3rd Grade Physical Science: Force & Motion on the Playground

Developed for Chapel Hill Carrboro City Schools
Northside Elementary School Outdoor Wonder & Learning (OWL) Initiative

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Overarching Unit Question
What can we learn about force and motion, and how can we apply it on a playground?

Essential Questions
Arc 1: What can playgrounds teach us about force and motion?
Arc 2: How do different forces change the position and motion of objects around us?
Arc 3: How can we use our knowledge of forces and motion to plan and build playgrounds that are fun?

Transfer Goals
- Use scientific approaches and methodologies to investigate phenomenon, claims, results and information.
- Identify real-world dilemmas and opportunities and apply scientific thinking to develop solutions for them.

Enduring Understandings (Science)
- We can learn about objects by observing them.
- The position and motion of objects around us change, depending on forces affecting them.
- We can use our knowledge of forces and motion to solve problems in the real world.

Target Science Essential Standards
3.P.1 Understand motion and factors that affect motion.
3.P.1.1 Infer changes in speed or direction resulting from forces acting on an object.
3.P.1.2 Compare the relative speeds (faster or slower) of objects that travel the same distance in different amounts of time.
3.P.1.3 Explain the effect of earth’s gravity on the motion of any object on or near the earth.

Secondary Target Standards (ELA, Math, Social Studies)
ELA
RI.3.1 Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers.
RI.3.4 Determine the meaning of general academic and domain-specific words and phrases in a text relevant to a grade 3 topic or subject area.
RI.3.5 Use text features and search tools to locate information relevant to a given topic efficiently.
RI.3.7 Use information gained from illustrations and the words in a text to demonstrate understanding of the text.
W.3.2 Write informative/explanatory texts to examine a topic and convey ideas and information clearly.
**W.3.5** Conduct short research projects that build knowledge about a topic.

**W.3.6** Recall information from experiences or gather information from print and digital sources; take brief notes on sources and sort evidence into provided categories.

**SL.3.1** Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 3 topics and texts, building on others’ ideas and expressing their own clearly.

**SL.3.3** Ask and answer questions about information from a speaker, offering appropriate elaboration and detail.

**Math**

**3.G.1** Reason with two-dimensional shapes and their attributes.

**3.MD.2** Solve problems involving customary measurement.

**3.MD.3** Represent and interpret scaled picture and bar graphs.

**3.MD.7** Relate area to the operations of multiplication and addition.

**3.MD.8** Solve problems involving perimeters of polygons, including finding the perimeter given the side lengths, and finding an unknown side length.

**Unit Overview**

In this unit, students will learn about force and motion using hands-on activities on the playground and in the classroom. Students will start off the unit in Arc 1 by beginning to think about the playground as a place to learn about science. Force and motion concepts will be introduced using the book *Newton and Me* by Lynne Mayer. The playground will then be used to make observations about force and motion and about how fun a playground is intertwined with force and motion. Students will perform experiments using ramps to further their explorations of how force and motion impacts speed and direction.

Using the knowledge they have gained, in Arc 2, students will collaborate to create experiments on the playground. Designing and creating a Rube Goldberg machine in the classroom will continue this application of how force changes the position and motion of an object.

In Arc 3, a field trip to a nearby playground is used to create an additional experiment to deepen their knowledge of force and motion. To think about force and motion from another perspective, groups will design and build a playground for a millipede. The culminating activity will be to use all they have learned to research and choose what additional type of playground equipment could be added to the school’s playground to have the playground more fully encompass the aspects of force and motion as well as to make the playground more fun.

**Note:** You may want to ask students at the beginning of the unit to bring in materials, such as empty paper towel rolls, toilet paper rolls, cereal boxes, or granola bar boxes, to share with the class for building materials for Learning Activity 9: Rube Goldberg Design Challenge and Learning Activity 11: Design a Millipede Playground.

**Duration**

15-22 days of 30 minute learning activities

**Note:** Length of unit depends on how many days you elect to spend with the various design challenges and Learning Activity 7: Colliding Cars from Wake UTD

**Vocabulary**

Direction, distance, force, friction, gravity, motion, relative speed, speed, air resistance, energy, engineering, inertia, mass, mechanical engineer

*Definitions of vocabulary words can be found on the Arc overview pages. Relevant vocabulary is also listed on each learning activity page.*
Go Outdoors! Tips & Tools 🌿

Taking your class outside for science or any lessons can be rewarding and challenging. Along with behavior and materials management tips with each lesson, this section is intended to help you have the tools you need to successfully take your class outside.

Before You Go Outside
- Create **ground rules** with students for all outdoor lessons. Post the rules for students to be able to easily see.
- Ask for **parent volunteers**. Extra help can make an outdoor learning experience much more manageable.
- Teach students proper use, including safety, of the science tools they will be using.
- Set expectations before go. Give instructions both inside and repeat once outside.
- Have a clear **objective** for going outdoors. This will help focus students’ attention.
- Be flexible. Structure lessons to take advantage of **opportunities and challenges**.
- Establish a meeting spot and emergency plan. Have a signal for emergency situations.
- Take students outside for short exercises to practice rules before longer outdoor lessons.
- Use **same door** to always go outside for learning. Emphasize this is different than going outside for recess.

While You Are Outside
- **Model** the activities and outdoor skills for students. Show them what you expect them to be doing.
- **Participate in the activity**. Get down on your students’ level. Get your hands dirty.
- **Model respect for nature** with your students.
- The outdoors is full of **teachable moments**. Use “I wonder” statements to engage students in questioning the experience. Have students write down questions to be researched back in the classroom.
- Allow students to be **leaders** in the activity. Ask students to volunteer as teacher assistant or materials manager.
- Acknowledge that students want to explore and can do so once the assigned task is complete.

