This instructional segment will engage students in the study of machines, the effects of balanced and unbalanced forces, and the way gravity affects motion.

Student Science Performance

Grade or course: Fourth Grade	**Title:**
Topic: Force and Motion	Life in Motion

Performance Expectation for GSE:
S4P3. Obtain, evaluate, and communicate information about the relationship between balanced and unbalanced forces.

a. Plan and carry out an investigation on the effects of balanced and unbalanced forces on an object and communicate the results.
b. Construct an argument to support the claim that gravitational force affects the motion of an object.
c. Ask questions to identify and explain the uses of simple machines (lever, pulley, wedge, inclined plane, wheel and axle, and screw) and how forces are changed when simple machines are used to complete tasks.
(*Clarification statement:* The use of mathematical formulas is not expected.)

Performance Expectations for Instruction:
Students will

- Examine machines to look for components such as simple machines that help them work: screws, pulleys, levers, wedges, inclined planes, wheels and axles.
- Discover how life is different on the International Space Station because of microgravity.
- Investigate the difference between balanced and unbalanced forces and what causes an object to move.
- Use common materials and toys such as balls, marbles, toy cars, etc. to investigate how gravity and force affect movement.
- Measure and collect data to analyze and explain results.
- Find out about spin-offs of technology used that originated in the space programs.

Additional notes on student supports

Material suggestions: balls, marbles, toy cars, ramps, flexible tubing, balance scales, spring scales, meter sticks or tape, cans (empty and unopened), simple toys such as dominos, tops, yo-yos, etc.

Students will continuously obtain, evaluate, and communicate information. This is not a linear process. Students will communicate through writing and discussions to allow for formative assessment. This benefits the teacher, student, and whole group to guide instruction to clarify misconceptions or extend content.

Engaging Learners	**Phenomenon** Small Rube Goldberg Machines This is a compilation of small contraptions that show energy transfer using common materials to show the effects of balanced (didn't move) and unbalanced (resulting motion caused by another object colliding) forces. Have students ask questions about how these machines work. Have them think about machines in their everyday lives. Give them the following scenario: "You wake from a strange dream. You dreamed there were no machines in the world. Look around you and list all of the questions you would have if you lived in a world without machines." In small groups, have students take three machines they would miss the most and tell why and how life is changed without those inventions.

	Evaluating What machines would you want to invent first? Why? If you can find out all of the parts of the machine, you could get the parts and put them together.
	Communicating Sketch your machine and label all of its parts. Look for these simple parts of a machine: lever, pulley, wedge, inclined plane (ramp), wheel and axle, and/or screws. Does your machine contain any of those simple parts? Let's find out why.
	Obtaining Divide the class into small groups. Give each group the name of a simple machine: lever, pulley, wedge, inclined plane, wheel and axle, screw. Tell them that they are responsible for finding out the following information: ● What does this help us do? ● What does it look like? Draw a picture, take a picture, or cut out a picture of this machine in action. ● Find as many examples of where it is found as you can. ● How would your life change if this machine was no longer available? Students can organize their work on this handout: Simple Machines at Work. Have groups share their information with the rest of the class.
Exploring	*Obtaining*  ESA (European Space Agency) astronaut Samantha Cristoforetti waits next to the newly installed ISSpresso machine. The espresso device allows crews to make tea, coffee, broth, or other hot beverages they might enjoy. The International Space Station must consider all of the forces that behave differently in an atmosphere with a zero-gravity environment. Devices like these are a part of our everyday lives but think about all of the parts and simple machines that go into a device that works without gravity! It is mind boggling! Here is a video of Astronaut Commander Chris Hadfield showing how a simple thing like wringing water out of a washcloth is different. Wringing out a washcloth on the ISS Think about a day with zero gravity. How would your actions change during the day? Write a story about "A Day at School without Gravity" telling about what you think it is like.
	Communicating Well-known products that NASA claims as spin-offs include memory foam (originally named temper foam), freeze-dried food, firefighting equipment, emergency "space blankets", Dust Busters, cochlear implants, LZR Racer swimsuits, and CMOS image sensors.

<table>
<tr><td></td><td>Have the class record a list of machines that were invented because of a need for them to help do work. Have small groups take one of those inventions, tell its history, and list the simple machines in the invention that make them work.

