: Because of the very thin atmosphere, asteroids are constantly hitting the Moon and creating craters. On Earth, our atmosphere protects us by burning up most asteroids before they hit the surface.

Activity: Moon-Earth Corners Game

2

Length of day is 24 hours **Answer - Earth:** A Moon day is about 29.5 Earth days or about a month long. The day refers to the Sun returning to the same position in the sky. The exception is living in permanently shadowed craters in the polar regions where you would never see the Sun!	**Scientists know everything about this body** **Answer - Neither:** We have a lot to learn about the Moon, but we are still discovering new things about our home every day!
A mix of landforms, water, vegetation, and life **Answer - Earth:** Earth has vegetation due to the large amount of liquid water.	**A steady rain of asteroids, meteoroids, and comets strike this surface.** **Answer - Moon:** Because of the very thin atmosphere, asteroids are constantly hitting the Moon and creating craters. On Earth, our atmosphere protects us by burning up most asteroids before they hit the surface.
Tallest mountain in the solar system **Answer - Neither:** Mars actually has the tallest mountain at 33,000 ft (3 times higher than Mt Everest). Lower gravity allows for higher mountains so the mountain on the Moon are taller than Earth.	**Water exists on this body** **Answer - Both:** Until 2008, we thought the Moon was dry. Recent discoveries have found ice water in permanently shadowed regions of the lunar poles. So water exists on the Moon!
So cold you will die if standing outside for too long. **Answer - Moon:** The Moon is cold! When in darkness, the Moon is about -280 degrees Fahrenheit (-173 degrees Celsius).	**This body has robots** **Answer - Both:** More than 105 robotic spacecraft have been launched to explore the Moon. And there are lots of robots on Earth!
Hurricanes, typhoons, and tornadoes **Answer - Earth:** Not only does the atmosphere regulate temperature, it also produces weather as we know it! The Moon has a very thin atmosphere.	**This body is almost entirely covered in charcoal-gray, powdery dust and rocks.** **Answer - Moon:** This is called lunar regolith and has the consistency of powdered glass with jagged edges that clings to everything. It can cause health issues and clog buttons and hydraulic systems of spacecraft.

https://solarsystem.nasa.gov/moons/earths-moon/in-depth/#overview_otp
https://www.universetoday.com/20524/how-long-is-a-day-on-the-moon-1/

Atmosphere provides protection from radiation **Answer - Earth:** The Moon has a very thin atmosphere that provides no protection. Earth's atmosphere protects us from most of the sun's harmful radiation, regulates temperature, and contains oxygen for humans to breathe.	**This body has living things.** **Answer - Earth:** In over 100 missions, humans have found no evidence of life on the Moon. However, the Moon could be the site of future colonization by humans. The Moon harbors water ice
This body is closer to the Sun. **Answer - Neither:** The Moon orbits the Earth as the Earth orbits the Sun, so part of the day the Moon is closer to the Sun than the Earth.	**Found in the Milky Way galaxy** **Answer - Both:** Both bodies are in the Milky Way Galaxy.
You would float away if standing on this body. **Answer - Neither:** Both bodies have gravity so no floating away! The Moon has 1/6 the gravity on Earth. A 100 lb person would weigh about 16 lbs on the Moon. You would bounce around everywhere!	**You would suffocate on this body.** **Answer - Moon:** Humans need oxygen to breathe. The thin atmosphere on the Moon provides no oxygen. You would pass out quickly without oxygen and die soon after.
Humans have visited or currently live here. **Answer - Both:** The Earth's Moon is the only place beyond Earth where humans have set food. 24 humans have visited the Moon and 12 have walked the surface. The last visitor was in 1972.	**Low atmospheric pressure will cause your blood to boil on this body.** **Answer - Moon:** The Moon's atmosphere is so thin that it is almost the same as being in the vacuum of outer space with no pressure. The low pressure drops the boiling point of blood causing it to boil, vaporize, and kill you.
This body is so hot you may be instantly mummified. **Answer - Moon:** The Moon gets very hot! When in full sun, the Moon is about 260 degrees Fahrenheit (127 degrees Celsius).	**This body is bigger.** **Answer - Earth:** The Moon is about a third of the width of the Earth.


Moon

Neither

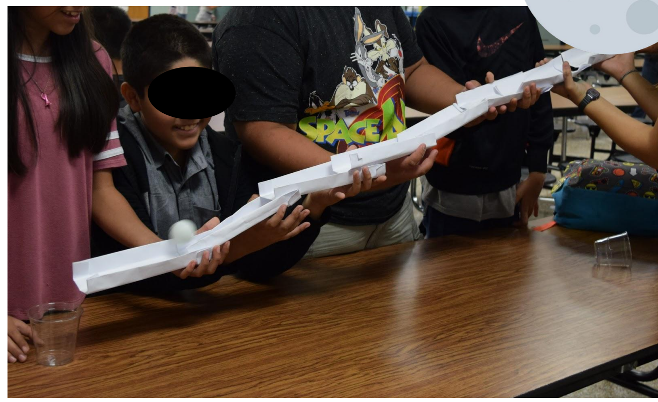
Both

Activity: Pipeline Challenge

2

Student groups work to move a ball by creating a track as a team.

Group Size: 4 - 8 students



Prior to Activity

1. Collect materials.
2. FInd a large open space for activity.

Materials
❑ 1 page of copy paper per person
❑ 1 cup per team (9 oz recommended)
❑ 1 ping pong ball per team

Activity Instructions

1. Put students in teams of 4 - 8 students. The larger the groups the more challenging the activity.
2. Provide each team with materials listed. Make sure each person has a piece of paper.
3. Have students form a line. The person at one end of the line has the cup. Place the cup on the ground (or a table). The person at the opposite end has the ball.
4. The goal is to have the ball land in the cup without touching the ball once in motion. The paper is to be used as the track. The ball must remain in motion at all times. If the ball stops or falls off the track, start over! The ball must land inside the cup at the end of the track.
5. Once the team accomplishes the task, move the cup farther way. You can even move it across the room! Now the team will realize that they have to do a relay race. Once the ball leaves the first person's track, that person must run to the end of the line ready to catch the ball and keep it moving!
6. Hint: Start with smaller groups for younger students, but we recommend no less than 4. Older students can even go up to 10+ students! Can you get the whole class to work together? You can also make this a competition or race between teams.

Mission 3
Getting to the Moon

Mission: Get to Moon

3

Mission Overview

Objective: Learn the engineering design process to design, build, and test a straw rocket.

Mission to Moon: Build a rocket to get to the Moon.

STEM Career: Engineer, Aerospace Engineer

Theme: Critical Thinking
Students have the tendency to jump right into a project without thinking through the best approach. Help them consider the different variables involved in a straw rocket instead of randomly building and testing through trial and error.

Activities:

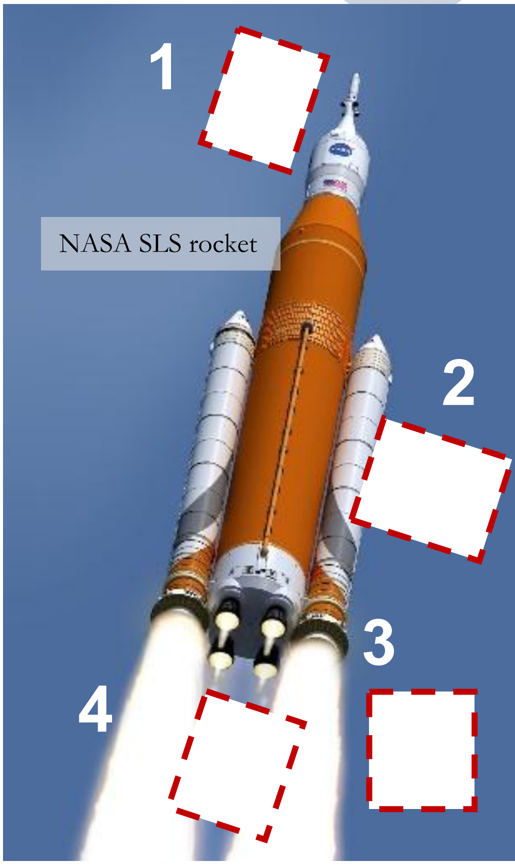
1. (Handout page 10) Read the message from Astronaut Alex and complete the "Mission Warm-up." Watch Go Forward to the Moon (1:30 min). Complete Mission Warm-up.
2. (Handout page 10) Discuss aerospace engineering and the NASA News on the SLS rocket. Show: The Most Powerful Rocket Ever Built (2.5 min) and What's an Engineer (4.5 min).
3. (Handout page 11) Show students the rocket launcher and how to launch a rocket. Complete the science background page on the forces of a rocket. Answer key is provided on next page.
4. (Handout page 12) Complete ***Straw Rocket Challenge***. For "Mission Background," students think about the different variables involved. Answer key provided on next page. Refer to these variables in helping students redesign their rocket. For "Brainstorming," have students draw an initial design and write down each of the rocket parts. This is a starting point to think about which variable to change. They should only change one variable at a time.
5. (Handout page 13) "Build and test" helps guide students in using different angles to maximize distance. Students should keep redesigning and testing to get the farthest distance.
6. Reflect with "Mission Reflection" and Alex message. You can show: Advancing the cause for humanity (3:30 min) or Lift off of Artemis 1 (3 min).

Mission: Get to Moon

3

Mission Overview

Forces of Flight: Fill in the blanks with the name of each force acting on the rocket. Draw an arrow in the box showing the direction of the force.