Safety First!
- Scout outdoor areas ahead of time if possible, to note **potential hazards** such as poison ivy.
- Students should **never be alone**. If a student needs to go back to the building, send 2 students.
- Take a **first aid kit and phone/walkie-talkie**. Consider bringing along staff trained in first aid/CPR.
- Let office staff know where you and your class are going if headed out on a walking field trip.
- **Stay on the trail/path**, unless otherwise directed. On the greenway, stay on the right side of path.
- **Do not eat wild plants**, unless harvesting in the garden with a teacher.
- Set **boundaries** for the students to stay within. You have to be able to see me and I have to be able to see you!

A Note on Nature Journaling 📚

Nature journals that you use with your class should be small composition books or other blank books that students use to make outdoor observations, including writing, drawing, and painting. Students can use colored pencils, watercolor pencils, or other materials to remember details of plants, animals, and habitats they are investigating around the schoolyard. This is different from a science notebook. However, some teachers may choose to have students paste blank pages into their science notebook to use for nature journaling pages.
Essential Questions
What can playgrounds teach us about force and motion?

NC Science Essential Standards – Unpacked Content
3.P.1.1 Students know that when a force acts on an object it will result in a change of speed and/or direction.

3.P.1.2 Students know that speed can vary. Students know that varying the speed of a moving object will affect the time it takes for the object to travel a particular distance.

3.P.1.3 Students know that the earth ‘pulls’ on all objects on or near the earth without touching those objects.

Lessons in this Arc
- Engaging Activity: Science & Playgrounds
- Learning Activity 1: Newton and Me
- Learning Activity 2: Dream Playground Design Challenge: Part 1
- Learning Activity 3: Playground Scavenger Hunt
- Learning Activity 4: Tug of War
- Learning Activity 5: Ramp Investigations – Ramp Height
- Learning Activity 6: Ramp Investigations – Ramp Surfaces

Go Outdoors!
- Engaging Activity: Science & Playgrounds
- Learning Activity 2: Dream Playground Design Challenge: Part 1
- Learning Activity 3: Playground Scavenger Hunt
- Learning Activity 4: Tug of War

Nature Journal Connection
- Engaging Activity: Science & Playgrounds

Duration
8 days of 30 minute learning activities

Background Information
A force can either be a push or pull that is enacted upon an object. When a force acts upon an object it will result in a change in speed and/or direction. Each force that is applied to an object has strength and direction. For each force exerted on an object, there is an equal and opposite force acting on it. This is known as Newton’s Third Law of Motion. Direction is the line along which anything lies, faces, or moves. Speed refers to how fast or slow something moves. This change in speed or direction results in motion. Motion is moving or changing position.
Because all matter is moving, motion is relative to a chosen point. The motion can be straight, zigzag, round and round, back and forth, fast and slow, or any other change in position.

Speed can vary and will affect the time it takes a certain object to travel a certain distance. **Relative speed** is the speed of an object in relation to another object or point. The quantity of space between two different places is the **distance**. **Friction** is a force that resists motion between two bodies in contact with each other. Friction can affect the speed of an object and can also produce heat.

**Gravity** affects the motion of any object on or near Earth. It is the natural force of attraction between two objects of mass. Earth pulls objects towards its center using gravity without touching them. Earth is spherical because gravity is center-directed.

**Vocabulary**
- **Direction** is the line along which anything lies, faces, moves, etc., with reference to the point or region toward which it is directed.
- **Distance** is the amount of space between two places.
- **Force** is a push or a pull exerted on an object.
- **Friction** is a force that resists motion between two bodies in contact.
- **Gravity** is the natural force that attracts any two objects with mass toward each other.
- **Motion** is moving or changing position (straight, zigzag, round and round, back and forth, fast and slow).
- **Relative speed** is the speed of an object in relation to a reference point.
- **Speed** is how fast or slow something moves.

**Literature Connections**

**Books**
- *Newton and Me* by Lynne Mayer (530 MAY)*

**Book Sets**
- Give it a Push! Give it a Pull! A Look at Forces by Jennifer Boothroyd*
- Roller Coaster! By Paul Mason*
- Motion: Push and Pull, Fast and Slow by Darlene Stille*

*currently available in Northside Elementary’s media center
Lesson Prep
✓ Review the science topics taught throughout the year.

Vocabulary
Force, motion

Procedure

Mini-Lesson
• Remind the students of the science topics they have learned about this year and share the topics they will be learning about the rest of the year before you give them their journaling prompt.

Independent Work
• Take students outside to observe the playground.
• Give them a few minutes to look around and complete the following nature journaling prompt on their own.
• Nature Journaling prompt:
  o Make a list of science concepts we could explore on the playground. How could we explore them?

Independent Group Work
• Have students turn and talk to a partner about what they wrote.
• Then have students briefly explore some of the different connections to science that can be made on a playground:
  o Use IR thermometers to collect temperature data of different surfaces.
  o Look at where shadows are on the playground and how that might change throughout the day.
  o Look for how plants impact the playground.

Assessment
• Bring the class back inside and create a class list of their ideas.
• Circle ones that have to do with force and motion.
• Star ideas that you will be exploring in this unit.
• You can use this discussion as a formative pre-assessment.

Behavior Management Tips
♦ Discuss how learning on the playground will look different than recess.

Learning Objectives:
Students will be able to recognize elements of science on their school playground.

Nutshell/Skill:
Students can find connections to science on the playground.

Science Essential Standards:

ELA Essential Standards:
W.3.6

Time:
30 minutes

Student Materials:
  o Nature Journals
  o Pencils
  o IR thermometers (optional)
Lesson Prep

✓ Preview Newton and Me.
✓ Choose desired activities to use with the book.
✓ Make copies of chosen student activities.

Vocabulary

Direction, force, friction, gravity, motion, speed

Procedure

Mini-Lesson

- Show students the cover of Newton and Me. Ask them to predict what the story might be about.
- Prompt students to look and listen for force and motion concepts.
- Read the story Newton and Me aloud to the class.
- Ask students to give you a thumbs up if their prediction was correct.

