A Wild Ride! Week 2: Grades 3-5

<table>
<tr><th>Day</th><th>Topics</th><th>Related Standards</th></tr>
<tr><td>1</td><td>Are You Up For a Challenge?</td><td>Define problems and design solutions pertaining to force and motion.</td></tr>
<tr><td>2</td><td>I Push, You Pull!</td><td>Obtain, analyze, and communicate evidence of the effects that balanced and unbalanced forces have on the motion of objects.

Define problems and design solutions pertaining to force and motion.</td></tr>
<tr><td>3</td><td>Don’t Look Down!</td><td>Construct an explanation using evidence to demonstrate that objects can affect other objects even when they are not touching.

Obtain, analyze, and communicate evidence of the effects that balanced and unbalanced forces have on the motion of objects.

Define problems and design solutions pertaining to force and motion.</td></tr>
<tr><td>4</td><td>Challenge Accepted!</td><td rowspan="2">Define problems and design solutions pertaining to force and motion.</td></tr>
<tr><td>5</td><td>How Can We Make It Even Better?</td></tr>
</table>

A Wild Ride! Week 2

Day 1: Are You Up For a Challenge?

Teacher/Parent Background:

Scientists and engineers are always faced with challenging questions and problems. In order to best explain the world around them or propose valuable solutions, scientists and engineers follow steps to accomplish these goals. In engineering fields, engineers use the Engineering Design Process to propose solutions to problems in order to make the world a better place.

Overview:

What do scientists and engineers do when they are faced with a challenge? In this activity, students will be introduced to the strategies of scientists and engineers by learning about the steps of the Engineering Design Process in order to begin defining their own, week-long challenge: *How can we design a roller coaster using force and motion concepts?*

Related Standards:

- Define problems and design solutions pertaining to force and motion.

Key Terms:

- Scientists: people who ask questions, experiment and explain the world around them
- Engineers: people who design and build things to solve specific problems
- Engineering Design Process: a set of steps engineers use to propose solutions to problems
- Constraints: limitations or restrictions

Materials List:

- Internet access
- Journal
- Pen/pencil
- Computer/phone with audio
- *Student Resources - Pages 5-6*
    - *Scientist Pictures*
    - *The Engineering Design Process Image*
    - *Step 1: Ask Table*

Activity Description:

- Ask students to share a recent problem or challenge they were faced with and how they went about solving the problem. For example:
    - Problem:
        - My bike tires became flat.
    - Steps:
        - I asked questions about what caused the tires to go flat.
        - I asked my family and friends what they have done when their bike tires have become flat.
        - I learned about how to repair flat bike tires by listening to the advice/past experiences of family/friends and by watching a video.
        - I used the appropriate tools to fill the tires with air and then tested the bike out by riding it around the neighborhood.
        - I asked questions about how the bike tires are riding now and if any changes need to be made to make them ride even better.
- Tell students that scientists and engineers are also often faced with challenges. Ask students to describe what they think a scientist and an engineer are and what they do. Then, show students examples of different kinds of scientists and engineers, using the *Scientist Pictures* and *What is an Engineer? Video*.
- Explain to students that scientists and engineers are people just like us; people who are curious and want to know more about the world, including how to make it a better place for all!
        - *Scientists* are people who ask questions, experiment and explain the world around them.
        - *Engineers* are people who design and build things to solve specific problems.
    - Facilitate the following discussion with students:
        - Have you ever been a scientist or engineer? Indeed, you have!
        - When you ask questions and investigate/perform an experiment in order to explain something about the world around you, you are a scientist!
        - When you ask questions about a problem and design/build things to test out possible solutions, you are an engineer!
    - Show students the *Engineering Design Process Image* and explain each step of the process, encouraging them to record main ideas.
        - **Step 1: Ask** -
            - Ask questions about the problem.
            - Consider what you need to know to solve the problem.
            - Ask about what others have done to solve the problem/similar problems.

- Consider the *constraints* or limits you have to stay within while solving the problem.
  - Example: time, materials, etc.