Force 1: _____drag_____ force is slowing the rocket down because of the friction from the air.

Force 2: ____lift______ force is determined by the shape of the body and fins to stabilize and control direction of flight.

Force 3: ____gravity_____ is a constant force pulling objects towards Earth.

Force 4: ___thrust____ force is created through a chemical reaction that expels gases and pushes rocket upward.

Mission Background: Variables are things you change in an experiment such as the number of fins on the rocket. List all the variables you can change on the rocket.

Possible variables include: number, shape, and position of fins, length of body tube (straw), size and shape of nose cone, angle of launcher, thrust from launcher

Activity: Straw Rockets

3

Students will build and launch straw rockets to travel the farthest distance.

Group Size: Individually

Prior to Activity

1. Gather materials listed.
2. Build an example straw rocket using instructions on next page.
3. **Set-up testing station.** Place rocket launchers at the end of a long hallway. Create a starting line for testing. Use a measuring tape (100 ft) or markers at every 10 feet to determine distance. With markers, students can measure distance to the closest foot.
4. Test your rocket first to determine best launch angle and column height.

Materials Per Student
❑ 1 Straw ❑ 1 Index cards ❑ 1/2 inch modeling clay ❑ Masking Tape ❑ Scissors ❑ Pencils
Testing Station Materials
❑ Pitsco Straw Rocket Launcher ❑ Measuring tape for distance ❑ Markers for distance

Activity Instructions

1. Demonstrate how to build and launch a straw rocket. You can also build 2 rockets with different fins or nose cone size to demonstrate the change in distance.
2. Challenge the students to build a rocket to travel the farthest distance. Keep the launcher at a set column height (this controls the amount of power or thrust on the rocket).
3. How can students change the variables on their straw rocket (like number of fins) to change the distance traveled? *Students will become competitive!*

How to Build a Rocket

1. Draw the chosen fin shape on an index card. The most *aerodynamic* fins (have the least drag or air resistance) are triangles, but students are allowed to experiment. Students should also think about symmetry to keep their rocket straight. Folding a card in half allows for two identical fins.
2. Cut a piece of tape as long as the edge of the fin. Attach the fins so they are evenly spaced around the straw. Trim off any excess tape using the scissors. Make sure the tape does not block the straw opening.
3. Carefully shape the clay to match the desired nose cone shape. The surface of the nose cone needs to be smooth. Press the nose cone on top of the straw rocket body. The outside edge between the straw and nose cone should be sealed carefully with the clay.
4. Launch the straw rocket using the Pitsco Straw Rocket Launcher by lifting the rod (light green column with numbers) and releasing. Do not slam down launcher.

Building Tips

- Amount of modeling clay does not need to be exact. Students can request more if needed. However, less is better for farther distance.
- Make sure the tape does not cover the straw opening
- To launch the rocket, pull up the bar and release. Do not force it down.

Extension Activities

Activity 1: Optimize Launch Angle

1. Build a straw rocket.
2. Launch straw rocket at multiple angles and measure the distance traveled.
3. Graph the results. Which angle resulted in the farthest distance?
4. Repeat with a different straw rocket to determine if optimal angle is different for each rocket design.

Activity 2: Optimize Rocket Design

Optimize your rocket design by systematically testing one variable at a time.

5. **Select rocket variable.** Ex: straw length, number of fins, nose cone mass, angle of launcher
6. **Determine hypothesis.** For each variable, predict how it will affect distance. Ex: a heavier rocket will fly farther.
7. **Build 4 – 6 straw rockets to test this variable.** Or build one rocket, test, and then change the variable. Keep all other variables the same.
8. **Test each rocket under identical conditions including launch angle and height.** Think about how you will measure farthest distance. Will it be landing spot or stopping spot (after gliding)? Record results in the table.
9. **Graph testing results.**
10. **Repeat for another variable.**
11. **Complete reflection questions.**

Mission 4
Welcome Tower

Mission Overview

Objective: Use the engineering design process to design a tower and learn about solar energy.

Mission to Moon: Construct a welcome sign for your Lunar base powered by the sun.

STEM Career: Mechanical Engineer

Theme: Initiative
Have confidence in your abilities! Challenge focuses on having confidence to apply effort to the activities immediately without waiting on others to start for them or provide hints.

Activities:

1. (Handout page 14) As students enter the room, they may begin working on the "Mission Warm-up" box. Review the Launchpad Oath as a class.
2. (Handout page 14) Introduce the mission by reading the message from Astronaut Alex. Discuss "Mechanical Engineers." Watch Mechanical Engineer (5 min)
3. (Handout page 14) Discuss "NASA News" on the lunar Gateway. Show: Space after the space station: The Lunar Gateway and beyond (3 min)
4. (Handout page 15) Have students read over the "Science Background" discussing the various ways to power a lunar base. Have students discuss the pros and cons for each energy source. Show: Will we ever live on the Moon? (3 min) Consider showing Nuclear Power (3 min) or STEMonstrations:Solar Energy (2 min)
5. (Handout page 16) Complete the ***Welcome Tower Challenge*** using the instructions on the following pages.
6. (Handout page 17) Complete the testing phase of the Tower Challenge outside on a sunny day. If students are unsuccessful at meeting the design constraints, they must redesign, rebuild, and retest. Follow the activity by completing the "Solar Tower Math" problems.
7. (Handout page 17) Reflect with "Mission Reflection" and Alex message. Watch What if we covered the Moon in solar panels? (3:30 min)

Science Background Answer Key

Solar Panel

How does it work? Converts sunlight into electricity

- ☐ A night on the Moon is about 14 days long - a real challenge to using solar energy
- Moon's polar sites have longer periods of sunlight
- Environmentally friendly
- You can build multiple solar panels so one is always in daylight
- Moon has "peaks of eternal light" or places that almost always see sunlight.
- You can place solar panels in orbit and beam the power down as microwave rays

Nuclear Power

How does it work? Harness the energy from splitting atoms to generate electricity.

- Fission system is compact, reliable, safe system
- Does not rely on sunlight
- ☐ Technology is still under development
- ☐ Need specialized skills to fix
- ☐ Nuclear accident is possible

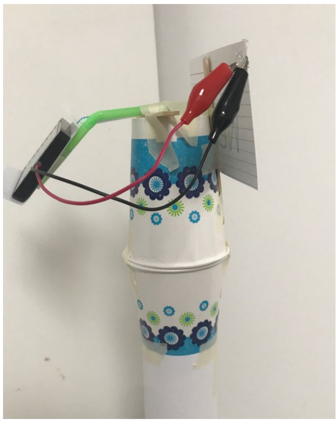
Fuel Cell

How does it work? Combines hydrogen from a tank and oxygen from the air to produce electricity, leaving water and heat as its only byproducts.

- Hydrogen needed could be sourced locally using the Moon's polar water and surplus solar power.
- Lightweight
- ☐ Technology is still under development
- ☐ Lower power output so ideal as a backup power source

Mission Background Answer Key

Question: Mission Background: To maximize the sunlight, your solar panel needs to rotate to face the sun as it moves across the sky. Ask students to think about how to use the materials to allow for maximum rotation. The example pictured used bendy straws to create two angles.



Activity: Welcome Tower

4

Students will build a welcome tower powered by a solar panel!

Group Size: Partners or teams of 3

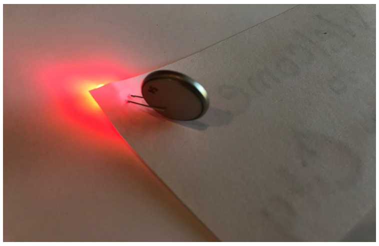
Materials Per Team	Testing Materials
❑ 3 5oz paper cups ❑ 4 craft sticks ❑ 2 sheets of paper ❑ 5 Index cards (1 = welcome signs) ❑ 1 small paper plate ❑ 3 bendy straws ❑ Masking Tape ❑ Markers	❑ Ruler ❑ 2V, 200mA Solar panel ❑ 2V, 5mm LED light ❑ Coin cell battery (save for Mission 8)

Prior to Activity

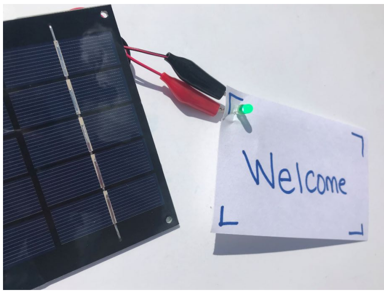
1. Gather materials listed.
2. Test that LEDs and solar panels work by connecting the panels to the LEDs and taking them outside in direct sunlight. Short prong connects to black alligator clip; long prong connects to red alligator clip.

Activity Instructions

1. **Mission**: Build a structure to hold a welcome sign powered by solar energy.
2. **Create Welcome Sign:** As a team, students will first create a welcome sign team using an index card. They will need to come up with a name of their lunar base to add to the sign.
3. **Light up Welcome Sign:** Show students how to attach an LED light to the card by poking through a corner. Show students how you can use a battery to light up the LED light (place an LED leg on either side of the battery - if nothing happens, switch around the battery).
4. **Explain Solar Panel:** Instead of using a battery, we will use a clean, renewable source of energy: the sun! Show students the solar panel and how it attaches to the LED light. The light won't turn on until you are in direct sunlight.
5. **Explain Tower Challenge:** Challenge the students to build a device to support both their welcome sign and solar panel at least 1 foot (30 cm) in the air. The solar panel needs a clear view of the sun to work properly. For an advanced challenge, ask students to build a holder for the solar panel that rotates or tilts to follow the sun. Design constraints:
    a. Base is a paper plate.
    b. Solar panel and welcome sign must be at least 1 foot (30 cm) in the air.
    c. Solar panel must have full exposure to the sun (no blocking by the sign).
    d. Solar panel can not be taped or permanently connected to the structure.
    e. *Advanced*: Solar panel must be able to tilt to follow the Sun.



