PLANET PIONEERS

EDUCATOR GUIDE

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EXHIBITION OVERVIEW

Imagine being able to explore the planets! What would you find? How would things be different from or similar to life on Earth?

Most importantly, how would you get there, survive, and return home?

All of these questions and more are explained in Scitech's Planet Pioneers exhibition. Comprised of 17 hands-on exhibits, Planet Pioneers will put budding astronauts to the test when they attempt to source their own food, find shelter, and solve problems in an unknown land.

The exhibition engages visitors with exciting full-body experiences such as driving a 4-D Surface Exploration Vehicle, flying a virtual drone to solve environmental issues, and experiencing G-Force in a spinning capsule. Planet Pioneers will thrill students and spark their interest in learning about the science and engineering involved in space exploration.

ABOUT THIS GUIDE

Next Generation Science Standards (NGSS) were used to structure this guide. The guide is composed of 18 activities including two design challenges that are aligned with the NGSS Performance Expectations. These lessons and activities bridge the learning from the exhibition to the classroom.

The 18 activities cover a variety of 3rd to 8th grade performance expectations, so teachers can choose which activities best fit their students' needs and interests. The Design Challenges are focused on 3rd to 5th and 6th to 8th grade Engineering Design Performance Expectations to ensure that these lessons are applicable for all students.

ACTIVITIES

For each of the 17 hands-on exhibits, there are one or two corresponding activities described below. Some of them should be completed at the exhibition, but most of them are intended to be an introductory or follow-up activity to the student's field trip to Planet Pioneers.

ACTIVITIES

TIMING IS EVERYTHING

ACCELERATION OF GRAVITY

In this activity, students will calculate the acceleration of gravity.

Grade level: Middle School

Performance expectation: Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects. MS-PS2-4

Materials

- Meter stick
- Stopwatches
- Ball

Method

1. Ask students how fast gravity makes things fall and if things fall faster the farther they fall. Discuss with students the difference between speed and acceleration.
2. Put students into pairs and pass out the materials. Tell students that they are going to drop a ball and record how long it takes to hit the ground from a height of one, two and three meters (you can use higher heights if available).
3. Have all the groups drop their ball from one meter and record the times. Have students repeat the test two more times, and have students calculate the average time it took the ball to reach the ground based on all of the class's data.
4. Have students predict how long it will take the ball to drop two meters. Conduct the test from two meters three times, and average the results of all the class data. Repeat the test three more times from a height of three meters, and calculate the class average.
5. Have students graph their results, and ask students to make an argument as to why the ball seems to be speeding up depending on how high it is. Be sure to discuss why the speed is different from each height while the acceleration stays about the same.
6. Have students try to calculate the accelerations due to gravity. Acceleration is calculated as meters per seconds squared.
7. The acceleration due to gravity on Earth is 9.8m/s2. Discuss with students why their findings were or were not close to the true value, and discuss ways the test could yield more accurate results.

PLANET BASE

ALL THE WATER IN THE WORLD

In this activity, students will find out how water is distributed around the world.

Grade level: 5

Performance expectation: Describe and graph the amounts and percentages of water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth. 5-ESS2-2

Materials

- 1 liter of water
- Measuring cup or graduated cylinder
- Salt eye-droppers
- Six 1-liter containers

Method

1. Discuss the planet base mission with students and ask about the types of resources that are needed for survival. Shift the focus of the discussion to water, and ask students where on Earth water is located.
2. Put class into six groups. Each group will represent one of the sources of water. The groups are ice, groundwater, lakes, swamps, rivers, and oceans. Hold up the liter of water, and tell students this represents all the water in the world. Ask groups to predict how much water should be allocated to each group.
3. Distribute the water as follows:

Ice: 20.6mL	Swamps: 0.01ml (about 5 drops)
Groundwater: 9.0ml	Rivers: 0.002ml (1 drop)
Lakes: 0.08 ml	Oceans: 970ml

4. Have students graph the distribution of water.
5. Discuss how the water is distributed and where we get our drinking water. Add salt to the oceans group's water to demonstrate that most of the world's water is not drinkable. Have students update their graph to show only freshwater.
6. Discuss with students how only 3% of the world's water is fresh, and ask how that water should be distributed equitably among the word's plants and animals (including people).