- **Step 2: Imagine** -
  - Now that the problem has been clearly explained/defined, brainstorm more than one possible solution to the problem.
  - Draw and label diagrams, write-out words/phrases to help you brainstorm!
  - Pick your best solution to share with others.
- **Step 3: Plan** -
  - Share your best solution with others on your design team. Listen to the solutions of your peers, as well.
  - Work together to decide on one best solution to be built by the team. This solution should include ideas from the team; not just one member's ideas!
  - Draw and label a design of your solution and create a materials list with types and amounts of materials needed.
- **Step 4: Create** -
  - Build your design with your team!
  - Stick to your plan, including only using the types and amounts of materials you asked for.
  - Test it out! How did your solution work?
- **Step 5: Improve** -
  - Reflect on the results of your testing experience. What worked well? What didn't work so well?
  - Consider/discuss what your team can do to make your design better.
  - Re-plan, re-create and re-test your improved design. How did your solution work this time?

- Explain to students that they will be using the Engineering Design Process to address this week's challenge: *How can we design a roller coaster using force and motion concepts?*
- Guide students through the "Ask" step of the Engineering Design Process by asking students to record ideas/questions in the *Step 1: Ask Table*. See example below:

What is the problem?	What do you need to know to solve the problem?	What have others done when solving a similar problem?

- Possible student responses may include:
    - I need to know...
        - What is force and motion?
        - How does a roller coaster work?
        - What materials do we have to build the roller coaster?
        - How much time will we have to build the roller coaster?
    - Others have...
        - Used an app. or game to build online roller coasters.
        - Used metals, bolts, screws, plastics and wood to build roller coasters, like at *Disneyland* or *Castles N' Coasters*.
        - Built tracks and carts so that passengers can ride in roller coasters.
- Tell students that although we may not have the answers to these questions or "need to knows" at this time, we will find them out together in order to build our own roller coaster at home, just like an engineer!

Closure:

- Ask students to think back to how they described what a scientist and an engineer are and what they do. Engage in a discussion with students:
    - How would you now describe what a scientist and engineer are and what they do, based on what you learned today?
    - Thinking about what engineers do, what are you most looking forward to as we begin the roller coaster challenge?

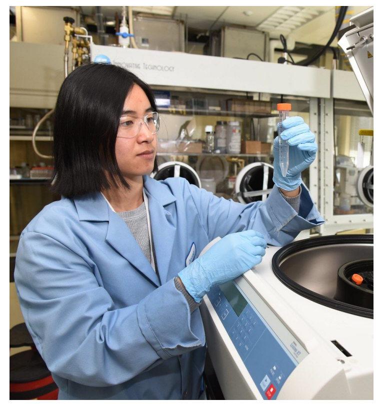
Extensions:

Watch: Crash Course Kids: *The Engineering Process*

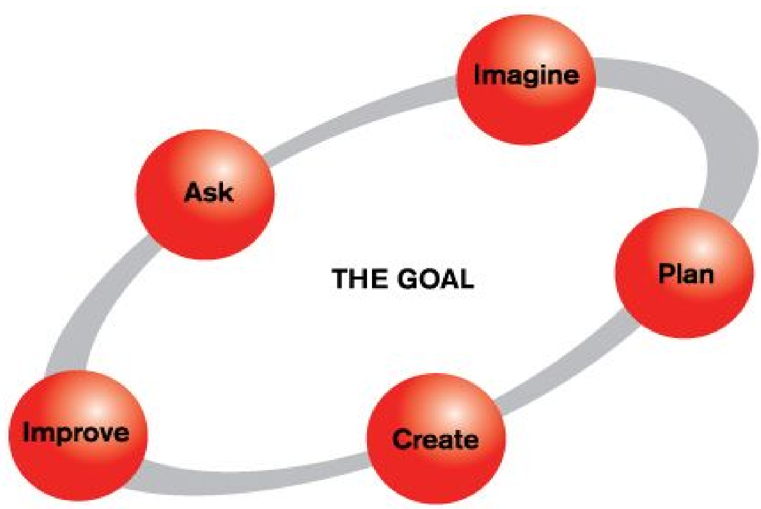
Research: Science Buddies: *Careers in Science*

Student Resources

Scientist Pictures

Zoologist	Environmental Scientist	Chemist
Studies animals	Studies environmental/health hazards	Studies the substances that make up the world around us
	 *Scientist Image: U.S. News, What to Do With an Environmental Science Degree?, 2019.*	

Engineering Design Process Image



The Engineering Design Process, EiE, Museum of Science, Boston.

Step 1: Ask Table

What is the problem?	What do you need to know to solve the problem?	What have others done when solving a similar problem?

A Wild Ride! Week 2

Day 2: I Push, You Pull!