A battery or solar panel can be used to light up the LED. Make sure to keep the batteries for Mission 8.



5. Instruct students to follow the engineering design process to brainstorm, design, and build their towers. Remind students that the towers need to be movable (so you can go outside), and the plate is a good base for transporting the towers.

6. The solar panel is likely going to be shared among teams so each team may need to first build the tower without the solar panel. When ready, they can come to the testing area to add the solar panel and determine if modifications are needed. The solar panel will change the center of gravity of the tower and may cause it to fall over. Students will likely need to re-design to provide additional supports.

7. **Testing:** Take students outside on a sunny day to test. If no sunlight, test indoors (light will not turn on). Add the solar panel to the tower. Demonstrate how to properly connect the solar panel to the LED by attaching the black alligator clip to the short leg and the red alligator clip to the long leg on the LED.

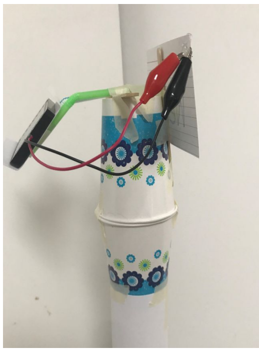
    a. Does the tower stay upright?

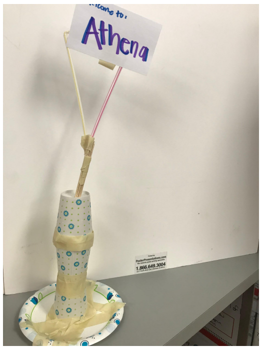
    b. Does the light turn on?

    c. Are the solar panel and sign at least 1 foot off the ground?

    d. Bonus: can the solar panel rotate or face more than one angle?

8. If a student does not successfully pass the tests, they must redesign, rebuild, and retest after writing down how they can make improvements. Note: if student teams are struggling with the solar panel, then have them focus on just holding it up at one angle. Or, you can remove the solar panel completely. Instead, modify the challenge to focus on just holding the welcome sign. Who can raise it up the highest using the provided materials?





If students are struggling with the solar panel, you can have them build the tallest tower to hold the welcome sign.

Mission 5

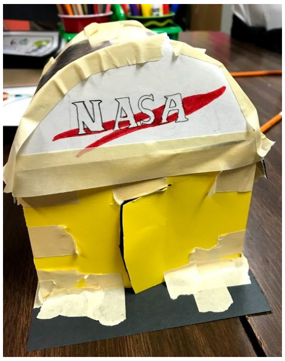
Build a Base

Mission Overview

Objective: Students will apply the scientific method to test which materials block ultraviolet (UV) rays. Students will use the engineering design process to design, build, and test a shelter.

Mission to Moon: Construct a base to protect astronauts from harmful radiation and asteroid impacts.

STEM Career: Material Scientist

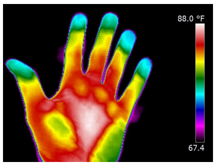


Theme: Problem Solving
Activities center around how astronauts need carefully work through the constraints and challenges to solve the overall problem.

Activities:

1. (Handout page 18) As students enter the room, they may begin working on the "Mission Warm-up" box. Review the Launchpad Oath as a class.
2. (Handout page 18) Introduce Launchpad by reading the message from Astronaut Alex. We recommend showing: Why Can't We Live on the Moon (3:50)
3. (Handout page 18) Discuss "Materials Scientists" and "NASA News. Show 3D Printed Moon Base (1 min) or 3D-printing a lunar base (5 min)
4. (Handout page 19) Complete the science background on different types of radiation. An answer key is provided on the following instructions pages. The bottom half of the handout gives an overview of how craters are formed.
5. (Handout page 19) Complete the ***Safety Shelter Challenge*** using the instructions on the following pages. The "Mission Background" section includes a chart to conduct a science experiment on which materials block UV rays.
6. (Handout page 20) Complete the testing phase of the Safety Shelter Challenge outside on a sunny day or using blacklight indoors. Follow the activity by completing the "Shelter Math" problems.
7. (Handout page 21) Reflect with "Mission Reflection" and Alex message. Show: We Could Live in Caves on the Moon (2:30 min)

Science Background Answer Key

Type of Radiation	Description	Examples	Is it harmful?
Infrared 	Causes molecules it touches to vibrate and create heat. We can't see it, but we can feel it as heat!	• Heat from the Sun • Heat from a fire • Toaster uses infrared to heat up bread • Used in remotes to turn on the TV	Sometimes
Visible Light 	Human eyes are most sensitive to this radiation. We can see this wavelength as different colors in a rainbow.	All the colors we see with our eyes!	No - we need it to see
Ultraviolet 	Causes sunburns and can damage your skin. The high level of energy can damage human cells and even mutate its genetic code.	• 10% of sunlight • Tanning booths • Black lights	Yes - causes sunburn and damages cells

Activity: Safety Shelter

Students build a shelter to protect an astronaut from harmful ultraviolet (UV) rays and asteroid impacts.

Group Size: Partners

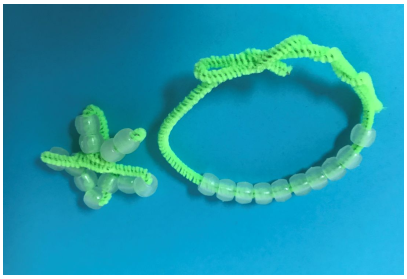
Build Materials
Astronaut Materials (per student): ❑ 10 UV beads ❑ 1 pipecleaner **Shelter materials (per team):** ❑ 10 Index cards ❑ 10 Craft sticks ❑ 6 Bendy straws ❑ 1 Cardstock ❑ 1 Paper plate ❑ 1 Paper bag ❑ Masking tape ❑ Scissors
Testing Station Materials
❑ Sunlight or Black Light ❑ Rocks or simulated rocks such as modeling clay, bouncy balls, or the pinto beans in a ziplock bag (about ⅓ cup)

Prior to Activity

1. Gather materials listed.
2. Build an example astronaut
3. Using paper bag, create kits of testing materials per group.
4. Practice challenge.

Activity Instructions

1. In this activity, students will first build an astronaut individually. Then, they form teams to design a safety shelter to protect their astronauts from UV radiation and asteroids.
2. **Mission**: Build a safety shelter to protect astronauts from UV rays and asteroid impacts. The constraints are as follows:
   a. Must have 4 walls and 1 entrance
   b. Astronauts (1 per team member) stay protected from UV rays (beads remain colorless) after 1 minute.
   c. Asteroids (rocks) must not make a hole or collapse the structure when dropped from 1 foot (30 cm) above the roof.
3. **UV Beads:** Before building, introduce students to the UV beads. Demonstrate the change to the beads when exposed to ultraviolet light (UV). 10% of the sun's rays contain UV light. You can go outside to demonstrate or use the black light.



> UV radiation comes from either direct sunlight or a black light. Before exposure, beads are white (top blue photo). After exposure beads turn different colors (bottom). You can create little astronauts using the instructions that follow or a bracelet. Let students take them home!

Build an Astronaut

Alternative: Create a bracelet with pipecleaner and beads.

1. Gather pipe cleaner and 11 UV beads.

2. Slide 1 bead to middle and fold pipecleaner in half

3. Slide bead onto both sides of pipecleaner

4. Spread pipecleaner apart again and slide 2 beads on each side for arms.

5. Bring pipecleaner ends together and slide on bead onto both of them at once.

6. Split pipecleaner ends again and add 2 beads on each end for legs.

7. Bend pipecleaner ends up and over end leg bead. Then slide through the top leg bead and waist bead. Wrap remaining pipecleaner end around the waist. Do this for both ends of the pipecleaner.

Helpful Tips

- It is helpful to have students see what happens to their astronaut when exposed to the UV before getting into the challenge so they know what to look for in a failure.
- The color on the beads from the UV exposure fades very quickly. It is best to check the astronaut for color immediately after the shelter is exposed to the sun/blacklight. Have a student shade the shelter while you check the astronaut if needed.

4. **UV Experiment (Mission Background Section):** As a class, conduct a scientific experiment to determine which materials block UV rays. Use a UV bead astronaut or a bracelet of beads for this.

   a. For our shelter, we need to select materials that will block UV rays. Not all materials will, so we need to think like a material scientist to test our options.

   b. Start with a piece of cardstock. Ask students to predict if it will block UV rays. Put the UV beads on a table. Cover with the cardstock. Shine a black light on the cardstock for 10 seconds. Remove. Show that beads are colorless, which means they did not receive UV rays.

   c. Test out additional materials. Try sunglasses, transparencies, plastic, and other clear or opaque materials.

5. **Asteroids:** Now that we know the kind of materials needed for UV protection, we also need to think about the asteroid impacts. Our shelter must be <u>strong enough</u> to withstand an impact from the "asteroids". Show the different asteroids that will be used for testing. Examples on next page.

6. **Design & Build:** Have students form teams and brainstorm ideas. Each student should draw their design idea before building. Provide the desired materials to each team and have them complete the challenge.