EXAMINE ROCKS

HOW SPECIAL IS THAT ROCK?

In this activity, students will determine techniques used to identify rocks and other materials.

Grade level: 5

Performance expectation: Make observations and measurements to identify materials based on their properties. 5-PS1-3

Materials

- A scale
- Rulers
- 10-20 various rocks and minerals of different shapes and sizes for each group. (If you don't have access to rocks and minerals, you can substitute them with any natural product like shells, leaves, sticks, etc.)

Method

1. Reflect on the Examine Rocks exhibit with your students. Ask them how and why they were able to identify various rocks and minerals.
2. Discuss why natural resources like iron and gas are so vital to humans, and ask students to discuss how we find these resources.
3. Ask students if they were to travel to another planet, how would they know which rocks contained the resources vital to human survival? How would they classify them? As a class, come up with a list of ways to classify. This list should include things like color, size, mass, and texture.
4. Put students in groups, pass out the rocks, and have students label them. Have groups choose three different ways to classify their rocks. Have them sort their rocks by each of these categories and record their findings (for example, if sorting by color: rocks A, D, and E were red, and if sorting by mass: rocks C, G, and H have a mass less than 10 grams).
5. Have groups find at least two rocks that are in the same group for all three categories. These are your group's special rocks. Each group should give their special rocks a name (something fun like kryptonite).
6. Have students make a dichotomous key for their special rocks (for example, they make a key that says this group of rocks has a mass over 100 grams, is dark in color, and is smooth).
7. Have groups swap keys and rocks with another group to try to find all of the other group's special rocks using the key. Have groups check each other's work and come back together as a class.
8. Discuss results. Which groups were able to identify all the special rocks? Why? What types of categories were most helpful? What new categories would you like to add? Do you think this is how scientist try to classify new objects they discover?

LIFE IN A VACUUM

CAN WE SURVIVE?

In this activity, students will explore how the atmospheres of other planets would affect life on Earth.

Grade level: 5

Performance expectation: Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact. 5-ESS2-1

Materials

- Internet access

Method

1. In the Planet Pioneers exhibition, students learned about how the atmosphere is different on various planets. As a class, discuss what they remember about the Life in a Vacuum exhibit. Write responses on the board.
2. Put students into groups, and assign them each a planet. Tell them they are going to research the atmosphere on their planet and then try to determine what would happen if Earth suddenly had a similar atmosphere. For example, the atmosphere on Mars has a lot of carbon dioxide but only a little oxygen. Therefore, students could conclude that if Earth were to have the same atmosphere as Mars, the plants (that need carbon dioxide to survive) would flourish while animals (that need oxygen to live) would die out. Challenge students to think not just about what would happen immediately but also the long-term effects of the change in the atmosphere.
3. Give students time to conduct their research, and have them create a presentation of their findings. Have groups present their work and discuss each as a class.

BOTTLE ROCKET

FUELING ROCKETS

In this activity, students will determine how much Alka-Seltzer is optimal to fly a film-canister rocket.

Grade level: 4

Performance expectation: Use evidence to construct an explanation relating the speed of an object to the energy of that object. **4-PS3-1**

Materials (per group)

- Stopwatch
- Meter stick
- Film canister
- Alka-Seltzer tablets (2 per group and cut into fourths)

Discuss with students how manipulating the fuel levels in the Bottle Rocket exhibit affected how the rocket flew.

Ask students to identify any trends they noticed.