Independent Work

- Questions and activities are at the back of the book and on the publisher’s website, including a teaching activity guide. The teaching activity guide includes vocabulary, reading graphic organizers, and science graphic organizers. Some of the materials are available in Spanish.
- Recommended activities to use:
  - For Creative Minds has students connect the book with force and motion ideas. (Also, in the back of the book.)
  - From the Teaching Activity Guide: Force and Motion True/False p. 15-16 and Science Journal Vocabulary Activity p. 17-18

Assessment

- Answers for the activities are at the end of the guide, p. 21-23.
- Quizzes can be found on the publisher’s website.

Opportunities for Extended Learning

1. Videos on Brainpop on Gravity, Forces, and Isaac Newton. These videos could be used at any point throughout the unit.
2. Force, Sports, and Fitness - Interactive online activity combining text features and a lesson on force. Intended as a homework activity to be done with parents but could also be done as a classroom activity.
Lesson Prep

- Review the following pages in Swing Set Makeover, located in the Northside Elementary Media Center Professional Collection.
- Read p. 61-63, 77-83 and any additional pages such as the learning theory used (p. 16-17) & teacher background information (p. 53-57).
- Make copies of Fun Factor Survey handouts p. 77-83, 1 per student.
- Choose images of playgrounds from Internet Resources on p. 75 or use the images provided on p. 76 of Swing Set Makeover.

Vocabulary

Direction, distance, force, friction, gravity, motion, relative speed, speed

Procedure Part 1

Guided Practice

- Discuss how people find different playground equipment more or less fun and why.
- Discuss how you could evaluate playground equipment on the basis of how fun it is.
- Students will complete page 1 of the Fun Factor Survey to determine their personal metric of fun.
- Working in groups*, students will use their data to create a Fun Factor Survey to assess various playgrounds.
- Practice evaluating playgrounds by looking at a few pictures of different playgrounds. Evaluate at least one picture before going outside.
- Explain that students will use their Fun Factor Survey results for the Dream Playground Design Challenge at the end of the unit.
- Tell students that while learning about force and motion their job is to evaluate their playground for its fun factor and use of force and motion.
- They will eventually be solving the problem of what playground equipment could be added to increase the fun factor of their playground, taking advantage of the laws of force and motion.

*The same groups assigned for this activity should also be used for the Playground Experiments, Playground Field Trip, and Dream Playground Design Challenge: Part 2. These four activities are connected and build on each other, culminating in the Dream Playground Design Challenge. The Playground Experiments and Playground Field Trip could also be done as stand-alone activities.
**Procedure Part 2**

**Independent Group Work**
- Go outside to the playground most often used by your class.
- Have students **evaluate** its fun factor using the *Fun Factor Survey*.
- Students will also begin thinking about how to optimize the playground to their preferences.
- Students will **use the results of their Fun Factor Surveys** for Learning Activity 12: Dream Playground Design Challenge: Part 2. Their Fun Factor Surveys will also be referred to in Learning Activity 8: Playground Experiments and Learning Activity 10: Playground Field Trip.

**Assessment**
- As this activity is used to complete the project for Learning Activity 12: Dream Playground Design Challenge: Part 2, it will be incorporated into the assessment of that activity.

**Opportunities for Extended Learning**
1. Have students create a bar graph of the fun factor survey results. (p. 65-66, 84 in *Swing Set Makeover: Grade 3 STEM Road Map for Elementary School*).

**Behavior Management Tips**
- Before going outside, discuss how learning on the playground will look different than recess.
- Remind students of the goals of the lesson before going outside.
- Notify students of how much time they have left to finish their Fun Factor Survey while outside to refocus them to the task at hand.
Lesson Prep

✓ Make copies of the Playground Scavenger Hunt, 1 per student.
✓ Note: This activity provides an opportunity to integrate the study of math and science concepts in one activity. It can be taught within this science unit, or when shapes, area & perimeter are taught in 3rd grade mathematics.

Vocabulary
Direction, distance, force, friction, gravity, motion, relative speed, speed

Procedure

Mini-Lesson
• This is an inquiry-based activity. Students will be learning in the process of completing the scavenger hunt, so do not give them answers beforehand.

Independent Group Work
• Students will work in teams of 2 or 3 to complete a playground scavenger hunt.
• The scavenger hunt includes looking for different aspects of force and motion on the playground as well as looking for shapes and finding perimeter and area of objects.
• Take students to the playground to complete the scavenger hunt.

Assessment
• Debrief and discuss what students found on their scavenger hunt.
• Ask students to share what they found for each item on the scavenger hunt. As a formative assessment, have the other students give a thumbs up or thumbs down in agreement or disagreement as each student shares an item they found.

Opportunities for Extended Learning
1. Watch this video on forces and motions at an amusement park (2:59).

Behavior Management Tips
♦ Ask students to remind you of the expectations for outdoor learning.
♦ Discuss how learning on the playground will look different than recess. Some exploration of the playground will be necessary to complete the scavenger hunt.
Playground Scavenger Hunt

Force and Motion

Where on the playground do you use a **pull force**? Name and sketch the playground equipment you found. Add an arrow showing the force.

Find equipment on the playground that uses **friction**. Name and sketch what you found. Add an arrow showing the force.

Where on the playground do you use a **push force**? Name and sketch what you found. Add an arrow showing the force.

Where on the playground do you **move vertically** (up and down)? Name and sketch what you found. Add an arrow showing the force.

Find something on the playground that uses **gravity**. Name and sketch what you found. Add an arrow showing the force.

Where on the playground do you **move** in a circle? Name and sketch what you found. Add an arrow showing the force.
Math

Find and sketch a parallelogram. Where did you find it?

Find the perimeter of one of the shapes you found. Measure to the nearest foot. Show your work.

Shape: ___________________________

______ + _______ + _______ + _______ =

____________ feet

Find and sketch a rectangle. Where did you find it?

Find the area of one of the shapes you found.

Shape: ___________________________

_________ x _________ = __________ feet²

Find and sketch a rhombus. Where did you find it?

Find the perimeter of a section of the ropes dome.

______ + _______ + _______ + _______ =

____________ feet

Find and sketch a trapezoid. Where did you find it?

Find the area of another section of the ropes dome.