Teacher/Parent Background:

Examples of force and motion are all around us! In science, motion describes the change of an object's position and a force describes a push or a pull. Forces cause motion and can be applied by pushing and/or pulling on objects. Factors such as the weight of the object and the strength of the force can impact an object's speed.

Overview:

In this activity, students will engage in a hands-on investigation to explore how forces (pushes or pulls) affect the motion of various household objects! Students will return to their week-long challenge: *How can we design a roller coaster using force and motion concepts?*, in order to reflect upon what they have learned that will help them address the challenge and what they still need to know to move forward.

Related Standards:

- Obtain, analyze, and communicate evidence of the effects that balanced and unbalanced forces have on the motion of objects.
- Define problems and design solutions pertaining to force and motion.

Key Terms:

- Position: the location of an object
- Force: a push or a pull
- Motion: change of position
- Speed: the measurement of how far an object moves in a certain amount of time

Materials List:

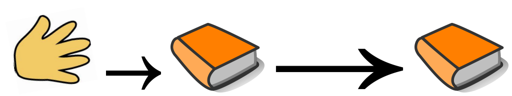
- Internet access
- Journal
- Pen/pencil
- Colored pencils/crayons
- Various household objects - tables, floor spaces, books, doors, chairs, balls
- *Student Resources - Pages 6-7*
    - *Investigation Data Table*
    - *Learned Chart*

- Computer/phone with audio - optional for *Extensions*

Activity Description:

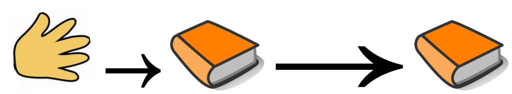
- Ask students to review the "Ask" step of the Engineering Design Process from *Day 1: Are You Up For a Challenge?*. Briefly discuss with students:
  - How do engineers begin to solve a problem they are faced with?
  - Just like engineers, you have been given a problem to solve! What is your challenge for the week? What do you need to know to help you solve the problem?
- Explain to students that they are going to investigate what force and motion is in order to begin answering their "need to knows". Ask students to discuss the following:
  - What do you think of when you hear the word "force"?
    - Possible student responses may include:
      - Being made to do something.
        - "I was forced to clean my room."
      - Using strength to break something open or set something free.
        - "The lid was stuck, so I had to force the pickle jar lid open."
  - In all of these descriptions, there is something they all share or have in common. All of these descriptions result in an action taking place, something has to change. Let's investigate these ideas with some objects around the house to see if "force" does in fact refer to an action taking place, resulting in something changing.
  - Review the following investigation directions with students:
    - Using various objects (books, chairs, balls, etc.) around the house, do something to the objects/make an action take place to make something change. Record your observations.
      - Show students an example:
        - For example, I will slide a book across the table using my hand.
        - In this situation, sliding the book with my hand was the action taking place and the book moving to the other side of the table was the result; the book's *position* or location changed.
        - Let's record this example in a data table, to represent our observations of the action taking place and the result.
          - Show students what to record in the ***Example*** row of the *Investigation Data Table*:

- Draw a diagram of this example to show to students. Show students how to use arrows to show an action taking place and its result.
- Ask students to record this in the ***Example*** row of the *Investigation Data Table*. See example below:

Objects	Action	Result	Diagram of Action and Result
Example: Hand and book	Hand slides the book across the table	The book moves to the other side of the table.	

  - Then, ask students to discuss:
    - How could we bring the book back to it's first position by doing something to the book/making the book undergo an action?
    - Ask students to discuss. Possible student ideas may include:
      - We could move to the other side of the table and slide the book back.
      - We could stretch our arm out and drag the book back to our side of the table.
    - Ask students to explore their ideas with the book and record their results in the ***1*** row of the *Investigation Data Table*. Then, ask students to find two more objects around the house and record observations.
    - Once students have completed their investigation and recorded their observations, regroup.
- Tell students that when we first started this investigation, we were attempting to see if a "force" did in fact refer to an action taking place, resulting in something changing. Facilitate a discussion by asking:
- In our investigation, did we see something similar: Did we see actions taking place or changes as a result of the actions? What is an example of this?
  - Ask students to share their investigation observations. Possible student responses may include:
    - Yes, when actions took place, changes happened. For example, when I pulled the book it changed its position and moved closer to me.