Method

1. Tell students that they are going to build their own rockets by putting Alka-Seltzer and warm water into film canisters to make them fly.
2. Before beginning, ask each group to make a prediction about the relationship between the amount of fuel (energy) put in the canister to how fast the canister goes.
3. Put students in groups and pass out materials. Tell students they are going to launch their rocket three times and measure how fast if flies.
4. Ask students to stand near a tall wall. Put in one quarter of an Alka-Seltzer tablet and warm water into the film canister, set it top-down, and wait for it to launch.
5. One group member will use the stopwatch to time how long it takes from launch until the canister reaches its peak. Another group member will measure how high the canister reaches on the wall.
6. Groups will repeat this process with half of an Alka-Seltzer tablet and then again with a whole tablet.
7. Have each group put their data on the board. Students then will use the class data to calculate the speed of each rocket by dividing the height it traveled by the time it took to reach its peak for each of the three trials.
8. Discuss the results as a class. What trends were there? What were some errors in this experiment?

BOTTLE ROCKET

MASS AND ENERGY OF ROCKETS

In this activity, students will identify how mass affects the flight of baking soda and vinegar rockets.

Grade level: Middle School

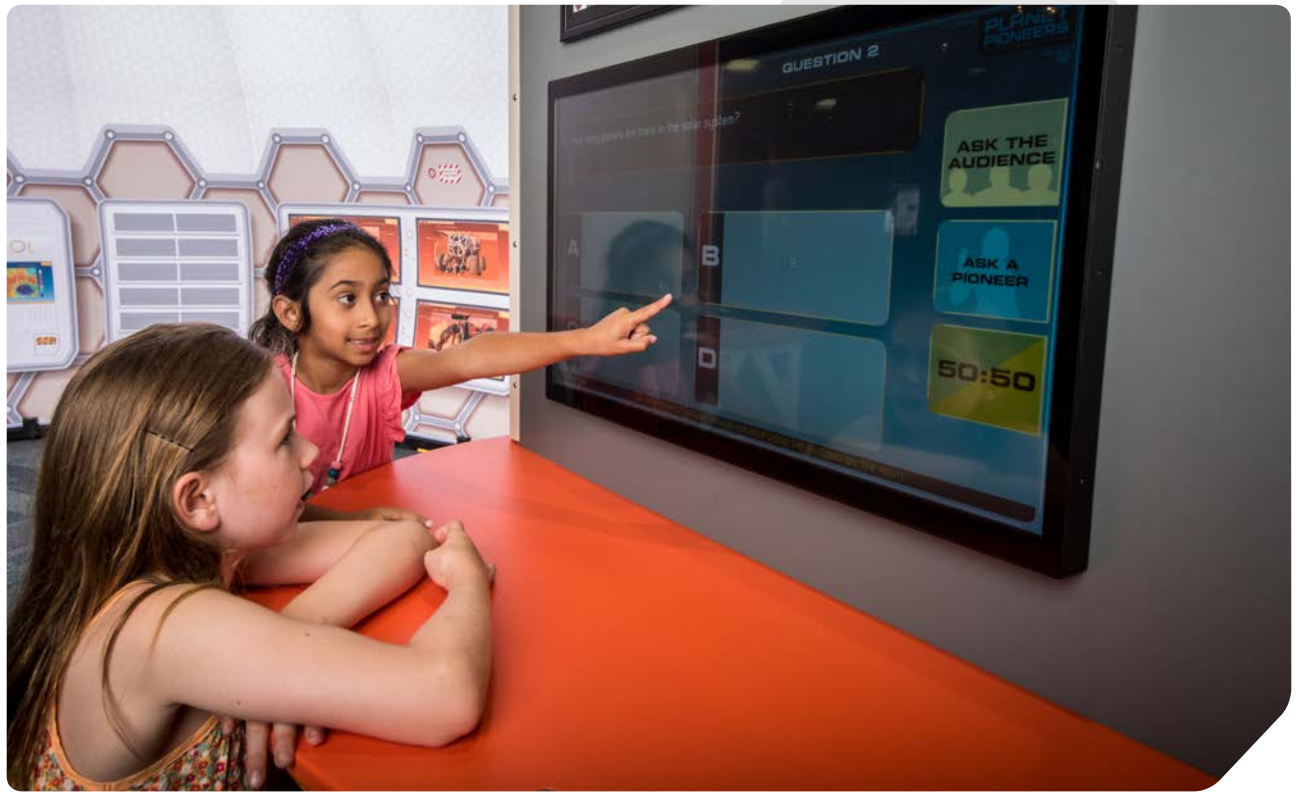
Performance expectation: Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object. **MS-PS3-1**