7. **UV Testing:** After building shelter, go outside to test for protection. Another option is to shine the black light on each wall of the shelter. It takes about 10 seconds of UV exposure to get a rich color from the beads.
   a. Make sure shelter has 4 walls and an entrance. Place astronauts inside.
   b. Exposure shelter to UV rays.
   c. Move shelter away from UV exposure and immediately remove the astronaut to check for exposure (color change). You can also carefully open door to check for exposure. If beads remain colorless, test is a success!
   d. If needed, discuss what needs improvement and redesign structure. Allow beads to return to color-less state.

8. **Asteroid Testing:** Complete this ***after*** UV testing as it will destroy the shelters! We recommend doing this as a competition to see which shelter can withstand the most impact.

   a. Collect rocks of different weights. If you have a scale, weigh the rocks and test with increasing weight. Alternatives to rocks are shown on next page.

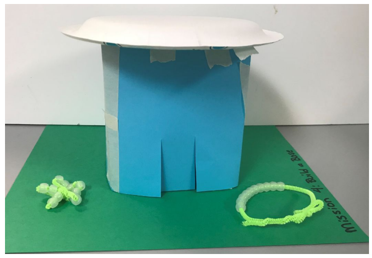
   b. Line up all the shelter designs. Make sure they are far enough apart so that an asteroid doesn't bounce during testing and accidently hit another shelter.

   c. Begin with lightest rock, drop from a set height such as 2 feet or knee height.

   d. The test is successful if no holes are made in the structure and the structure does not collapse. Move on to the next shelter. Drop from the same height using the same rock on each shelter. The shelters the survive the impact move to the next round!

   e. Use a heavier rock or a higher drop height. Observe which shelters were able to withstand the heaviest rocks. Why?

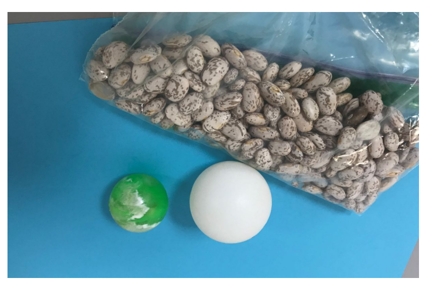
Activity: Safety Shelter



The shape of the roof will affect how well the shelter is protected from the asteroids. For example, a pointy roof may allow the asteroids to "roll off."

Rock testing can occur inside a bin to prevent rocks from hitting students. You can go outside and find rocks of different weights and shapes. Alternatives to rocks are a bouncy ball, modeling clay, or a bag of pinto beans from mission 6.

For rock testing, we recommend doing this as a competition between shelter designs. Which shelter can withstand the most or biggest asteroid impact? Use the same rocks on all the shelters, and keep increasing the size and weight until they are all destroyed!



Mission 6
Staying Alive

Mission Overview

Objective: Use the engineering design process to design a device to grow plants in a hydroponic greenhouse.

Mission to Moon: Build a device to grow plants on the Moon.

STEM Career: Botanist

Theme: Resilience
Activities emphasize the need to persevere through difficulties and be patient when waiting for success and results.

Activities:

1. (Handout page 22) As students enter the room, they may begin working on the "Mission Warm-up" box. Review the Launchpad Oath as a class.
2. (Handout page 22) Introduce lesson by reading the message from Astronaut Alex. Play this scene from the Martian (1 min).
3. (Handout page 22) Discuss "Botanists" including how they are related to biologists, and "NASA News". We recommend showing: How NASA is Learning to Grow Plants in Space and on Other Worlds (6 min)
4. (Handout page 23- Science Background) Complete the science activity and discuss both the different parts of a plant and photosynthesis. An answer key is provided on the following page. Consider showing How does a Seed Become a Plant (3:46 min) to introduce the concept of growing a plant from a seed. Also show Crash Course: Photosynthesis (3 min)
5. (Handout page 24) Complete the ***Hydroponic Plant Device Challenge*** using the instructions on the following page.
6. (Handout page 25) Complete the testing phase of the Hydroponic Plant Device Challenge. If students are unsuccessful at meeting the design constraints, they must redesign, rebuild, and retest.
7. (Handout page 25) Plotting the plant growth will need to take place over the next week or two. You can either keep the plants in a window in a classroom or have students take them home and plot the growth. Follow the activity by completing the "Your Plants Need Space" math problems.
8. (Handout page 25) Reflect with "Mission Reflection" and Alex message. Watch this video if time allows: Historic Vegetable Moment on the ISS (4 min)

Science Background Answer Key

1: The___radicle__ is the small stem of an embryo plant.

2: The __seed coat____ provides protection as the outer layer of a seed.

3: The __roots___ are how plants collect water and nourishment.

4: A __leaf___ is the main organ of photosynthesis and transpiration for the plant.

What 4 things do plants need?

1. Sunlight
2. Minerals
3. Water
4. Carbon Dioxide

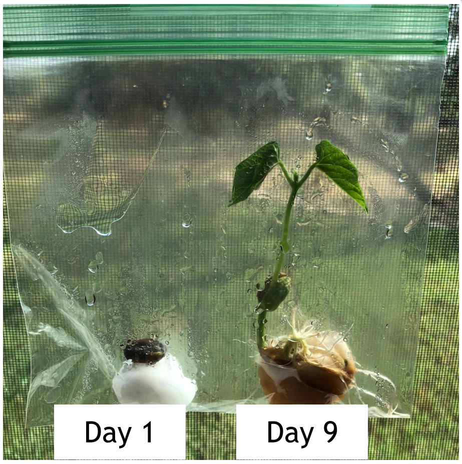
Mission Background Answer Key

Mission Background: In addition to sunlight, plants need water and CO2 to survive. How will your plant device meet your seeds' needs to allow it to grow?

Answer (answers should contain the following ideas): The cotton ball contains the water that the seed needs to germinate. Air is sealed into the bag, providing the plant with CO2. The bag is clear so it allows the sunlight to enter and provide the plant with the energy it needs for photosynthesis (the way a plant makes food for itself).

Students will build a device to hold a mini-greenhouse and watch their plants grow!

Group Size: Individual


Day 1 Day 9

Prior to Activity

1. Gather materials listed.
2. Soak pinto beans overnight
3. Create an example of a mini-greenhouse as described below.

Plant Device / Greenhouse Holder Materials	Mini-Greenhouse Materials
❑ 10 Craft sticks ❑ 1 sheet cardstock ❑ 2, 5 oz plastic cup ❑ 4 Index cards ❑ Masking Tape ❑ Scissors	❑ Plastic resealable sandwich bag ❑ 2 cotton balls ❑ 2 raw pinto beans (soaked) ❑ tap water

Activity Instructions

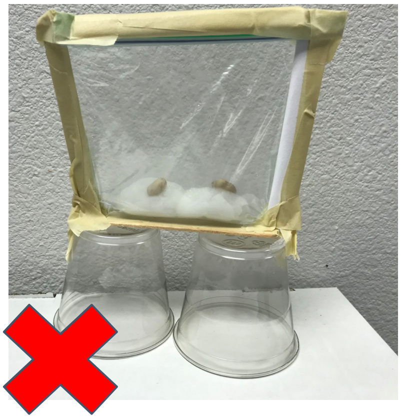
1. **Mission**: Build a structure to grow plants on the Moon.
   a. Plant container remains upright with opening facing upward.
   b. Plant container is held at least 6 inches above the ground.
   c. Plant container is only supported from the top and sides.
   d. Plant must be visible from both sides to get full sun exposure.
2. **Describe Mini-Greenhouse:** Demonstrate how to create a mini-greenhouse. A greenhouse protects plants from the weather and temperatures outside. The transparent walls trap the Sun's energy to keep plants warm. The plastic bag will act like a greenhouse.
3. **Build mini-greenhouse:** Allow students to collect their materials for the mini-greenhouse and assemble it as follows: submerge two cotton balls in <u>fresh</u> tap water (not the water used in soaking the beans) and place them into the plastic bag. Then place a pinto bean on top of each cotton ball. It is important that the beans remain in full contact with the cotton balls. Seal the bag, but <u>do not</u> squeeze any air out.

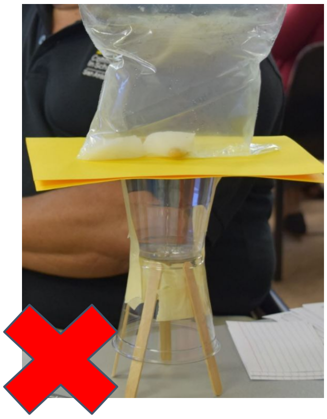
4. **Build Greenhouse holder:** Challenge the students to build a device to hold the mini-greenhouse so that it remains upright and maintains full access to sunlight for the plants. Follow the mission rules on the previous page. Use the provided worksheets to guide students through the engineering design process. *Extension:* Need another challenge? How high can you go?

5. The greenhouse should be placed in full view of the sun (a window is great). Students can use the handout to plot the growth of their plant! Growth will happen within a day or two.

Pictured are examples of greenhouse holders. The orange base is for one that is only raised 3 inches and the green base is raised 9 inches. You can adapt this clearance height based on the level of students.

The rule "can only be supported from top and sides" is to avoid the designs to the right that makes the challenge too easy!