_________ x _________ = __________ feet²
Lesson Prep
✓ Determine which field or open area you will use outside.

Vocabulary
Direction, distance, force, friction, motion, speed

Procedure
Mini-Lesson
• Review what a force is and how applying a force can affect an object.

Guided Practice
• Take students outside to a field or other open area.
• Divide the class into two groups for tug of war.
• Talk the class through having one side apply a gentle pull force and notice what happens.
• Repeat with the other side pulling.
• Challenge the class to pull with equal force so that the rope is not moving.
• Then challenge them to apply a strong pull force with the purpose of pulling the marked midpoint of the rope across a marked area toward them.

Assessment
• Ask students to explain why the team that won was able to pull the rope across the boundary.
• Have students vote with a thumbs up or down if they agree with their classmate’s answer as a formative assessment.

Opportunities for Extended Learning
1. You may choose to mix up the teams and repeat the game of tug of war. Discuss how this applies concepts of force and motion.
2. Have classes compete against each other using the same procedure. Include a discussion of how this connects to force and motion.

Behavior Management Tips
♦ Have students remind the class of expectations for outdoor learning and how to be safe during this activity.

Learning Objectives:
Students will be able to conclude that when a force is applied to an object it will result in a change of speed and/or direction.

Nutshell/Skill:
Students can recognize that a relationship exists between forces and changes in motion.

Science Essential Standards:
3.P.1.1

Time:
30 minutes

Student Materials:
➢ Large tug-of-war rope
Lesson Prep
✓ Make copies of the data sheet, 1 per group.
✓ Gather materials.
✓ Determine where each group will be working.

Vocabulary
Direction, distance, force, gravity, motion, relative speed, speed

Procedure
Mini-Lesson
• Conduct a class demonstration of how ramp height affects the movement of a ball.
  o Have the class form a circle.
  o Have a student volunteer stick their arms out straight in front of them. Place a ball on their arms.
  o Extend your arms and touch fingertips.
  o Take turns squatting to show how your arms form a ramp that the ball rolls down.
  o Have the class pass the ball around the circle by making ramps with their arms.
  o First, have the class do it slowly.
  o Then, challenge the class to do it more quickly.
• Discuss how they changed the speed of the ball, what made the ball move, and other aspects of their ramps.
• Ask students for real world examples of ramps (i.e. a ramp for a wheelchair).
• Review how to measure distance with students.
  o Emphasize consistency - always measuring from the same starting point and to the same ending point, i.e. bottom of the ramp to the back bumper of the car.
• Model using the tape measure with a student volunteer.
  o Ask students what to do if what they are measuring is longer than the tape measure (mark the spot at the end of the tape measure, then move the tape measure to measure from spot that was marked).
  o Students should be able to come up with a few ideas, but make sure all students know a way to handle this situation before starting as cars may travel farther than the tape measure is long.
  o Provide masking tape as a way to mark where the car starts and stops rolling.
Talk through the data sheet and directions with students.
  o Ask students why it is good practice as scientists to do the same thing more than once.
  o **Emphasize** that they will roll their object down the ramp at the same height 4 times **before** changing the ramp height.
  o Indicate where each group will be working on the floor.

**Independent Group Work**

- Students will work in groups to **test** how ramp height affects how fast and how far an object will roll.
  - The object rolled down the ramp can be a toy car, marble, or small ball.
- Students will record how far their object rolls down the ramp for each different height.
- Students will **collect data** and **answer questions** on the group data sheet, *Ramp Investigations: Ramp Height*.

**Assessment**

- Use the completed data sheet as an assessment.
  - The force causing the object to roll down the ramp is gravity.

**Opportunities for Extended Learning**

1. Have students make a **bar graph** of the data they have collected.
2. Recreate similar experiments on slides. You would need slides of different height for comparison.
3. Recreate experiments but mark a certain distance and time how long it takes for the car to reach that spot.

**Behavior & Materials Management Tips**

- Have job cards to give each group to assign a role to each person. Jobs may include **Scribe** – person who records data and reads directions, **Engineer** – person who builds the ramp and adjusts its height, **Driver** – person who rolls the object, and **Measurer** – person who measures how high the ramps is and how far the object rolls. Assign the engineer or driver to assist the measurer.
- Have one person (the engineer) from each group come to a central location to collect materials.
- Ramps should be built on the floor as objects are likely to roll farther than the table is long. Try to find an area for each group to work where groups are less likely to have conflicts over space and collisions.
Ramp Investigations: Ramp Height

Our question: How does ramp height affect the speed and distance an object rolls down a ramp?

We predict ____________________________________________________________

We know _____________________ is the force causing the object to roll down the ramp.

Our experiment:

• We will let the object roll down from the top of the ramp, without pushing it.
• Once the object stops moving, we will measure in inches (in) to the closest half inch the distance the object rolled from the end of the ramp to the back of the object.
• We will repeat for 4 trials at the same height.
• We will then change the ramp height and repeat the experiment.
• We will test 4 different ramp heights.
• We will record each ramp height and the distance measured in our data table.

Our data:

<table>
<thead>
<tr>
<th>Ramp Height</th>
<th>Trial 1 Distance in inches</th>
<th>Trail 2 Distance in inches</th>
<th>Trail 3 Distance in inches</th>
<th>Trail 4 Distance in inches</th>
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</tbody>
</table>

In the space below, provide an answer to the original question: How does ramp height affect the speed and distance an object rolls down a ramp?

Our results: ____________________________________________________________
Lesson Prep
- Make copies of the data sheet, 1 per group.
- Gather materials.
- Determine where each group will be working.