Materials (per group)

- Stopwatch
- Meter stick
- 16 oz. bottle
- Rubber stopper
- 3 pencils
- Tablespoon
- Baking soda
- Scissors
- Tape
- Paper towel
- Vinegar
- Metal washer
- Scale
- Safety goggles

Method

1. Discuss with students how manipulating the fuel levels in the Bottle Rocket exhibit affected how the rocket flew. Ask students to identify any trends they noticed.
2. Go over the terms mass, speed (distance/time), and kinetic energy (½mv2). Tell students that they are going to build their own rockets to test the relationship between kinetic energy and speed and kinetic energy and mass.
3. Put students in groups, and pass out materials. Tell students they are going to launch their rocket three times and measure the mass and how fast it flies.
4. To construct and launch the rocket, first be sure everyone is wearing their safety goggles and an adult is supervising. Have students tape three pencils to the bottle so it can stand up on its own with the bottle opening facing down.
5. Record the mass of the rocket. Turn the rocket over, and pour in 4 oz. of vinegar. Fold ½ tablespoon of baking powder into one quarter of the paper towel. Put baking-soda-wrapped in a paper towel into the bottle, place the rubber stopper on, shake twice, set down, and BACK AWAY! The rocket will launch quickly, so be sure everyone is standing at least 10 meters away.
6. One group member will use the stopwatch to time how long it takes from launch until the rocket reaches its peak, and another group member will measure how high the rocket reached on the wall.
7. Students will tape four washers on the sides of the rocket, record its new mass, and launch the rocket again. Students will add four more washers onto the rocket, record its mass and conduct a third and final launch.
8. Before constructing and launching, ask each group to make a prediction about the relationship between the kinetic energy of the rocket and its speed and the kinetic energy and its mass. Discuss why those relationships may be similar or different.
9. Conduct the experiment, and have all groups put their data on the board. Have groups use all the class data to calculate the speed and kinetic energy of each test and graph their result
10. Discuss the results as a class. What trends did they see? Is the relationship between kinetic energy and mass and kinetic energy and speed similar or different? Explain why.



WHO WANTS TO BE A PIONEER?

MAKE A QUIZ

In this activity, students will create their own quizzes about a planet.

Grade level: Middle School

Performance expectation: Analyze and interpret data to determine scale properties of objects in the solar system. **MS-ESS1-3**

Materials

- Internet access

Method

1. Ask students to reflect on the 'Who Wants to Be a Pioneer' exhibit, and ask them about the quiz they took about living on another planet.
2. Ask students to discuss which questions were interesting and which were not. Ask students to describe why they think some questions are better than others.
3. Put students into groups, and assign them each a planet or a moon, and challenge them to create a 10-question quiz about them. Tell students the questions should be in various forms (matching, multiple choice, short answer, etc.), should be engaging, and should reveal interesting and important facts about their planet or moon.
4. Have students read their questions to the class to see if anyone can answer them. When groups have gone over all the questions, they should ask the class to summarize what life would be like on their planet or moon. Have students reflect on which questions were most informative and why.

G-FORCE

MASS VS. GRAVITY

In this activity, students will determine what influences the force of gravity on the surface of planets.

Grade level: Middle School

Performance expectation: Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects. **MS-PS2-4**

Materials

- Internet access

Note: Complete this activity BEFORE visiting exhibition.