        - Yes, actions made changes happen. I pushed a rolling chair and it slid really fast across the floor!
- Based on the observations you are sharing, you seem to be using the words "push" and "pull" to describe the actions taking place that are causing a change.
- In fact, in the science community, we describe a *force* as a push or a pull. Forces like pushes or pulls can cause *movement/motion*, or a change of an object's position. A "pull" moves objects closer to you and a "push" moves objects farther away from you.
- Let's return to our data tables to determine if a push or a pull was used to cause the motion of objects that we observed in each of our investigation examples.
    - Ask students to revisit their data tables and determine if a push or a pull was used in each example from their investigation to cause the motion of objects. Show students an example by returning to the ***Example*** row:

Objects	Action	Result	Diagram of Action and Result
Example: Hand and book	Hand ~~slides~~ **pushes** the book across the table	The book moves to the other side of the table.	

- Although a push or a pull caused the motion of objects during our investigation, let's compare and contrast the details of the actions/results.
    - Ask students to engage in a discussion. If students need more experience with the main ideas of the discussion questions, provide time for them to re-investigate. Key questions and possible student responses include:
        - Did you push and pull the same way each time?
            - No, sometimes I pushed or pulled harder or lighter.
        - How did pulling or pushing differently affect the motion of the object?
            - Pushing or pulling harder made objects move faster or travel farther, while pushing or pulling lighter made objects move slower or travel less far.
                - When I pushed hard on the book, it quickly reached the other side of the table! But, when I pushed on the book lightly, it took longer to reach the other side of the table.
        - In the science community, we use the word *speed* to describe the measurement of how far an object moves in a certain amount of time. How does how hard/soft you push or pull on an object affect its speed?

- When pushing very hard on an object, its speed increases.
- When pushing softly on an object, its speed decreases.

Closure:

- Now that we have conducted an investigation and discussed our results, what have we learned about force and motion?
    - Ask students to discuss and record what they have learned in the *Learned Chart*.
    - Significant student learnings should include:
        - A force is a push or a pull.
        - Forces cause the motion of objects.
        - Motion is a change of an object's position/its location.
        - The way I push or pull on an object affects its speed.
- Looking back at the "Ask" step of our challenge, what else do we need to know to move forward?
    - Ask students to revisit the "Ask" step and update/add new ideas to their tables. Possible student responses may include:
        - I need to know...
            - How does a roller coaster work?
                - I already learned what force and motion is, but how does force and motion make a roller coaster work?
            - What materials do we have to build the roller coaster?
            - How much time will we have to build the roller coaster?

Extensions:

Watch & Play: BrainPOP jr. *Pushes and Pulls*

Continue the investigation by providing students with objects of various weights (a light ball, a heavy ball, etc.) and prompt them to investigate what happens to objects of different weights when the same strength of force is applied. Prompt students to try their best to push/pull the same way each time; not much harder or softer!

- The lighter the object, the greater the speed.
- The heavier the object, the less speed.

Student Resources

Investigation Data Table

Objects	Action	Result	Diagram of Action & Result
Example:			
1:			
2:			
3:			

Learned Chart

I Have Learned…
•   •   •   •   •   •   •   •   •   •   •

A Wild Ride! Week 2

Day 3: Don't Look Down!

Teacher/Parent Background:

Not all forces can be directly observed! The force of gravity cannot be seen, however, its effects on objects all around us can be observed daily; as the force of gravity pulls objects towards Earth's center. In addition to forces causing motion, there are forces (frictional force) that oppose the motion of objects, slowing them down and eventually bringing them to a rest. Engineers make good use of these forces to construct safe, fun roller coaster rides!

Overview:

In this activity, students will engage in a hands-on investigation to explore how the force of gravity and friction affect the motion of objects. Students will return to their week-long challenge: *How can we design a roller coaster using force and motion concepts*?, in order to reflect upon what they have learned that will help them address the challenge and what they still need to know to move forward.

Related Standards:

- Construct an explanation using evidence to demonstrate that objects can affect other objects even when they are not touching.
- Obtain, analyze, and communicate evidence of the effects that balanced and unbalanced forces have on the motion of objects.
- Define problems and design solutions pertaining to force and motion.