Vocabulary
Direction, distance, force, friction, gravity, motion, relative speed, speed

Procedure
Mini-Lesson
- Briefly explain what friction is and how it affects movement.
  - Include in your explanation the fact that friction is a force.
- Ask students for examples of when they have experienced friction.
  - Prompt students with questions about what they have done to slow down before, i.e. dragging feet when swinging or using the brakes on a bicycle.
  - Explain how they are using friction to slow themselves down.
- Review with students how to measure distance.
  - Emphasize consistency - always measuring from the same starting point and to the same ending point, i.e. bottom of the ramp to the back bumper of the car.
- Model using the tape measure with a student volunteer.
  - Ask students what to do if what they are measuring is longer than the tape measure (see Activity 5).
  - Students should be able to come up with a few ideas, but make sure all students know a way to handle this situation before starting as cars may travel farther than the tape measure is long.
  - Provide masking tape as a way to mark where the car starts and stops rolling.
- Go over the data sheet and directions.
  - Ask students why it is good practice as scientists to do the same thing more than once.
  - Emphasize that they will roll their object down the ramp on the same surface 4 times before changing to a different surface.
  - Tell students the specific height everyone should use for their ramp. The ramp height should not change for this experiment.
  - Indicate where each group will be working on the floor.
Independent Group Work

- Students will work in groups to test how friction affects how fast and far an object rolls by testing various ramp surfaces.
  - The object rolled down the ramp can be a toy car, marble, or small ball.
- Students will be recording how far their object rolls down the ramp for each different surface.
- Students will collect data and answer questions on a group data sheet, Ramp Investigations: Ramp Surfaces.

Assessment

- The completed data table can serve as an assessment.
  - Friction is the force that slows down and stops the object.

Opportunities for Extended Learning

1. Have students make a bar graph of the data they have collected.
3. Recreate experiments but mark a certain distance and time how long it takes for the car to reach that spot.

Behavior & Materials Management Tips

- Have job cards to give each group to assign a role to each person. Jobs may include Scribe – person who records data and reads directions, Engineer – person who builds the ramp and changes the surface, Driver – person who rolls the object, and Measurer – person who measures how high the ramps is and how far the object rolls. Assign the engineer or driver to assist the measurer.
- Have one person (the engineer) from each group come to a central location to collect materials.
- Ramps should be built on the floor as objects are likely to roll farther than the table is long. Try to find an area for each group to work where groups are less likely to have conflicts over space and collisions.
Ramp Investigations: Ramp Surface

Our question: How does ramp surface affect the speed and distance an object rolls down a ramp?

We predict ____________________________________________________________

We know _____________________ is the force that slows down and stops our object.

Our experiment:
- We will let the object roll down from the top of the ramp, without pushing it.
- Once the object stops moving, we will measure in inches (in) to the closest half inch the distance the object rolled from the end of the ramp to the back of the object.
- We will repeat for 4 trials with the same surface.
- We will then change the ramp surface and repeat the experiment.
- We will test 4 different ramp surfaces.
- We will record each ramp surface and the distance measured in our data table.

Our data:

<table>
<thead>
<tr>
<th>Ramp Surface</th>
<th>Trial 1 Distance in inches</th>
<th>Trial 2 Distance in inches</th>
<th>Trial 3 Distance in inches</th>
<th>Trial 4 Distance in inches</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In the space below, provide an answer to the original question: How does ramp surface affect the speed and distance an object rolls down a ramp?

Our results: ___________________________________________________________
Essential Questions
How do different forces change the position and motion of objects around us?

NC Science Essential Standards – Unpacked Content
3.P.1.1 Students know that when a force acts on an object it will result in a change of speed and / or direction.
3.P.1.2 Students know that speed can vary. Students know that varying the speed of a moving object will affect the time it takes for the object to travel a particular distance.
3.P.1.3 Students know that the earth ‘pulls’ on all objects on or near the earth without touching those objects.

Lessons in this Arc
- Learning Activity 7: Colliding Cars
- Learning Activity 8: Playground Experiments
- Learning Activity 9: Rube Goldberg Design Challenge

Go Outdoors! 🍃
- Learning Activity 8: Playground Experiments

Duration
3-8 days of 30 minute learning activities

Background Information
Force is equal to mass times acceleration. Mass is the amount of material in an object. Acceleration is the rate of change of velocity in relation to time. In physics, acceleration can be an increase or decrease in speed as it deals with the change in velocity. An object at rest still has forces acting on it but the net force is zero. Inertia is a property of matter where it will remain at rest or in unchanging motion unless acted on by some external force. This comes from Newton’s First Law of Motion. Friction is a force that resists motion between two bodies in contact with each other which means it usually causes an object’s speed to decrease. Air resistance slows an object as it moves through the air. It is a form of friction and is also referred to as drag.

Energy is the ability to do work. Energy can be in the form of heat, light, or motion. It must be transferred from one object to another to perform work. Engineering is the science or profession that specializes in developing ways to use nature’s power and resources in ways that are helpful to people. Much of engineering is concerned with using and improving how energy is used for human purposes.
Vocabulary

- **Air resistance** is the friction between air and an object that slows the motion of an object. Also called drag.
- **Energy** is the ability to do work and comes in different forms.
- **Engineering** is the science or profession of developing and using nature's power and resources in ways that are useful to people (as in designing and building roads, bridges, dams, or machines and in creating new products).
- **Inertia** is a property of matter by which it remains at rest or in unchanging motion unless acted on by some external force.
- **Mass** is the amount of material in an object.
Lesson Prep

✓ Review the Wake/UTD PBL lesson “Colliding Cars”.
✓ Gather materials.

Vocabulary
Direction, distance, force, friction, gravity, motion, relative speed, speed

Procedure

Guided Practice
• This is an inquiry-based lesson. Students will work in groups to solve a problem and should be allowed to direct their own learning.
• Have a student volunteer read the problem aloud.
• Discuss and create a chart of what we know, the need to know, and learning issues surrounding the problem given.

Independent Group Work
• Students work in a group to solve the problem: You are a safety engineer that designs cars, and you need to know more about what happens when cars collide so you can make cars safer.
• You have been given toy cars, car tracks, ramps, and tape measures.
• You will create a presentation and report to your boss.

Assessment
• Presentation of team results along with a written summary by each student. Rubric provided in Wake UTD lesson materials.

Opportunities for Extended Learning
1. In this video, Bill Nye shows how a ping pong ball doesn’t have enough momentum to knock down bowling pins and that a bowling ball does. Momentum is the quantity of motion of a moving body, measured as a product of its mass and velocity.
2. Worksheet - “Which one needs a harder push?” from the “Newton and Me” Teaching Activity Guide p. 20 - Worksheet that has students determining how relatively hard of a push balls of varying mass will need to reach a certain point.