Method

1. Ask students to describe mass then ask them to discuss gravity. How are the two related? How are they similar and different? How does acceleration fit into those two concepts?
2. Tell students that they will soon be visiting the Planet Pioneers exhibition and will visit an exhibit called G-Force where they will compare gravity on different planets. Tell students that before they go on their field trip, they will create a graph comparing the mass and the radius of all the planets compared to Earth's. When they visit G-Force, they will compare their graph to a graph in the exhibit that compares the surface gravity on all the planets to Earth's.
3. Have students look up the mass and radius of each planet and make a graph that shows both their relative masses and their relative radius size to Earth's. (Meaning: Earth will always have a value of 1, and the other planets will be calculated by dividing the mass or the radius of planet by the mass or radius of Earth.)
4. Ask students to make observations about their graphs and make a prediction how a graph comparing surface gravity on all the planets will be similar or different to their graphs.
5. Students should bring their graphs to the exhibition. When in the G-Force exhibit, have students look for the "Planetary Bodies" graph. Compare the "Planetary Bodies" graph to their own. Students should add the relative gravity to their graphs.
6. Discuss findings and identify trends. Challenge students to determine how to calculate gravity on the surface of a planet.
7. As students struggle with the equation, give them clues. Tell them the equation is based on the radius of the planet, its mass, and the gravitational constant 6.67x 10-11m3kg-1s-2.
8. Have the class members share their ideas, and them tell them the equation is G=g*M/r2. Discuss this formula with students, and be sure to discuss why more mass increases gravity and why a larger radius decreases gravity on a planet's surface.

ORRERY

THE FASTEST PLANET

In this activity, students will calculate the speed a planet is traveling through space to determine which is going the fastest.

Grade level: Middle School

Performance expectation: Analyze and interpret data to determine the scale properties of objects in the solar system. MS-ESS1-3

Materials

- Calculator (optional)

Method

1. Ask students if all planets orbit the sun at the same speed. Ask why or why not. Discuss with students that a year is the time it takes any planet to orbit the sun. Ask students if the size of the planet or how far away a planet is from the sun influences how fast it travels. Have students predict which planet is traveling the fastest and slowest.
2. While in the Orrery exhibition, tell students that they need to calculate the speed at which each planet is orbiting the earth. You can either have students figure out how to calculate this, or tell them it is the distance of the orbit divided by the length (time) of the orbit.
3. Have the students share their results, and ask them to identify trends. Students should notice that the planets move faster the closer they are to the sun. If students want to learn more, have them investigate Kepler's Third Law.

BUILD A HABITAT

CONSTRUCTING A SPACE STATION

In this activity, students will design a water bottle to resist changing temperature.

Grade level: Middle School

Performance expectation: Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer. MS-PS3-3

Materials

- 16-ounce water bottle
- Various art supplies (Styrofoam, colored paper, rubber bands, food coloring, etc.)
- Thermometer

Method

1. Ask students what they think would be the most important aspect of a house that is built on the moon.
2. Discuss with students how the temperature on the moon fluctuates from being very hot (around 1000 C) and very cold at night (minus 1750 C). Discuss that the temperature fluctuates so much because of the moon's lack of an atmosphere and its inability to store heat.
3. Tell students that they are going to be challenged with building a model moon station that is resistant to changes in temperature. Their station is going to be a bottle of water. Each group will get a bottle full of water and will be challenged with designing it so that it resists temperature change.
4. Talk to students about coolers, thermal mugs, and other things that are commonly used to keep beverages warm or cold. Brainstorm ways students can construct their bottle to contain some of these properties.
5. Have groups discuss and sketch their bottle station. Once you have seen their ideas, give groups their bottle and access to the materials. Give students time to construct their bottle homes.
6. When all groups are done, have them record the current temperature of the water in their bottle. Place the bottle in a freezer and wait for an hour. Remove the water bottle, record the temperature, and calculate the change from its initial temperature.
7. Have students share their results and discuss why some models worked better than others.
8. Assuming it is hot enough outside, have students place their bottles in the sun for an hour and record the change in temperature. If not, have them place their bottles near a heat source like a heating vent. Students should discuss how and why the models did better or worse in the cold as compared to the heat.
9. Come back together as a class and discuss the results, and ask them if they were to build another bottle what improvements they would make.