For example:
<table>
<tr><th>Invention</th><th>Need for invention</th><th>Simple machines in invention so it will work</th><th>Sketch, drawing or picture</th></tr>
<tr><td>Pencil with an eraser</td><td>To make writing and correcting easier and less messy than charcoal stick or quill pen
The concept of a pencil we most commonly known today is the concept of a writing point on one side, an eraser on the other, and a wooden shaft. This idea was patented by Hymen Lipman on March 30th, 1858.</td><td>Lever</td><td>  </td></tr>
</table>

Teacher Notes: Some technology like ladders, stairs, etc. don’t have an inventor, but are good examples of inclined planes. Spin offs like escalators and elevators do have inventors.</td></tr>
<tr><td></td><td>Evaluating and Connecting
Show students various classroom objects and have them find the simple machines that make them work such as scissors (lever and wedge), stapler (lever), staple (lever and wedge), ballpoint pen (screw, lever), rolling cart (wheel and axle), water faucet handle (wheel and axle, lever, and possibly connected by a screw), door knob (wheel and axle), hinge on door (lever), stairs or ramp (inclined plane), curtain or blinds (pulley), etc. Have students use measurement to explain how these simple machines make it easier to do work.
Teacher Notes: For example, pulling a string on the window blinds instead of climbing a ladder to fasten the blinds to the top of the window. What is the difference in length? Or carrying a load of books instead of using a cart to push a load of books.</td></tr>
<tr><td>Explaining
Finalizing Model</td><td>Obtaining
5 Fun Things to Do without Gravity
Over the course of its near 15 years of continuous habitation, 220 people from 17 different nations have visited the International Space Station. Astronauts onboard are typically active for at least 9 ½ hours per day doing science, exercising, and maintaining systems. Excluding scheduled time for sleep and lunch, astronauts have only 4 hours of free time per day during the workweek, and that includes time for meals and general hygiene.</td></tr>
</table>

	Even with a loaded calendar, the few who have such an opportunity to live in the microgravity environment find ways to make the most of this experience. Here are a just few of their favorite things about living in space:
	Evaluating Have students discuss questions in small group: ● Would these machines behave differently on the International Space Station? Why or why not? ● If they would work differently, how would modifications help? ● What other questions do you have about machines on the International Space Station? ● How can you find out answers to these questions?
	Communicating Have students use their research to construct an argument based on the claim that machines work differently in zero gravity than when they are on Earth.
Elaborating Applying Model to Solve a Problems	**Phenomenon** Video of astronauts playing with a soccer ball Soccer on Earth and Soccer on the ISS Playing games on the International Space Station When an astronaut plays with a soccer ball in zero gravity on the International Space Station, how is it different from when you play with a kickball or soccer ball on Earth? Football on the ISS This 8-minute video begins with the astronaut setting up the camera and finding the materials. Preview the video to see what portion you wish to use with your class to show how the sport is different in zero gravity. STEM Lessons from Space This resource contains several lesson plans and videos to use to show the differences on the International Space Station and Earth. International Toys in Space Choose the ones you want to share with the class. Pause the video to have students discuss what will happen to the movement of the toy without gravity and with gravity. Have an example of the one you choose for students to try the activity in the classroom so that they can see the difference first hand.
	Obtaining Objects stay in place because the forces acting on them are equal and balanced. What force is acting on a ball sitting on a desk? What force could put the ball in motion? Use a ruler that has a groove down the middle and set it on a level table. Place 5 marbles touching each other in the groove. Take a different marble and roll it into the 5 marbles. What happened? If the force was equal, only one marble rolled away leaving 5 marbles.

	Try rolling 2 marbles into the 5 marbles touching each other. What happened? If the force was equal, 2 marbles rolled away. Continue doing the same thing with 3 marbles, 4 marbles and finally 5 marbles. What happened? What do you think would happen on the International Space Station? Explain your thinking. Have pairs of students plan and carry out investigations to show how an unbalanced force causes the motion of an object to slow down, speed up, or change direction.
	Have students use various balls, marbles, toy cars, and ramps to investigate how balanced and unbalanced forces affect objects. Have students collect data from their investigations such as weight, distance traveled, etc. **Investigation ideas:** ● They can investigate how changing the angle of the ramp or length of the ramp changes the ball's movement. ● They can change the surface of the ramp to discover how friction changes the ball's movement. ● They can use flexible tubing to make ramps that bend and form curves. ● They can measure the weight of the rolling object to see if the weight makes a difference in the ball's movement or distance traveled. ● They can use dominoes or blocks to see how a rolling object transfers energy to move the domino or block. ● They can use different cans (empty and unopened) to see if the contents make a difference as they roll down a ramp.
	Evaluating and Communicating Students will present their ideas to the class with a demonstration showing steps for others to follow to do the same thing. Have them write, sketch or record their findings explaining when the force was balanced or equal and when the force was unbalanced.
Evaluation	***Assessment of Student Learning***
	Formative Assessment Students imagine life without machines. This gives the teacher insight to how much students know about machines and their components.
	Students use journals and writing to share their thinking and explanations. Handouts help students organize their research. Students record data from investigations to show measurements and results.
SEP, CCC, DCI	**Science Essentials**
Science and Engineering Practices	● Asking questions and defining problems ● Constructing an argument from evidence ● Developing and using models ● Analyzing and interpreting data
Crosscutting Concepts	● Energy and Matter ● Cause and Effect

Disciplinary Core Ideas	From *A Framework for K-12 Science Education*: ● PS2.A: FORCES AND MOTION ● PS2.B: TYPES OF INTERACTIONS ● PS2.C: STABILITY AND INSTABILITY IN PHYSICAL SYSTEMS ● PS3.C RELATIONSHIP BETWEEN ENERGY AND FORCES

Additional Supports for struggling learners:

The following supports are suggestions for this lesson and are not the only options to support students in the classroom. These supports target students that struggle with science material, this lesson or a previous lesson. These are generalized supports and do not take the place of IEP accommodations as required by each student's Individualized Education Program.