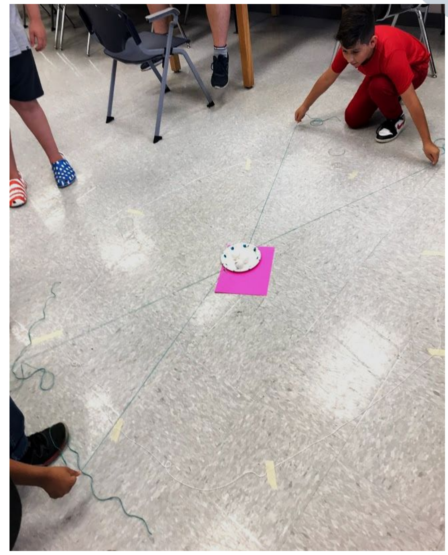




Mission 7

Collect Samples

Mission Overview



Objective: Use the engineering design process to design a device to transport ping pong balls.

Mission to Moon: Build a device to transport rock samples from inside a crater.

STEM Career: Biomedical Engineer

Theme: Leadership
Activities emphasize the role of a leader to direct the team to work together to accomplish a goal.

Activities:

1. (Handout page 26) As students enter the room, they may begin working on the "Mission Warm-up" box. Review the Launchpad Oath as a class.

2. (Handout page 26) Introduce lesson by reading the message from Astronaut Alex. We recommend showing: NASA Developing Mining Rover for Moon (2:30 min)

3. (Handout page 26) Discuss "Biomedical Engineers." We recommend showing Engineers Created a New Bionic Arm (4 min) or Victoria - Biomedical Engineer (5 min)

4. Read "NASA News" to show how NASA uses robots on space missions. A video on the InSight rover: Why NASA is Sending an $850 Million Hammer to Mars. (3:30) min

5. (Handout page 27) Complete the science activity to learn about impact craters on the Moon. Consider showing Moon 101 (3 min).

6. (Handout page 28) Complete the ***Moon Grabber Engineering Challenge*** using the instructions in the teacher guide. Use the handout to introduce the challenge, complete the Mission Background, and Brainstorm design ideas. You can show: Northeastern puts NASA's Valkyrie space robots through its paces (5 min)

7. (Handout page 29) Complete the testing phase of the challenge. If students are unsuccessful at meeting the design constraints, they must redesign, rebuild, and retest.

8. (Handout page 30) Reflect with "Mission Reflection" and Alex message. Watch this video if time allows: or How 3D printed prosthetic hands are changing kids' lives (4 min) or The Mind-Controlled Bionic Arm (11 min)

Science Background Answer Key

SIMPLE CRATERS
- Relatively small
- Smooth bowl shape
- Depth of ⅕ to 1/7 the crater diameter

Simple Craters: __A, D_

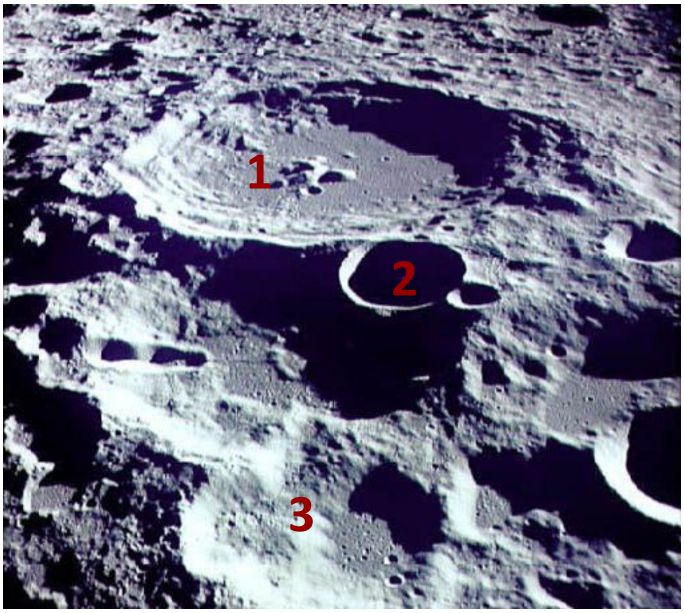
COMPLEX CRATERS
- Relatively large
- Contains a central peak or peak ring
- Depth of 1/10 to 1/20 the crater diameter

Complex Craters: _____B,C____

THE AGE OF CRATERS

How do scientists determine the age of a crater? Their features give us hints on when they may have formed. Read each description and assign it to a number from the photo.

- ___2___ crater is relatively new due to the preservation of the walls and depth.
- ___3___ crater is very worn and contains younger craters within it, indicating that it is older.
- ___1___ crater shows some collapsing of the walls after impact with a few younger craters within it. It is neither the youngest nor the oldest crater in the picture.



Activity: Moon Grabber

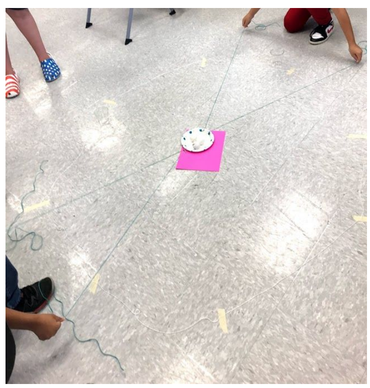
7

Students build a grabber to collect rock samples in a crater on the Moon.

Group Size: Partners

Prior to Activity

1. Gather materials listed.
2. Create kits of materials per group.
3. Create a large circle about 5 feet in diameter using string and tape. Place a plate with 3 ping pong balls in center. The plate should be 2.5 feet from the circle (radius of the circle).



Materials Per Group
❑ 7 Popsicle sticks
❑ 2 ft Masking Tape
❑ 4 Plastic straws
❑ 1 Paper bag
❑ 5 ft Yarn
❑ 2 Spoons
❑ 2 Rubber bands

Testing Station Materials
❑ Ping pong balls
❑ Plate
❑ String and tape to make collection area
❑ 9 oz, Plastic Cup for collection box

Build a Moon Grabber

1. Mission: Build a device to pick up rock samples and place into collection box. (Students usually work to collect one rock sample at a time).
2. Design constraints:
   - Each team member must have a role in collecting the ball. If a large group, one member can be the leader and give directions.
   - No body part can cross the circle of the crater during testing.
   - No body part can touch the rocks (ping pong ball) during the mission
   - Your grabber must be able to pick up rocks and move to collection cup without dropping.
3. Think about: How can my partner and I work together to accomplish this challenge? Can we build a device without needing to enter the crater?

4. For brainstorming, show students the available materials. Ask them to think about different designs. Make sure teams sketch a design before building. Note that there are a lot of different ways to solve this challenge. Encourage creativity.

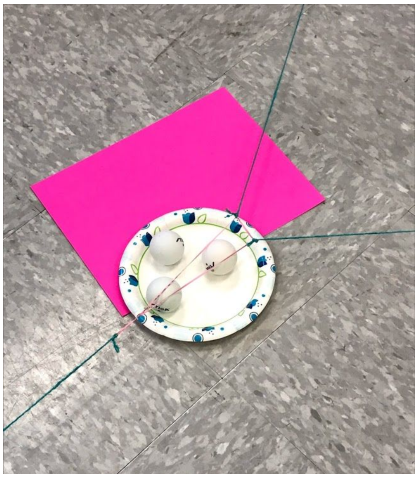
5. **Building:** Teams may get stuck during building, so encourage them to just go for it and re-design as they test. When testing, they will realize that certain materials such as popsicle sticks are not enough to grab the ball. This challenge requires creative use of materials.

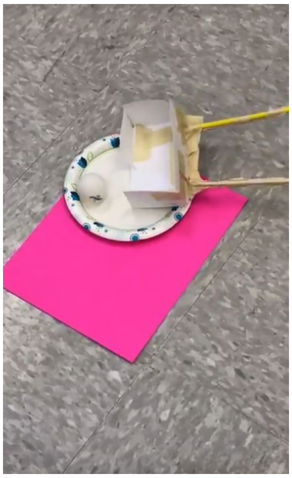
6. **For testing:** Students are not allowed to get in line for testing if their team members are not present. When testing, teams have as many chances to try as there are ping pong balls on the plate. If they are trying to pick up a ping pong ball and it hits the floor - it is gone forever (for that testing trial)! They can no longer try to pick it up for the rest of their testing round. This gives the students a finite amount of testing so they can share the testing area with others students, and it forces them to go back and re design.

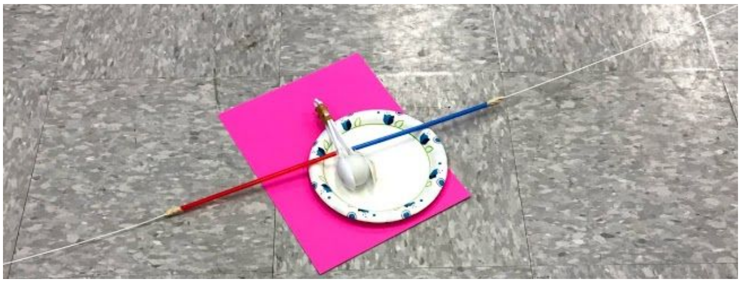
7. **Re-design**: How can we *reinforce* or strengthen the design so it can reach the middle of the crater? How can you make your collection device longer?

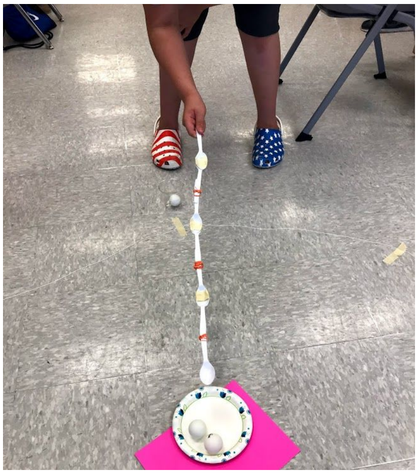
8. **Extensions:** If teams finish early, remove a material such as the spoons and have them re-design with a material replacement. You can also challenge them to pick up different materials such as pencils to represent different type of rock samples. This also works great with candy as a rock sample!