Key Terms:

- Gravity: a force of attraction that pulls objects on Earth towards its center
- Friction: a force that opposes or slows down motion

Materials List:

- Internet access
- Journal
- Pen/pencil
- Colored pencils/crayons
- Computer/phone with audio
- Floor space
- Ball (medium size/weight)
- Ramp

  - Stack of books
  - Piece of cardboard/wood
  - Duct tape (as needed to secure the ramp)
- *Student Resources - Page 6*
  - *Ramp & Ball Data Table*

Activity Description:

- Ask students to review the "Learned" table from *Day 2: I Push, You Pull!*. Briefly discuss with students:
  - What did you learn about force and motion during our investigation?
    - A force is a push or a pull.
    - Forces can cause the motion of objects.
    - Motion is a change of an object's position, or its location.
    - The way I push or pull on an object affects its speed.
- It seems like we have already learned a lot about force and motion concepts to help us during our challenge! However, let's look back at the "Ask" step of our challenge; what else do we need to know to move forward?
  - Ask students to revisit the "Ask" step and discuss other "need to knows". Possible student responses may include:
    - How does a roller coaster work?
      - I already learned what force and motion is, but how does force and motion make a roller coaster work?
- In order to learn more about this, we are going to need to investigate how force and motion concepts make a roller coaster work!
- To begin, let's take a virtual field trip to visit a real roller coaster...*The Big Thunder Mountain Railroad* at Disneyland!
    - Play the video: *360° Ride on Big Thunder Mountain Railroad Disneyland*
- I don't know about you, but I could really feel those pushes and pulls as if I was actually riding the roller coaster in person! Let's discuss, what examples did you observe of how forces affected the roller coaster ride and it's passengers?
  - Ask students to discuss. Possible student responses may include:
    - The cart of passengers is pulled up the track, reaching hills.
    - Then, the cart of passengers zooms down the track, after reaching hills.
- It seems that the cart is pulled as it first starts to travel up the track and then, CLICK, CLICK, CLICK...it speeds down the track and the passengers go wild!

- But, there is not a giant hand pushing or pulling the cart down the track. What brings the cart down the track?
- In order to help us answer that question, let's investigate!
    - First, ask students to build a ramp on the ground, using the stack of books and a piece of cardboard/wood.
        - As needed, assist students in using duct tape to secure the piece of cardboard/wood to the top of the stack of books.
    - Ask students to place the ball at the top of the ramp and release it, being careful not to add an outside force by pushing on the ball.
        - Ask students to record their observations of the ball's motion from start to finish in the *Ramp & Ball Data Table*.
    - Once completed, discuss the results of the investigation:
        - What did you observe during the ramp/ball investigation?
            - At first, the ball was not moving. Then, I released it and it traveled down the ramp.
            - It came to a rest on the ground after it left the bottom of the ramp.
        - Did you push the ball down the ramp?
            - No
        - If not, then how was the ball able to travel down the ramp? Was a force involved?
            - Yes, something pushed or pulled it down the ramp.
        - In fact, there was a force acting on the ball, making it travel down the ramp. You can't see this force, but you can see its effects on objects on Earth every day! In the science community, we describe this interaction as *gravity*, a force of attraction that pulls objects on Earth towards its center.
        - When you released the ball, the force of gravity was able to act fully upon the ball, pulling it down the ramp, as your hand was no longer in the way/holding it back.
- We now know that the force of gravity pulls objects towards Earth's center, just like the ball was pulled down the ramp! But, what does this have to do with a roller coaster? What brings a roller coaster cart down the track?
    - Play the video: [How Do Roller Coaster Work?]() from timestamp 0:00 - 4:40.
    - Engage students in a discussion of main ideas:
        - What part of the train or cart helps it move as fast as possible along the track?
            - It's wheels help the train/cart travel quickly on the track!
            - Without wheels, the train/cart would have to slide along the track and would be slowed down by a force called *friction*. Friction is a force that opposes or slows down motion. Without wheels, the force of friction

would slow the train down. That wouldn't make for a fun ride!

- At the start, what helps the train/cart travel up the track?
    - A chain powered by a motor pulls the train/cart up the track.
- Once the train/cart reaches its highest point/hill, what drives it down the track?
    - The force of gravity pulls the train/cart down the track.
- Since we want to make our roller coasters as thrilling as we can, how do you think we need to design our first hill in order to make our train/cart travel through other hills/the rest of the track?
    - Our first hill should be the tallest. This will allow the train/cart to increase its speed and travel along the rest of the track.