Behavior Management Tips
◆ Have each group discuss how they will work as a team. Will they divide the work based on specific jobs? Will they take turns? Will they raise their hand when they want a turn or have input?
◆ Have one person from each group come to a central location to collect materials.
◆ Ramps should be built on the floor as toy cars are likely to roll farther than the table is long. Try to find an area for each group to work where groups are less likely to have conflicts over space and collisions.
Lesson Prep

✓ Make copies of the Playground Experiments graphic organizer, 1 per student.
✓ Preview the video “Swings Slides, and Science” (3:37).

Vocabulary
Direction, distance, force, friction, gravity, motion, relative speed, speed, air resistance, energy, engineering, inertia, mass

Procedure

Mini-Lesson
- Before going outside ask students to tell you what they know about force and motion so far.
- Record student responses in a manner that the class can see.
- Tell them that they will be working in groups* to test one of these ideas.

Guided Practice
- Walk through the graphic organizer using one of the previous experiments they have done as an example, i.e. tug of war.

Independent Group Work
- Students will be given a graphic organizer with parameters which guide them to create and perform an experiment involving force and motion. Students will be working in groups*.
- The experiments will be inquiry-based involving gravity, friction, slides, climbing, spinning, push, pull.
- The graphic organizer will walk students through designing and implementing a simple experiment.
- To allow a more thorough exploration of force and motion, students will complete two experiments - one per day.
  - To allow for more choices, one day could be done at the upper grades playground and the other on the lower grades playground.

*The groups assigned for this activity should also be used for the Dream Playground Design Challenge: Part 1, Playground Field Trip, and Dream Playground Design Challenge: Part 2. The Playground Experiments and Playground Field Trip can be done as stand-alone activities.
Mini-Lesson

- **After** students have **completed** their playground experiments, show them “Swings Slides, and Science” (3:37) from SciShow Kids, which demonstrates the physics of playgrounds.
  - You can adjust the speed at which the characters speak by changing the playback speed in the settings on the video.
- By playing the video **after** they have done their experiments, the students have had the opportunity to learn through their investigations, and the video will add to and, hopefully, **confirm** what they have discovered.
- Use the video as a way to **discuss** what they did and solidify **connections** to force and motion.

Assessment

- The completed graphic organizer can serve as an assessment.

Opportunities for Extended Learning

1. **Falling for Gravity** activities - Gravity and air resistance - Introduce the concept of air resistance or drag. Reinforce the idea that Earth’s gravity is pulling all objects towards Earth.
2. Watch the **Hammer vs. Feather – Physics on the Moon** video of Commander David Scott dropping a feather and a hammer on the moon. (1:22)
3. Watch the **Mythbusters clip** of a recreation of the experiment on the Moon. (3:52)

Behavior Management Tips

- Ask students to remind you of the expectations for outdoor learning.
- Discuss how learning on the playground will look different than recess. Some exploration of the playground will be necessary to complete the playground experiments.
Playground Experiments

- Your group will be designing and testing an experiment about **force and motion** using playground equipment.

- Choose **where** on the playground you want to do your experiment.

- Discuss with your group how you think **force and motion** relates to your chosen piece of playground equipment. Questions to think about during your discussion:
  - How is gravity involved?
  - Is friction important?
  - Do you push or pull anything?
  - How does it move?
  - How do you move?
  - How are force and motion interacting with your body?
  - Connect it to your Fun Factor Survey.

- **Draw or describe:**

  **Our question about force & motion on our playground** (what we want to know)

  [Blank space for question]

  **What we already know**

  [Blank space for existing knowledge]

  **Our prediction** (what we think will happen)

  [Blank space for prediction]

  **Testing** our prediction (what we will do)

  1. ________________________________
  2. ________________________________
  3. ________________________________
  4. ________________________________
Our data / observations

Our conclusion (what we learned)

How was your prediction different from your conclusion?

How is gravity affecting your body when you play on this piece of equipment?

I still wonder about _____________________________________________
Lesson Prep
✓ Ask students to bring in any empty paper towel rolls, toilet paper rolls, cereal boxes, or granola bar boxes to share with the class.
✓ Gather materials for students to use to create their Rube Goldberg.
✓ Make copies of the graphic organizer, 1 per student.

Vocabulary
Force, friction, gravity, motion, speed, engineering, inertia

Procedure

Mini-Lesson
• Introduce students to Rube Goldberg and the idea of Rube Goldberg machines. The official Rube Goldberg website has lots of resources, including information about the man, his cartoons, and inventions.
• Students need to understand the idea that a Rube Goldberg machine completes a simple task in a fun, complicated way.
• Along with the resources found on the official Rube Goldberg site, you may choose to show a video of a contraption such as a GlodieBlox commercial showing girls creating a Rube Goldberg to turn off the tv (2:07) or the World’s largest Rube Goldberg machine (4:44) or one of a Rube Goldberg created by a child to feed his dog (2:09).

Independent Group Work
• Students will work in groups to create a Rube Goldberg contraption.
• Their contraption must have at least 4 separate steps to it and complete a task.
• Students will complete a graphic organizer as they work.

Assessment
• The completed graphic organizer can serve as an assessment.

Opportunities for Extended Learning
1. Have groups present their contraptions to the class.

Behavior & Materials Management Tips
♦ Before allowing them to collect materials, have groups show you their completed design on the graphic organizer.
Rube Goldberg Design Challenge

Remember: A Rube Goldberg machine completes a simple task in a fun and complicated way.