Allow the students to struggle with this challenge. DO NOT give them ideas or show pictures before they have at least attempted. Then, only ask guiding questions such as how can you make your device "grab" the ball or perhaps "scoop" the ball? They also will be tempted to look at the other teams, but make sure they realize there are multiple solutions.









Mission 8

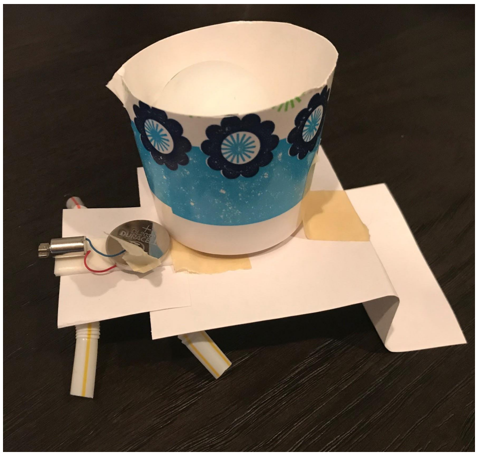
Build a Rover

Mission: Build a Rover

8

Mission Overview

Objective: Use the engineering design process to design a rover to carry a ping pong ball (rock sample).



Mission to Moon: Find a way to transport your rock samples.

STEM Career: Electrical Engineer

Theme: Adaptability
This challenges focuses on how well students adjust to unexpected changes or unfamiliar situations. Everyone faces adversity or experiences a failed plan, but you control how you respond to it.

Activities:

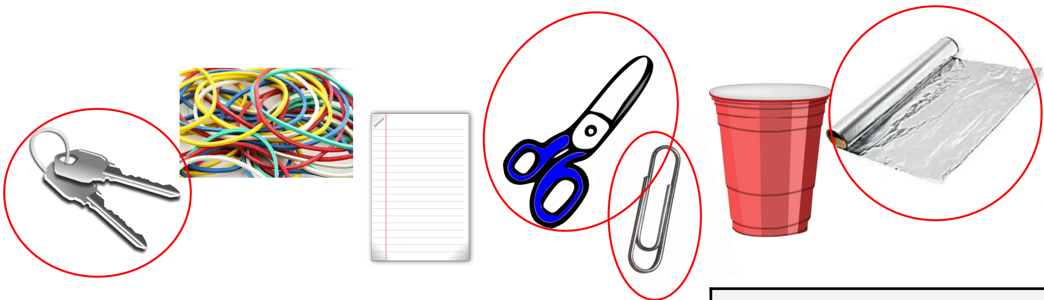
1. (Handout page 30) As students enter the room, they may begin working on the "Mission Warm-up" box. Review the Launchpad Oath as a class.
2. (Handout page 30) Introduce lesson by reading the message from Astronaut Alex. We recommend showing: Design of Lunar Rover was mostly guesswork (2:30 min)
3. (Handout page 30) Discuss "Electrical Engineers" and "NASA News". Watch: Tri-ATHELETE (2:30 min), Awesome Robots Inspired by Nature (5 min), or BB-8 visits the robots of Nasa (3:30 min).
4. (Handout page 31) Complete the ***Energy Stick Activity***. Use the "Science Background" section to test different materials for conductivity. Discuss electricity and open and closed circuits. Show: The Power of Circuits (5 min).
5. (Handout page 32) Complete the ***Rover Challenge***. Ask students to answer the Mission Background question and brainstorm design ideas.
6. (Handout page 33) Complete the testing phase of the Rover Challenge. If students are unsuccessful at meeting the design constraints, they must redesign, rebuild, and retest. A rover math questions is also included.
7. Reflect with "Mission Reflection" and Alex message. Watch this video if time allows: Mission: Solar System - Sandeep Yayathi, Robotics Engineer (4 min)

Mission: Build a Rover

8

Science Background Answer Key

Circle the things below that you think will conduct electricity.



What other conductive materials can you find? List them below!
Non-conductive: Modeling Clay, Eraser, Pencils, anything plastic, clothing Conductive: Play Doh, anything metal, humans, some jewelry

Electricity Answer Key

After reviewing the answers on electricity, ask students to think about examples of open and closed circuits. One common answer is a kay Connect concepts to rover challenge by showing the motor and battery. By connecting the wires, you are completing the circuit to allow electricity to flow between motor and battery. This is called a closed circuit. A closed circuit allows electricity to flow like flipping a light switch to turn on the light. When you attach the wire to the battery, you close the circuit and power the motor.

1. Electricity is the ___flow__ of electrons.
2. A circuit is a _path_ through which electricity can flow.
3. A **closed** circuit is a __complete_ circuit that allows for the electricity to flow from one end to the other without interruption.
4. An **open** circuit is an ___incomplete_ circuit that does NOT allow the electricity to flow from one end to the other.

Activity: Energy Stick

8

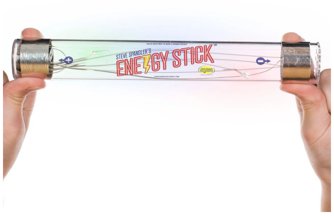
Test materials for conductivity.

Group Size: Class

Prior to Activity

1. Gather materials listed.
2. Try out the energy stick.

Testing Station Materials
❑ Energy Stick
❑ Foil
❑ Paper
❑ Scissors
❑ Paper clips
❑ Rubber bands
❑ Other materials for conductivity test (steel mug, house keys, etc.)



Energy Stick Instructions

1. Gather students in a circle or facing the front.
2. Show students energy stick. Place a hand on each end of the energy stick and watch it turn on. A small amount of electricity is flowing through your body and completing or closing the circuit! Let go of one hand and watch it turn off.
3. Try creating a human circuit. Have the entire class hold hands (or a just a few for a demo) and place the energy stick between two students. The electricity is flowing through the entire class!
4. Use the energy stick to test which materials are conductors. Conductors allow the flow of electricity. Metals are conductors. A material that stops the flow of electricity is an insulator. Examples include paper, pencil erasers, and plastic.

Activity: Rover Challenge

8

Students build a rover to carry a ping pong ball.

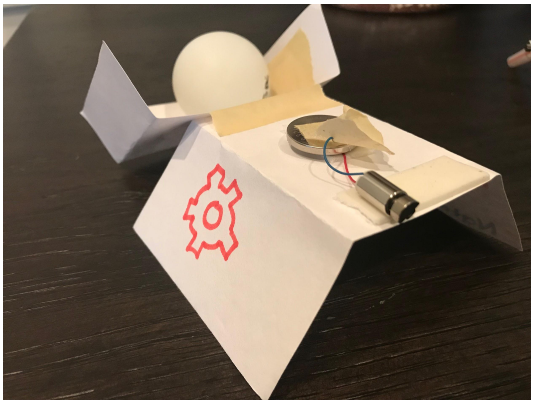
Group Size: Individual

Prior to Activity

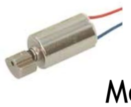
1. Gather materials listed.
2. Make sure all batteries and motors are stripped to allow for about ½ inch exposed wire.
3. Test out batteries and motors. Do not place coin batteries all together touching. This can drain the batteries.
4. Build an example rover.
5. Create kits of materials per group.
6. Practice challenge.

Build a Bristlebot

1. Explain that students will build their own rover to move rock samples (ping pong ball).
2. Show the How To Video to review how to build the bristlebot. Students are building a similar objects, except no toothbrushes!
3. Show students the motor and battery. Explain that the battery will power the motor to spin. This motor is the same thing found in cell phones that vibrate. Show students what happens when you connect both wires on battery to motor. Have students feel the vibrating. Explain that an unbalanced weight at the end of the motor causes the vibration. What happens when you block the weight at the end? This will stop the motor from moving! **The vibrating motor will move the rover as long as it is light enough.**



Materials Per Student
Each student builds a rover
❑ 1 3 V battery
❑ 1 1.5 V vibrating motor
❑ 2 inch of foam tape
❑ 1 pipecleaner
❑ 2 bendy straws
❑ 2 index cards
❑ Masking tape
Testing Station
Have far can you carry 1 ping pong ball?
❑ Ping pong ball
❑ Track: Rovers don't like going straight! You can make this challenge easier by creating a "track" for testing as shown.

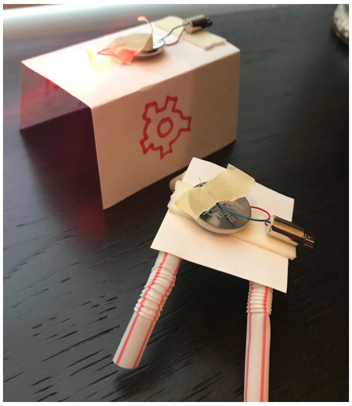


Motor

Battery

Science Background Connection: Connect concepts to rover challenge by showing the motor and battery. By connecting the wires, you are completing the circuit to allow electricity to flow between motor and battery. This is called a closed circuit. A closed circuit allows electricity to flow like flipping a light switch to turn on the light. When you attach the wire to the battery, you close the circuit and power the motor.

4. Show students an example of a rover that can move using the vibrating motor. This is an *example*, but it doesn't mean this is the best way to build a rover! Also in the photo is a rover with straws as legs. We don't typically like examples, but this is a difficult challenge to visualize.