PICK YOUR CREW

PICK YOUR CREW

In this activity students will identify what characteristics are needed to make a great group.

Grade level: 3 to 5

Performance expectation: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost. **3-5-ETS1-1**

Materials
None

Method

1. In the 'Pick Your Crew' exhibit, students answered questions to identify their personality type and then tried to determine what other types of personalities would complement them while traveling to space. In this activity, students generate a list of characteristics that are needed to successfully complete a school project. This activity is a great way to determine groups for the design challenges in this Educator Guide.
2. Have students share what their personality type was from the 'Pick Your Crew' exhibition. Ask students if they agree with the personality type they were given. Have students share which questions they thought helped best answer what type of personality they were.
3. As a class, discuss and list the traits that make a good group member for school projects, and come to a class consensus on the four or five traits that are most vital and that best complement one and another.
4. Put students into random groups, and assign one trait to each group. Have each group create a 5-10 question survey that helps answer whether or not a person fits that personality trait. For example, if the personality trait is task master, a possible question could be, "Is it more important to complete your homework on time or to make sure your work is 100% accurate?"

   Compile all the survey questions give to each student. Have each student identify their personality type, and create groups accordingly.

SURFACE EXPLORATION VEHICLE

EXPLORE EARTH

In this activity student's use Google Maps to explore the patterns of Earth's features.

Grade level: 4

Performance expectation: Analyze and interpret data from maps to describe patterns of Earth's features. **4-ESS2-2**

Materials

- Access to Google Maps

Method

1. Ask students how scientists knew about other planets before they could actually travel to them. Talk to them about how satellites and unmanned spacecraft send images of the planets back to Earth and how scientists use this data to try to determine what the planets are like.
2. Tell students that we don't have access any satellites or unmanned spacecraft, but we do have Google Maps. Put students in groups, and tell them that they are going to explore Earth's features using Google Maps.
3. Ask students what some of Earth's features are. The responses can range from anything from mountains to oceans to deserts. Record responses on the board.
4. Assign each group a computer, and tell them they are going to look for patterns in the Earth's features. First, students should find each continent and describe the color each side. For example, the south is brown and dry; the east and west are green and wet; and the north is white with ice. Next, students should choose one or two of the features listed on the board and find them all over the world using Google Maps. After finding them, they should describe the colors and other features around them. For example, it is dry to the west of the mountains and wet to the east.
5. Once students have finished their exploration, share out results as a class. Identify any trends, and offer explanations for the patterns they see.

WHAT TO PACK

PLANNING YOUR TRIP

In this activity, students will pretend that they are planning a trip to a planet by researching its characteristics and packing their bags with the things they'll need.

Grade Level: 1

Performance expectation: Analyze and interpret data to determine scale properties of objects in the solar system. **MS-ESS1-3**

Materials

- Internet access

Method

1. Tell students that they need to pack their bags for a vacation to a nearby planet, but before they go, they need to figure out what they should bring. Just like with a vacation on Earth, it's important to understand where you're going and what you'll need!
2. Assign each student a planet or a moon, and have them conduct research on what that planet is like. They need to research things like size, composition of atmosphere, topography, temperature, etc.
3. Once students have finished researching, they need to create a presentation that includes a list of things they will pack and explain why they packed those things. Some examples might be to bring weighted boots because there is so little gravity or bring a flying suit because the planet is made of gas. Encourage students to be creative as long as what they pack is based on information about their planet.
4. Have students present to the class.