1. Which task is your group’s Rube Goldberg machine going to do? **Circle** your choice:
   - Put a ball/marble in a cup
   - Roll a car through a tunnel
   - Turn on a flashlight

2. Your Rube Goldberg machine must complete at least **4 steps** to complete its task.

   Describe Step 1.      Describe Step 2.
   ______________________________________  ______________________________________
   ______________________________________  ______________________________________
   ______________________________________  ______________________________________
   ______________________________________  ______________________________________

   Describe Step 4.       Describe Step 3.
   ______________________________________  ______________________________________
   ______________________________________  ______________________________________
   ______________________________________  ______________________________________
   ______________________________________  ______________________________________

   Will you need additional steps to complete your Rube Goldberg machine? ________________________

3. **Draw** a diagram of your group’s plan for a Rube Goldberg machine.

   [Diagram space]
4. Working as a team, **build** and **test** your group's Rube Goldberg machine.

5. Does your Rube Goldberg machine complete its task? ______ How can you **improve** your design?
   **Change** your design to make it complete its task or to make it better.

6. **Draw** your group's completed Rube Goldberg machine. **Number** the steps. **Label** the forces: gravity, friction, push, pull.

7. **Describe** how you used force and motion to accomplish your task.

______________________________________________________________________________________

______________________________________________________________________________________

______________________________________________________________________________________

______________________________________________________________________________________
Essential Questions
How can we use our knowledge of forces and motion to plan and build playgrounds that are fun?

NC Science Essential Standards – Unpacked Content
3.P.1.1 Students know that when a force acts on an object it will result in a change of speed and / or direction.

3.P.1.2 Students know that speed can vary. Students know that varying the speed of a moving object will affect the time it takes for the object to travel a particular distance.

3.P.1.3 Students know that the earth ‘pulls’ on all objects on or near the earth without touching those objects.

Lessons in this Arc
❖ Learning Activity 10: Playground Field Trip
❖ Learning Activity 11: Design a Millipede Playground
❖ Learning Activity 12: Dream Playground Design Challenge

Go Outdoors!
√ Learning Activity 10: Playground Field Trip
√ Learning Activity 11: Design a Millipede Playground

Nature Journal Connection
❖ Learning Activity 11: Design a Millipede Playground

Duration
4-6 days of 30 minute learning activities plus travel time for field trip

Background Information
Engineers design and build things to solve a particular problem. Many types of engineers exist including mechanical engineers, electrical engineers, and aerospace engineers. Mechanical engineers would be involved in designing and creating playgrounds as they solve problems that involve anything mechanical such as machines, tools, and engines as well as aspects of the manufacturing industry.

Vocabulary
• A mechanical engineer is an engineer that deals with tools, machinery, and the application of mechanics in industry.
Lesson Prep
- Make copies of the Playground Experiment graphic organizer (end of this lesson) and Fun Factor Survey (Swing Set Makeover, p. 83).
- Determine which playground you want to visit for this field trip.
- Walk the route you will journey with your students to identify any hazards and any potential stopping points for discussions.

Vocabulary
- Direction, distance, force, friction, gravity, motion, relative speed, speed, air resistance, energy, engineering, inertia, mass

Procedure
- **Independent Group* Work**
  - Take students to another playground to complete additional playground experiments and compare playground equipment.
  - As you walk to your nearby playground, pause periodically to make force and motion observations or other observations from previous science units (i.e. plants).
  - You can also give them questions to focus on as they walk.
    - Have questions written on index cards or slips of paper to pass out to the students as you walk.
    - Students can trade questions with another student or group periodically.
  - Once at the playground, students should work in their groups* to complete the Fun Factor Survey for the playground they visit. Refer to Learning Activity 2.
  - Students will also complete one experiment using the same graphic organizer from Learning Activity 8: Playground Experiments.

*The groups assigned for this activity should also be used for the Dream Playground Design Challenge: Part 1, Playground Experiments, and Dream Playground Design Challenge: Part 2. The Playground Experiments and Playground Field Trip can be done as stand-alone activities.

Assessment
- Discuss how this playground compares to the school playgrounds.
  - Ask questions about fun factor as well as force and motion.
- Discuss the Playground Experiments graphic organizer.
- Use these discussions not only to assess student understanding but also to correct any remaining misconceptions.
Opportunities for Extended Learning

1. While on their field trip, students could also complete the *Playground Scavenger Hunt* from Learning Activity 3, if time allows.

Behavior Management Tips

♦ Ask students to remind you of the expectations for outdoor learning.
♦ Discuss expectations for the walk to the playground.
♦ Discuss how learning on the playground will look different than recess. Some exploration of the playground will be necessary to complete the playground experiments.
Playground Experiments

❖ Your group will be designing and testing an experiment about **force and motion** using playground equipment.

❖ Choose **where** on the playground you want to do your experiment.

❖ Discuss with your group how you think **force and motion** relates to your chosen piece of playground equipment. Questions to think about during your discussion:
  ✓ How is gravity involved? ✓ How does it move?
  ✓ Is friction important? ✓ How do you move?
  ✓ Do you push or pull anything? ✓ Connect it to your Fun Factor Survey.
  ✓ How are force and motion interacting with your body?

❖ **Draw** or **describe**:

**Our question** (what we want to know)

What we already **know**

**Our prediction** (what we think will happen)

**Testing** our prediction (what we will do)

1. __________________________________________________________

2. __________________________________________________________

3. __________________________________________________________

4. __________________________________________________________
Our data / observations

Our conclusion (what we learned)

How was your prediction different from your conclusion?

How is gravity affecting your body when you play on this piece of equipment?

I still wonder about ____________________________

______________________________________________________________________________________
Lesson Prep

✓ Make copies of the graphic organizer, 1 per student.
✓ Preview the Design Challenge: Millipede Playground PowerPoint.
✓ Gather materials.

Vocabulary
Direction, distance, force, friction, gravity, motion, relative speed, speed, air resistance, energy, engineering, inertia, mass, mechanical engineer

Procedure

Mini-Lesson

• Briefly introduce millipedes and the design challenge using the PowerPoint.
  o Students will be mechanical engineers for the design challenge.
  o Ask students, “What do you think would be on a millipede playground?”.
  o Connect the idea of creating a playground for millipedes to people having different abilities and different preferences. You can connect this with earlier activities by discussing how not everyone’s fun factor surveys looked the same.