Closure:

- Today, we have learned a lot about how roller coasters use the force of gravity to pull the train/cart down a track! To help us make sense of all that we learned, let's take some time to reflect.
    - Ask students to discuss and record what they have learned by adding to their "Learned" table.
        - Significant learnings should include:
            - Gravity is a force that pulls objects towards Earth's center.
            - Once a train/cart is pulled up to a high hill using a chain, the force of gravity pulls it down the track.
            - It's wheels work against the force of friction, helping it travel quickly along a track.
            - When designing our roller coaster, the first hill should be the tallest. That way, the train/cart can gain a lot of speed to travel through the rest of the track.
- Looking back at the "Ask" step of our challenge, what else do we need to know to move forward?
    - Ask students to revisit the "Ask" step and update/add new ideas to their tables. Possible student responses may include:
        - I need to know...
            - How many hills can my roller coaster have?
            - Can my roller coaster have loop-de-loops?
            - What materials do we have to build the roller coaster?
            - How much time will we have to build the roller coaster?

Extensions:

Watch & Play: BrainPOP jr. - *Gravity*

Watch: Crash Course Kids - *Danger! Falling Objects*

Continue the Investigation - Some students may be questioning what specific forces keep the train/cart in motion after it travels down the first hill and how the train/cart can travel through a loop-de-loop.

- Play the duration of the video and engage students in a discussion of these main ideas:
  - What keeps the train/cart in motion after it travels down the first, big hill?
    - The force of gravity makes the train/cart speed-up, giving it momentum or power. The higher the first drop, the more speed and momentum the train/cart can build up and the farther it can go, before it eventually slows down and comes to a stop.
  - What has to happen for the train/cart to make it up a second hill in the track?
    - The train/cart will have enough momentum to go back uphill against the pull of gravity as long as the second hill is shorter than the first hill.
  - How does the train/cart travel through a loop-de-loop?
    - When the train/cart starts from a high enough hill and is traveling fast enough, the train/cart's momentum can be enough to carry it upside down through a loop-de-loop.
    - The train/cart wants to go straight up but the track guides it, making it follow the track of a loop.

Student Resources

Ramp & Ball Data Table

Ball On Top of Ramp	Ball Traveling Down Ramp	Ball's Ending Position

A Wild Ride! Week 2

Day 4: Challenge Accepted!

Teacher/Parent Background:

When scientists and engineers are faced with a challenging question or problem, they follow steps to best address their task. In engineering fields, engineers use the Engineering Design Process to propose solutions to problems in order to make the world a better place. Engineers start by clearly defining the problem, imagining possible solutions and designing a plan before they create their solutions.

Overview:

In this activity, students will utilize the steps of the Engineering Design Process in order to design a plan for their challenge: *How can we design a roller coaster using force and motion concepts?*

Related Standards:

- Define problems and design solutions pertaining to force and motion.

Key Terms:

- Engineering Design Process: a set of steps engineers use to propose solutions to problems

Materials List:

- Parental/adult supervision
- Internet access
- Journal
- Pen/pencil
- Roller coaster Materials (see here & here for additional material ideas/examples)
    - Foam tubing/pool noodles - cut in half lengthwise
    - Masking tape roll
    - Scissors
    - Ruler/measuring tape
    - Paper cups
    - Marbles - various weights
    - Various household objects, such as blocks, boxes, books, etc.
- *Student Resources - Pages 4-6*
    - *Challenge Details*

- *Step 2: Imagine*
- *Step 3: Plan*

Activity Description:

- This week we have learned a lot about how force and motion concepts make a roller coaster work! Let's revisit our whole "Learned" chart to recap our week!
  - Ask students to discuss what they have learned, referencing their "Learned" chart. Significant student learnings should include:
      - A force is a push or a pull.
      - Forces cause motion of objects.
      - Motion is a change of an object's position/its location.
      - The way I push or pull on an object affects its speed.
      - Gravity is a force that pulls objects towards Earth's center.
      - Once a train/cart is pulled up to a high hill using a chain, the force of gravity pulls it down the track.
      - When designing our roller coaster, the first hill should be the tallest. That way, the train/cart can gain a lot of speed to travel through the rest of the track.
- Let's look back at the "Ask" step of our challenge: *How can we design a roller coaster using force and motion concepts*? What do we still need to know?
  - Ask students to revisit the "Ask" step and discuss other "need to knows". Possible student responses may include:
    - <u>I need to know...</u>
      - How many hills can my roller coaster have?
      - Can my roller coaster have loops?
      - What materials do we have to build the roller coaster?
      - How much time will we have to build the roller coaster?
- To answer the remaining "need to knows", review the *Challenge Details* with students. Encourage students to ask clarifying questions about the challenge details.
- Provide time for students to become familiar with the building materials.
  - Prompt them to feel and bend the foam tubing, prop-up the tubing with cups, blockes, boxes, books, etc.
- Then, direct students to revisit their remaining "need to knows". Possible student responses/questions may include:
  - How much time will we have to build the roller coaster?
    - Now that the challenge has been clearly defined and we have accomplished the "Ask" step, you will have today to imagine and plan for your solution. Tomorrow, you will build, test and improve your solution.