SPACE POTATOES

OPTIMAL GROWING CONDITIONS

In this activity students will identify the conditions most vital in growing plants.

Grade level: Middle School

Performance expectation: Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.
MS-LS1-5

Materials

- Bean seeds
- Various types of soil
- Plant pots of various sizes
- Water
- Light

Method

1. After visiting Planet Pioneers, tell students that they are going to pretend to make a colony on Mars. Most of the logistics have been worked out, but they need to determine the optimal conditions to grow food.
2. Ask students what is needed for plants to grow, and list their answers on the board. Students should list things like amount of water, amount of light, type of soil, and amount of soil. Be sure they list responses as something measurable. For example, if students give an answer of "water," help them rephrase their response to include the amount of water.
3. Put students into groups, and tell them that each group is going to choose one of the variables listed on the board and is going to design an experiment to see how that variable influences the growth of beans. Each group will get three beans and will grow their beans under three different conditions.
4. Each group should develop their experiment so that only their variable is manipulated. Meaning: if a group chooses amount of water, they need to determine how much water to give each of their three bean plants. They also need to be sure that all the other variables stay the same. For example, the amount and type of soil will need to be the same. The exposure to sunlight needs to be the same. Everything other than amount of water should stay the same.
5. After checking each group's experimental design, have each group conduct their experiment. Students should grow their beans for a month and collect data on the beans' height every other day.
6. After a month, have each group graph their results and post them around the room. As a class, discuss the results. Which variables seemed to be the most important, and which were less important?
7. Based on the data, have each group determine what they think are the optimal conditions to grow bean plants. Give each group one more pot and bean, and tell them these are the beans they are taking to Mars. Give them one month to grow their beans under these conditions, and come together as a class to discuss their results.

PROJECTILE LAUNCH

CATAPULT LAUNCH

In this activity, students will design, build, and revise a catapult and try to launch a mothball into the target area.

Grade level: 3

Performance expectation: Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved. 3-5-ETS1-3

Materials

- Popsicle sticks
- Plastic spoon
- Mothball
- Rubber bands

Method

1. After visiting Planet Pioneers, ask students how scientists can get spacecraft to land exactly where they want. Talk to students about the engineering design process then tell them that they are going to be space scientists and design a catapult that will be able to land their spacecraft (mothball) precisely where they want.
2. Put students into groups, and pass out the materials. Have each group create the same catapult by following these steps:

Step 1: Make a stack of four popsicle sticks and rubber band them together on each end.

Step 2: Take two other popsicle sticks and stack them together. Rubber band one end.

Step 3: Pull the two popsicle sticks apart and place the 4-stick stack between them to make a cross.

Step 4: Rubber-band the 4-stick stack to the 2-stick stack.

Step 5: Rubber-band the handle of the spoon to the upper popsicle stick in the 2-stick stack. The head of the spoon should extend just beyond the end of the top popsicle stick.

3. Sit in a circle, and place a target in the middle. Have each group launch the mothball by placing it in the spoon, pulling the spoon down and releasing it.
4. Discuss with the class if their catapults where accurate or not. Discuss ways to improve both the design and how to launch the mothball.
5. Give students more rubber bands and popsicle sticks and allow them to experiment with different ways to make their catapult more accurate.
6. Sit in circle again, and test new designs. Come back together as a class, and discuss the various design solutions.

SCAN THE PLANET

FIND THE ICE

In this activity, students will use Google Earth to calculate how the amount of ice varies longitudinally.