Independent Group Work

• Students should work in groups to apply their knowledge of force and motion to design and create a playground for millipedes.
• Students will complete a graphic organizer as they design and build their playground.
• Once playgrounds are created, millipedes can be found and collected from outside, typically underneath logs in the forested areas, to test the playgrounds.
  o Playgrounds could be carried outside to be tested, so that millipedes could easily be returned to their habitats.
  o You can allow students to use other creatures they find, such as beetles.
• Students should record their observations of the millipedes in their playgrounds in their Nature Journals.

Assessment

• The completed graphic organizer can serve as an assessment.
Opportunities for Extended Learning

1. Students could test another group’s millipede playground. They could then discuss with that group how the two compare.

2. Watch a video about engineers or the engineering process, such as “What’s an Engineer?” from Crash Course Kids, “Solve Problems: Be an Engineer!” from SciShow Kids, or “The Engineering Process” from Crash Course Kids. The playback speed of the video can be adjusted in settings to slow down the speed of the speaker.

Behavior & Materials Management Tips

♦ Have students show you their completed design before gathering materials.
♦ Remind students to be gentle with the millipedes, as they are living things.
♦ Remind students that the goal is for the millipedes to test the playground, so the millipedes must be allowed to explore the playground.
Millipede Playground Design Challenge

1. Discuss with your group what you think will be fun for a millipede. Think about your fun factor survey and previous experiments in this unit.

   a) How could you use **gravity** in your playground design?

   ____________________________________________________________________________________

   b) How could you use **friction** in your playground design?

   ____________________________________________________________________________________

   c) What could you create that would be fun for the millipede to **push**?

   ____________________________________________________________________________________

   d) What could you create that would be fun for the millipede to **pull**?

   ____________________________________________________________________________________

2. In the box, **draw** a diagram of the playground you want to create for your millipede. **Label** your diagram with the forces and motions used, such as gravity, friction, push, pull, straight, and slow.
3. As a group, use the materials provided to **create** a playground for a millipede.

4. How did you need to **change** your design when you built the playground? **Why?**

5. **Draw** your group’s millipede playground. **Label** your diagram with the forces and motions used.
Lesson Prep
- Make copies of the graphic organizer, 1 per group.
- Make copies of the presentation rubric, 1 per group.
- Review p. 189-214 in Swing Set Makeover: Grade 3 STEM Road Map for Elementary School to better understand the design challenge and modifications recommended.

Vocabulary
Direction, distance, force, friction, gravity, motion, relative speed, speed, air resistance, energy, engineering, inertia, mass, mechanical engineer

Procedure
Independent Group Work
- Students will work in groups* to use their experiments from this unit to come up with a plan of how they would modify the existing playground to optimize the fun factor.
- Project a picture of the school playground to remind students what pieces of equipment are already there.
- Students will use the graphic organizer to record their information to be presented.
- They should use the same company that provided the current equipment, KOMPAN, to find the exact pieces they would like to add.
- Students will create a slideshow and present what they choose to add and why to the class.
- Allow classmates to ask questions after each presentation.

*The groups assigned for this activity should be the same as the ones used for the Dream Playground Design Challenge: Part 1, Playground Experiments, and Playground Field Trip. The Playground Experiments and Playground Field Trip can be done as stand-alone activities.

Assessment
- Use the rubric on p. 210 of Swing Set Makeover: Grade 3 STEM Road Map for Elementary School to assess the student presentations.
Dream Playground Design Challenge

1. What was your total fun factor score for our school playground? __________

2. Based on your Fun Factor Survey, what fun factor needs the most improvement? ________________

3. What connections to force and motion can you make about the fun factor that needs improvement? ______________________________________________________

4. You have surveyed and experimented with different playgrounds. Using the data, you have gathered, your group will be choosing a piece of playground equipment to add to our playground to make it your dream playground. Our playground has equipment from a company called KOMPAN. Search https://www.kompan.us/play to find a piece of playground equipment that would increase your fun factor score.

5. What piece did your group chose? _______________________________________________________

6. What is the perimeter of this piece of equipment? _________________________________

7. How much area will this piece of equipment take up on our playground? _________________

8. How would it rate on your Fun Factor Survey? ________________________________

9. How does the piece you chose use force? _____________________________________________

10. How is it different than other existing pieces? _________________________________________

11. How might shadows and heat from the sun be important in your selections?

12. When have you felt heat on the playground?

13. You will be presenting your choice to the class. Create a Google Slides presentation that includes a picture of your chosen piece of playground equipment and the answers to the questions on this paper.
Unless otherwise noted, activities written by Lauren Greene, Dana Haine, Toni Stadelman, and Sarah Yelton
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Learning Activity 1: Newton and Me
BrainPOP. (n.d.). Isaac Newton. Retrieved from
https://www.brainpop.com/science/motionsforcesandtime/isaacnewton/
Newton and Me Teaching Activity Guide. (2010.). Retrieved from
https://unctv.pbslearningmedia.org/resource/reach-with-stem-forces-sports-fitness/forces-sports-and-fitness/

Learning Activity 2: Dream Playground Design Challenge: Part 1

Learning Activity 3: Playground Scavenger Hunt

Learning Activity 7: Colliding Cars
Newton and Me Teaching Activity Guide. (2010.). Retrieved from
https://www.youtube.com/watch?v=y2Gb4Nlv0Xg

Learning Activity 8: Playground Experiments
AIRBOYD. (2010, April 01). Hammer vs Feather - Physics on the Moon. Retrieved from
https://www.youtube.com/watch?v=KDp1tiUsZw8

**Learning Activity 9: Rube Goldberg**

**Learning Activity 10: Playground Field Trip**

**Learning Activity 11: Design a Millipede Playground**
Crash Course Kids. (2015, May 29). The Engineering Process: Crash Course Kids #12.2. Retrieved from https://www.youtube.com/watch?v=fxJWin195kU&list=PLhz12vamHOnZ4ZDC0d56c9HRN5Qrm0jHO&index=2

**Learning Activity 12: Dream Playground Design Challenge: Part 2**