General supports for the following categories:

Reading:	Writing:	Math:
1. The teacher can have students match letters prior to reading to remind them of the alphabet. 2. The teacher can have students identify words that they know in the text as the class reads. 3. The teacher should remind students to use strategies when they are reading.	1. The teacher can provide practice for students in the area of writing both in context and practicing just letters. 2. The teacher can provide a sentence starter for the students. 3. The teacher should continually give encouragement to the students. 4. The teacher can provide constructive positive feedback during the writing process to help students understand the expectations.	1. Provide students with opportunities to interact with numbers. 2. The teacher can provide manipulatives to allow the students to count and interact with materials.

Supports for this specific lesson if needed:

Performance expectations for instruction:

1. The teacher should provide information to students in various formats to reach as many students as possible.
2. The students should be given adequate time to complete each part of the lesson.
3. The students should be allowed to express their knowledge in various formats.
4. The teacher should be sure to provide multiple ways for the students to communicate their knowledge of the material.

Engage:

1. The teacher should consider showing the video more than once to allow students to make observations about the Rube Goldberg Machines.
2. The teacher should consider providing students with question stems to assist students with generating questions.

3. The teacher should consider reading aloud the scenario so that students can begin to think about machines that they use in life.
4. The teacher should use intentional and flexible grouping to group students. Best practice is to use data to drive student groupings.
5. The teacher should be sure to provide multiple ways for the students to communicate their knowledge of the material. This could include labeling images, drawing pictures, writing or verbally explaining.
6. Students may need additional time to complete their assignment.
7. The teacher should provide students with multiple formats to share their work. These formats could include using technology, gallery walks or presentations.
8. The teacher should be prepared to repeat directions as needed.

Exploring:

1. The teacher should have clear and consistent discussion guidelines. These guidelines should make students feel more comfortable and be more likely to participate.
2. The teacher should consider showing the video more than once as needed for students to make observations.
3. The teacher should be sure to provide multiple ways for the students to communicate their knowledge of the material. This could include labeling images, drawing pictures, writing or verbally explaining.
4. Students may need additional time to complete their assignment.
5. The teacher should consider providing students a list of products that NASA has helped develop. Then have the students research one of the products to see how NASA contributed to their design.
6. The teacher should consider providing students with sources to use in their research.
7. The teacher should consider providing students with an organizer to record information from their research.

Explaining:

1. The teacher should have clear and consistent guidelines for discussions. These guidelines should help students feel more comfortable and more likely to participate in the discussion.
2. The teacher should use intentional and flexible grouping to group students. Best practice is to use data to drive student grouping.
3. The teacher should consider providing students with an organizer to construct their argument.
4. The teacher should be sure to provide multiple ways for the students to communicate their knowledge of the material. This could include labeling images, drawing pictures, writing or verbally explaining.
5. The teacher should provide students with multiple formats to share their work. These formats could include using technology, gallery walks or presentations.
6. Students will need additional time to complete their assignment.

Elaborating:

1. The teacher should have clear and consistent guidelines for discussion. These guidelines should help students feel more comfortable and be more likely to participate.
2. The teacher should consider showing videos more than once as needed for students to make observations.
3. The teacher should have clear and consistent guidelines for the activity. These guidelines should help students feel comfortable, be more likely to participate and ensure a safe experience for all students.
4. The teacher should have students make observations as they move through the activity. Then discuss these observations.

5. The teacher should consider showing the video more than once for students to make observations.
6. The teacher should consider providing students with an organizer for students to use to plan their investigation.
7. The teacher should use intentional and flexible grouping to group students. Best practice is to use data to drive student groupings.
8. The teacher should have clear and consistent guidelines for students working in groups. These guidelines should help students feel more comfortable and be more likely to participate in group work.
9. The teacher should be sure to provide multiple ways for the students to communicate their knowledge of the material. This could include labeling images, drawing pictures, writing or verbally explaining.
10. The teacher should provide students with multiple formats to share their work. These formats could include using technology, gallery walks or presentations.

Evaluating:

1. Students may need additional time to complete their assignment.
2. The teacher should be sure to provide multiple ways for the students to communicate their knowledge of the material. This could include labeling images, drawing pictures, writing or verbally explaining.

Simple Machines at Work

Machine we are researching _____

Draw a picture, take a picture, or cut out a picture of this machine in action.

What does this help us do?	Find as many examples of where it is found as you can.	How would your life change if this machine was no longer available?

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