Grade level: 4

Performance expectation: Analyze and interpret data from maps to describe patterns of Earth's features. 4-ESS2-2

Materials

- Computer with access to Google Earth

Method

1. Scientists use satellite images to try to discover minerals and ice on other planets. Ask students what types of things they would look for in the satellite images.
2. Tell students that we have access to very specific satellite images using Google Earth. Tell students that they are going to become scientists and try to find a pattern of where ice is located on Earth.
3. Put students into pairs, and give them access to a computer, and load Google Earth. Ask students to predict what location on Earth has the highest percentage of ice.
4. Show students on a globe where the Equator, Tropic of Capricorn, and the Tropic of Cancer are. Tell students that they are going to use Google Earth to scan all the land in four zones (North Pole to the Tropic of Cancer, Tropic of Cancer to Equator, Equator to Tropic of Capricorn, and Tropic of Capricorn to the South Pole).
5. Give students time to explore the Earth and look for ice. Have students estimate then record the percent of land covered by ice in the four zones. Students should also record other observations they have (for example, ice is often found near mountains).
6. Have students share their results and discuss the patterns they find. Talk to students about why there is more ice on top of mountains and the farther you move away from the equator.

DESIGN CHALLENGE!

FIX THE PROBLEM

EGG DROP

In this design challenge, students will design and construct an egg drop device. The goal is to be able to drop an egg from 10 feet without it breaking.

Grade level: Middle School

Performance expectation: Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. **MS-ETS1-3**

Materials

In parentheses are the prices that will be used during the activity.

- Toothpick ($2)
- String ($2)
- Paperclip ($2)
- Straw ($3)
- Cotton ball ($5)
- Pipe cleaner ($5)
- Rubber band ($5)
- Paper ($6)
- Cotton ($10)
- Newspaper ($20)
- Balloon ($20)
- Plastic sheet ($20)
- Eggs

Method

1. Discuss with students that one of the most difficult aspects of space travel is calculating how to land on planets with different forces of gravity and different atmospheres than Earth. In this activity, students will be given the design challenge to build a device that can drop an egg 10 feet without it breaking for as cheaply as possible.
2. Put students into groups, show them materials they will be able to use, and give them 10 minutes to discuss their design. Have groups share their ideas to the class.
3. Tell students that they will need to work within a budget. Post the cost of the materials on the board, and tell groups they have a budget of $100. Have groups sketch their design and calculate the cost of the materials.
4. Give teams 30 minutes to construct their devices then take them outside and have groups test their creations one at a time. Discuss which designs work and which don't.
5. Have students revise and test their devices again and discuss what improvements were made.
6. Reflect on the design challenge as a class, and discuss the relationship between the cost of devices and how successful they were.

DESIGN CHALLENGE!

LAND THE ROCKET

PARACHUTES

In this design challenge students will learn the principles of conducting controlled experiments by designing and constructing parachutes.

Grade level: 3 to 5

Performance expectation: Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved. **3-5-ETS1-3**

Materials

- Tissue paper
- Newspaper
- Paper clips
- Washers
- String
- Plastic bags
- Coffee filters
- Tape
- Aluminum foil
- Stopwatch

Method

1. Tell students that similar to what they did in the Land the Rocket exhibit, they are going to design, build, and test a parachute with the goal of hitting a target and having the slowest descent rate of any group in the class.
2. Draw a picture of a parachute on the board, and ask students to list all the variables that can be manipulated on it. Put the list on the board. The list should include things like length of the strings, type of material, and size of the parachute top. Tell students that these are the independent variables. The dependent variable will be the descent rate.
3. Tell students that each group will choose ONE variable to test how it effects the descent rate. Have groups choose one of the variables on the board and create three parachutes where their variable is different on each. For example, if students choose string length, they would make one parachute with 5cm strings, one with 10cm strings, and a third with 15cm strings. Tell students that all other variables need to stay the same. For this example, the size of the top of the parachute, the type of material, and all other aspects of their three parachutes should be exactly the same.
4. Test parachutes by dropping them from 10feet and recording the time it takes for them to reach the ground. Have groups graph their results and post graphs around the room.
5. Have students make observations of the graphs and discuss the results. Have students discuss what would be the best design, and have students design, construct, and test their new and optimal parachute.
6. Come back together as a class, and discuss which designs had the best results and why. Discuss what worked and didn't work in the design process.

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