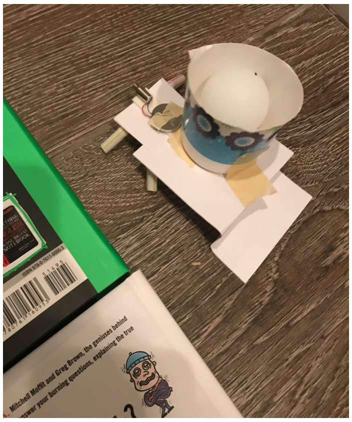


5. How to build:
   - Use mounting tape to attach battery and motor to the index card. Press firmly.
   - Connect wires of motor to wires of battery to close the circuit and power the motor.

Move Samples

1. Mission: Design a rover that can carry a ping pong ball (rover) as far as possible. Design Constraints:
   a. Only use provided materials.
   b. Must carry at least 1 ping pong ball a distance of 1 foot.
   c. Use the vibrating motor to propel the robot.

2. Have students design a rover with the provided supplies before allowing building. Think about keeping the weight balanced and minimizing supplies used (a heavy rover won't travel very far).
3. Allow students all materials for building.
4. This activity requires continual testing. We recommend providing the ping pong ball from the start to allow students to continually refine their designs. The biggest challenge will be keeping it light and moving forward.
5. Bring students together for a final race. You can create tracks by taping down yard sticks or using textbooks. Who can carry a ping pong ball the farthest distance?



Building Tips

- **Keep Falling Over?** Keep your center of gravity in the middle (especially the motor and battery), otherwise you will tip over.
- **Motor falling off?** Make sure to firmly press into tape.
- **Motor not working?** Make sure that each wire on the motor is attached to a different side of the battery, but the two motor wires can't touch. Check that nothing is blocking the rotating weight on the motor.
- **Not going straight?** Think about adding legs to balance or push your rover in a certain direction.
- **Not moving at all?** The heavier the rover, the slower it will move. How can you decrease the weight?

Mission 9
Entertainment

Mission: Entertainment on Moon

Mission Overview

Objective: Students apply the engineering design process to design and build a roller coaster.

Mission to Moon: Provide entertainment on the Moon

STEM Career: Civil Engineer & Psychologist

Theme: Creativity
Engineering involves a lot of creativity! There is not one way to design a rocket, airplane, roller coaster, or car. Your design needs to solve the problem, but an engineer gets to put their unique stamp on the final result.

Activities:

1. (Handout page 34) As students enter the room, they may begin working on the "Mission Warm-up" box. Review the Launchpad Oath as a class.
2. Introduce lesson by reading the message from Astronaut Alex.
3. Discuss "Psychologist" and "NASA News". Civil engineers are also mentioned in the Astronaut Alex message. We recommend showing: Life on Station (5 min) - please remind students that this is life on the International Space Station orbiting the Earth. Crew on the Moon will not be floating around!
4. (Handout page 35 - Science Background) Ask students to complete the handout on mental health considerations on living on the Moon. Hints are provided on the next page. An additional mental health activity it to practice "roller coaster breathing." You can find more information here or through this video.
5. (Handout page 36) Complete the ***Roller Coaster Challenge***. Ask students to answer the Mission Background question and brainstorm design ideas. Show these rollercoaster videos to introduce the challenge: Physics of Roller Coasters (3:30 min) or Top 10 Tallest Roller Coaster Rides (4 min)
6. (Handout page 37) Complete the testing phase of the Roller Coaster Challenge. If students are unsuccessful at meeting the design constraints, they must redesign, rebuild, and retest. Math questions are also included.
7. (Handout page 37) Reflect with "Mission Reflection" and Alex message. Watch this video if time allows: Moon Village (4:30 min)

Mission Success

9

Science Background Answer Key

The table below has some examples of how humans get happiness on Earth as well as challenges on the Moon. Refer back to Moon facts from Mission two.

Happiness on Earth	Challenges on Moon
Human Connection	You can't bring all of your family and friends to the Moon! Lunar colonies will have limited space. How will you maintain social connections?
Entertainment	No movie theaters, theme parks, restaurants...what wil you do for fun? Limited supplies can fit on a rocket to the Moon so you will need to be selective on what you bring. Remember, the difficult environment will mean you have to stay inside the Lunar base or inside an astronaut suit.
Purpose / Work	What is your purpose on the Moon? On Earth, you may be a teacher, doctor, lawyer, engineering, or a number of different jobs. What will you do on the Moon?
Music / Art	Music and art is important to our society on Earth. How will you bring this to the Moon?
Landscape / Weather	The moon is a vast expanse of grey rocks. No parks, trees, or oceans. The minimal atmosphere means no clouds or a blue sky. How do you think this will affect humans on the Moon?

Activity: Rollercoaster

9

Students build a roller coaster to provide entertainment while on Mars.

Group Size: Partners

Materials Per Group	Testing Station
❑ 8 craft sticks ❑ 10 sheets construction paper ❑ 8 paper plates ❑ 6 index cards ❑ Masking tape	❑ Ping pong ball ❑ Plastic/paper cup ❑ Ruler

Prior to Activity

1. Gather materials listed.
2. Create kits of materials per group.

Build a Roller Coaster

1. Mission: Build a roller coaster to get a ball into a cup.
2. Design constraints.
    a. Ball travels from a minimum height of 18 inches (45 cm) above the cup.
    b. Ball makes at least 1 turn.
    c. Ball lands in cup.
    d. Nothing inside cup.
3. Students will collect supplies and build their roller coasters. As students complete the minimum design constraints, you can provide more materials. This is a great project for a family showcase!

Mission 10
Mission Success

Mission Success

10

Mission Overview

Objective: Reflect on Mission to Moon and celebrate!

Mission to Moon: Celebrate success

STEM Career: STEM Careers

Activities:

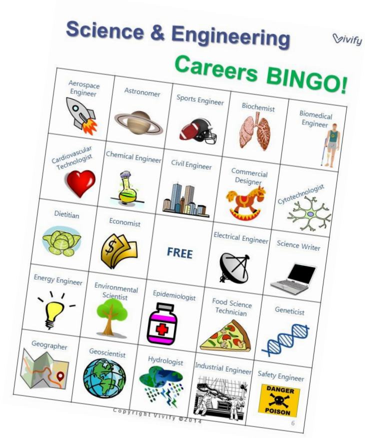
1. (Handout page 38) As students enter the room, they may begin working on the "Mission Warm-up" box. Review the Launchpad Oath as a class.
2. Introduce lesson by reading the message from Astronaut Alex. Show: We Go as the Artemis Generation (1 min)
3. (Handout page 38) Discuss "STEM Careers" as a recap to the weekly career highlights. We recommend showing What is Engineering? (6:30 min)
4. Read "NASA News" to explore different careers at NASA. We recommend showing: We Are NASA (3 min)
5. (Handout page 39) Complete the ***Heart Rate Experiment*** in connection to a post-mission health check. Watch Your Body in Space (2 min)
6. (Handout page 40) Complete the ***STEM Careers BINGO Game***.
7. (Handout page 41) Complete reflection activities. How We Could Build a Moon Base TODAY (10 min)
8. Optional - Complete the ***Coke Mentos Geyser*** as a celebration of success or try out Steve Spangler Atomic Slime with the black light!
9. Pass out Launchpad certificates.

Activity: STEM Careers BINGO

10

Students learn about STEM careers with a BINGO game.

Group Size: Class



Prior to Activity

1. Review career descriptions and BINGO game cards.
2. Print BINGO game cards and collect game markers.
3. Cut out STEM career descriptions and place into a container.
4. Access Google slides presentation: https://docs.google.com/presentation/d/1UxrJviV-EcnnjbqzepK5UbYwHITe06SB6lH5Hq6q5r0/edit?usp=sharing

Materials
❑ STEM Career Descriptions
❑ Container to place descriptions
❑ BINGO boards
❑ BINGO game markers (paperclips work well)
❑ Online Google Slides BINGO PPT

Activity

1. Pass out BINGO boards to each students along with 24 markers such as paper clips, beans, coins, etc.
2. If using the Google Slides PPT, open presentation to the first career slide. In "Present" mode, the name of the career will not appear until you click. This allows the students to first read the slide and attempt to guess the STEM career. The same can be accomplished by reading the career description from the paper version.
3. Announce the STEM career.
4. Note the different spark connections on the slide. Ask students to think about which career relates to their spark.
5. The first student to get 5 across, down, or diagonally wins! The FREE space can be used.

Activity: Coke Mentos Geyser

10

Create a big geyser with Coke and Mentos candy!

Group Size: Class

Prior to Activity

1. Gather materials listed.
2. Find a suitable location OUTSIDE. The soda can reach a height of 40 feet.

Materials Per Group
❑ 2L Diet Coke
❑ Geyser Tube
❑ Mentos

Activity

1. Go outside to an open area like a field or parking lot.
2. Carefully open bottle.
3. Place bottle on ground so it does not tip over.
4. Load seven Mentos into the Geyser Tube. The goal is to get all Mentos into the bottle at the same time.
5. Pull trigger to drop Mentos and RUN! <u>Make sure students do not run towards the reaction.</u>

- Why Diet Coke? Diet coke is used because there is no sugar, which makes it less sticky than regular soda.
- Students will want to drink the Diet Coke! Decide ahead of time if you will allow this or make them pour it out. It won't have carbonation.
- Students will want to eat the Mentos. You may reserve extras for eating after the demonstration.