- Guide and actively assist students through the "Imagine" step of the Engineering Design Process by reviewing *Step 2: Imagine*. Key details/directions include:
  - Now that the problem has been clearly explained/defined…
    - brainstorm more than one possible solution to the problem.
    - keep in mind the materials/design requirements, as they should be incorporated into your designs.
    - draw and label diagrams of your designs, write-out words/phrases to help you brainstorm!
    - pick your best solution to share with others.
      - **Note:** Depending on the learning environment, the adult/parent may be the only other person in the "class". Act as a sounding board for the student, allowing him/her to share their best solution ideas.
- Next, guide and actively assist students through the "Plan" step of the Engineering Design Process by reviewing *Step 3: Plan*. Key details/directions include:
  - Work together to decide on one best solution to be built by the whole team. This solution should include ideas from the team; not just one member's ideas!
  - keep in mind the materials/design requirements, as they should be incorporated into your solution.
    - **Note:** Depending on the learning environment, the adult/parent may be the only other person in the "class". Act as a design team member by listening to their ideas and sharing additional thoughts/your ideas. You will both work as a team to design a plan.
  - Draw and label a design of your solution and create a materials list with types and amounts of materials needed.
    - **Note:** The amounts of materials will depend on the availability of materials. Limit quantities as you see fit.

Closure:

- Ask students to think about tomorrow's activities. Engage in a discussion:
  - Thinking about what engineers do, what steps will be taking tomorrow to propose your best solution to the challenge?
  - What are you most looking forward to?

Extensions:

Watch: Crash Course Kids - *Let's Fly! Is One Solution Better Than Another?*

Student Resources

Challenge Details

Dear Student,

Arizona Science Center is interested in adding a new exhibit to its *Get Charged Up!* gallery. Since *Get Charged Up!* is all about force and motion, staff members would like to introduce guests to the science behind roller coasters! You have been tasked with designing a roller coaster to be reviewed by Arizona Science Center's Exhibit Technicians for their new exhibit. Please closely follow all details outlined below:

1. **Use the steps of the Engineering Design Process to design the best possible roller coaster. This includes:**
    a. Imagining possible solutions - there are many possible solutions to this one challenge; think big!
    b. Planning your chosen solution
    c. Creating and testing your solution
    d. Improving your solution to make it even better

2. **You may only use the following materials:**
    a. Foam tubes - for the roller coaster track
    b. Making tape - to secure parts of the track or to help create roller coaster design features
    c. Scissors - to cut the tape
    d. Marbles - for the roller coaster's train/cart
    e. Paper cups, blocks, boxes, books - to support the roller coaster and to catch rolling marbles
    f. Measuring tape/ruler - to measure the length of the track

3. **Your roller coaster must include/stay within the following design requirements:**
    a. One hill
        i. Note: Many guests would enjoy a second hill, if it is possible.
    b. One loop-de-loop
    c. Track length cannot exceed 48 inches or approximately 122 cm.

We eagerly await your design proposals. Best of luck!

Arizona Science Center, Head Exhibit Technician

Step 2: Imagine

Possible Solution #1 (include a diagram with labels)

Possible Solution #2 (include a diagram with labels)

Step 3: Plan

Team Solution (include a diagram with labels)	Materials List (include material types and amounts)

A Wild Ride! Week 2

Day 5: How Can We Make It *Even* Better?

Teacher/Parent Background:

When scientists and engineers are faced with a challenging question or problem, they follow steps to best address their task. In engineering fields, engineers use the Engineering Design Process to propose solutions to problems in order to make the world a better place. Once engineers have established a plan, they create/test their designs and make improvements in order to propose the best possible solution.

Overview:

In this activity, students will utilize the steps of the Engineering Design Process in order to create, test and improve designs to address their challenge: *How can we design a roller coaster using force and motion concepts?*

Related Standards:

- Define problems and design solutions pertaining to force and motion.