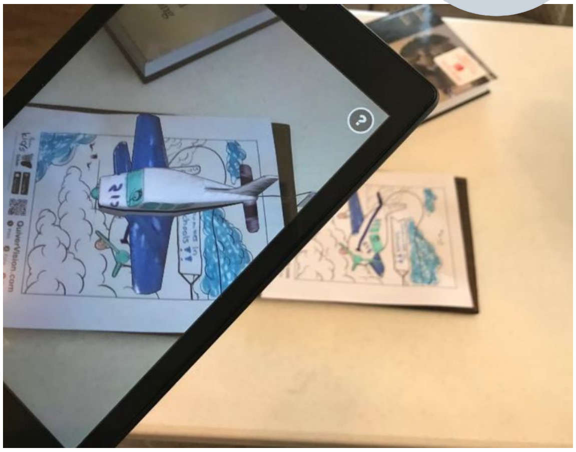
What is happening? The carbon dioxide gas inside the Diet Coke is being released. Initially, water molecules are trapping the carbon dioxide. When the Mentos is dropped in and falls to the bottom it disrupts this water mesh. All the gas is released and literally pushes all the liquid up and out of the bottle. What remains in the balloon is released carbon dioxide gas. These are all physical changes.

Extension Activities

Activity: Virtual Coloring

Bring a drawing to life with augmented reality!

Group Size: 3 - 4 students



Prior to Activity

1. Test out the Quiver app. Note that some coloring sheets required extension packs.
2. Print out coloring pages.

Materials
❑ Tablet
❑ Coloring Page
❑ Colored Pencils

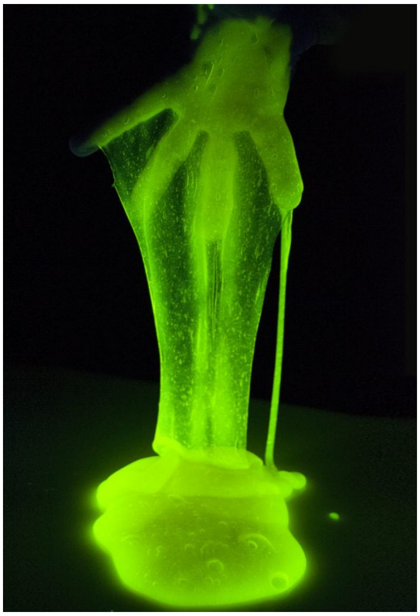
Activity

1. Provide students with coloring page and coloring pencils.
2. Color as desired.
3. Open the Quiver app.
4. Click the butterfly icon. Place camera over the coloring page. Watch as drawing comes to life!
5. Try tapping the screen to move and interact with an object.

Activity: Atomic String Slime

Learn the chemistry behind polymers with atomic string slime that also glows under a black light!

Group Size: Individual



Prior to Activity

1. Recommend doing this in the cafeteria or outside!
2. Practice making slime ahead of time.

Activity

1. Steve Spangler slime is amazing, and no glue is required! Only two ingredients combine to make the perfect slime everytime.
2. Mix the Activator solution with the PVA solution following the shaker cup instructions.
3. Super Slime is like microscopic spaghetti – long chains of slippery, slimy molecules called a polymer. The Activator solution links together to long polymer chains to form the world's best slime.
4. Plus the slime glows under a black light! When the energy from the black light "excites" the fluorescent dye, you end up with brightly glowing slime.

Testing Station Materials
❑ Shaker cup per student
❑ Activator Solution
❑ Slime Solution

Activity: Moon Phases

Learn about the phases of the Moon and why they occur using Oreos!

Group Size: 1-2 students

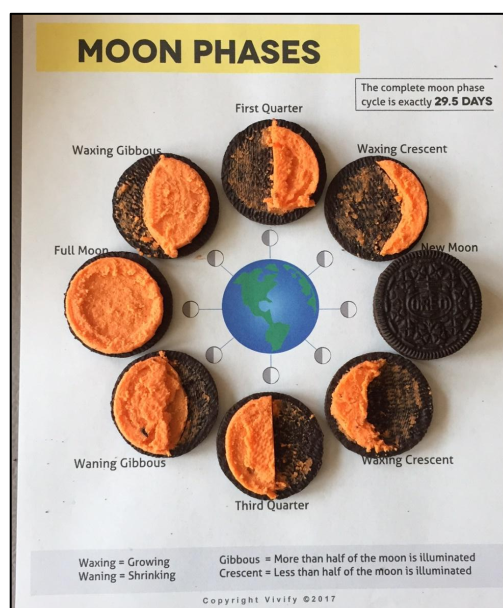
Materials
❑ Oreos
❑ Handout
❑ Plastic knives (opt.)

Prior to Activity

1. Gather enough Oreos for each student or pair of students to have 8.
2. Print Moon Phases page.

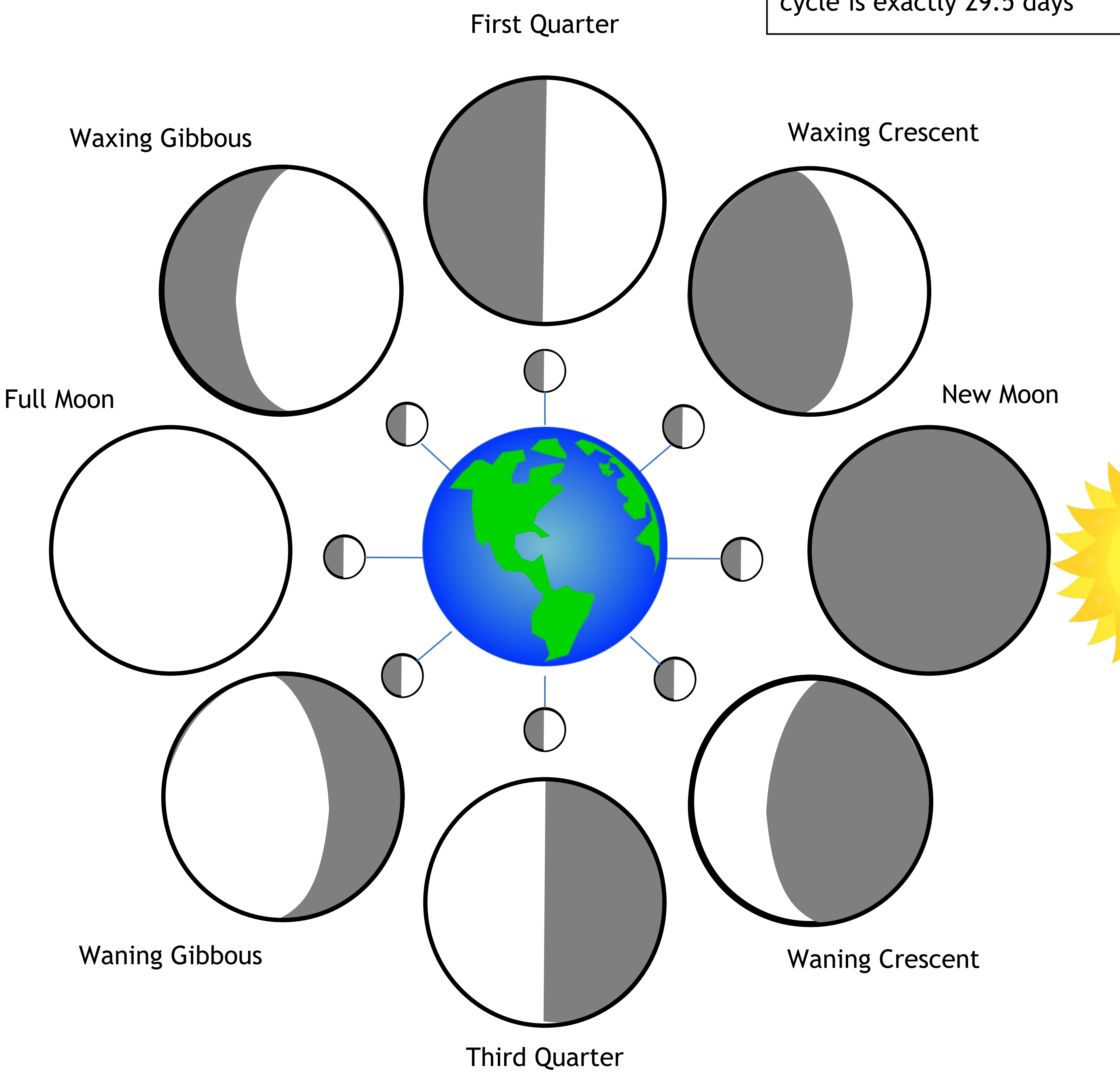
Activity

1. Hand out the Moon Phases sheet and discuss:
    1. Why we see the moon?– it reflects the Sun's light
    2. Why do we not see the whole moon all the time?– because of the moon's orbit around the Earth (refer to the illustration on the handout showing the relative location of the Sun, Earth, and Moon as the Moon orbits around the Earth)
2. Pass out 8 Oreos (or less, if more than one phase may be made out of each Oreo) to each person or group.
3. Practice making each moon phase out of the Oreos, letting the icing represent the illuminated part of the moon, and the cookie representing the dark part of the moon. Students may bite off the parts of the Oreo to make the phases or use plastic knives to cut them into the appropriate shapes.



Moon Phases

The complete moon phase cycle is exactly 29.5 days



Waxing = Growing
Waning = Shrinking

Gibbous = More than half of the moon is illuminated
Crescent = Less than half of the moon is illuminated