Key Terms:

- Engineering Design Process: a set of steps engineers use to propose solutions to problems

Materials List:

- Parental/adult supervision
- Internet access
- Journal
- Pen/pencil
- Roller coaster Materials (see here & here for additional material ideas/pictures)
  - Foam tubing/pool noodles - cut in half lengthwise
  - Masking tape roll
  - Scissors
  - Ruler/measuring tape
  - Paper cups
  - Marbles - various weights
  - Various household objects, such as blocks, boxes, books, etc.
- *Student Resources - Pages 4-5*

- *Step 4: Create and Test*
- *Step 5: Improve and Re-test*

Activity Description:

- Today is finally the big day...we get to build and test our roller coaster designs! Before we jump right into building, let's first revisit our plans.
  - Ask students to review their design plans by referencing *Step 3: Plan*. Guide students through a "checklist" in order to evaluate their plans and move on to creating their designs:
    - Check your plans for the following:
      - Does your plan have a diagram with labels?
      - Does your plan have a materials list that includes both types and amounts?
      - Does your plan follow the materials and design requirements?
        - Review the *Challenge Details* with students.
    - If your plan is missing something, please take time with your team to address it.
      - **Note:** Depending on the learning environment, the adult/parent may be the only other person in the "class". Act as a design team member by listening to their ideas and sharing additional thoughts/your ideas, if the plan is missing any requirements.
- Now that we have reviewed our plans, let's begin the creating process!
  - Guide and actively assist students through the "Create/Test" step of the Engineering Design Process by reviewing *Step 4: Create and Test*. Key details/directions include:
    - Build your design with your team!
    - Stick to your plan, including only using the types and amounts of materials you asked for.
    - Test it out! How did your solution work; what did and did not work well? Record the testing results.
      - When appropriate, review testing results using *Step 4: Create and Test*, including the *Success Criteria* section, to assist students in reflecting on what did/did not work well.
      - **Note:** Depending on the learning environment, the adult/parent may be the only other person in the "class". Act as a design team member by sharing the building, testing and reflecting responsibilities.
- Our time is up! How can we make your design even better?
  - Next, guide and actively assist students through the "Improve" step of the Engineering Design Process by reviewing *Step 5: Improve and Re-test*. Key details/directions include:

        - Based on your testing results, discuss and decide what your team can do to make your design even better. Remember to still stay within the material and design requirements!
            - Review the *Step 5: Improve and Re-test*, including the *Team Suggested Improvements*, to assist students in discussing and deciding what to improve and how they will do so.
                - **Note:** Depending on the status of the materials, some may be able to be re-used and some may not.
                - **Note:** Depending on the learning environment, the adult/parent may be the only other person in the "class". Act as a design team member by sharing the reflection/discussion responsibilities.
        - Begin to re-create and re-test your improved design!
            - **Note:** Depending on the learning environment, the adult/parent may be the only other person in the "class". Act as a design team member by sharing the rebuilding and retesting responsibilities.
    - Our time is up! How did your solution work this time?
        - Prompt students to discuss, once again referencing the *Success Criteria* to determine what worked/did not work well.

Closure:

- As we approach the end of our week-long challenge, let's reflect!
    - What was the most enjoyable part of this process? Why?
    - What was the most challenging part of this process? Why?
    - Overall, how successful would you rate your final design, on a scale of 1-5 (1 is unsuccessful)? Explain your rating.

Extensions:

Continue the Investigation: Prompt students to extend the challenge with the following prompts:

- How can you make your design *even* better?
    - What improvements would you make now? Why?
    - What were the testing results of this version?
- How can you make a roller coaster with two hills?
- Using a stopwatch and marbles of different weights, time each marble's ride down the coaster.
    - Which one is the fastest? Why do you think?
    - Which one travels the farthest? Why do you think?

Student Resources

Step 4: Create and Test

What Worked Well?	What Didn't Work So Well?

Success Criteria…

- Did you only use the available material amounts and types you planned for?
- Did the track length stay within 48 inches or approximately 122 cm?
- Did the design include one hill?
- Did the design include one loop-de-loop?
- Was the train/cart able to successfully travel from the start of the track to the end of the track?

Step 5: Improve and Re-test

Team Suggested Improvements
We have decided to improve…   To improve this, we will…

Re-testing Results

What Worked Well?	What Didn't Work So Well?

Did you only use the available material amounts and types you planned for?

Did the track length stay within 48 inches or approximately 122 cm?

Did the design include one hill and one loop-de-loop?

Was the train/cart able to successfully travel from the start of the track to the end of the track?