THE REPRESENTED WORLD

Recreational STEM
STEM Road Map Module Title
Recreational STEM

STEM Road Map Theme
The Represented World

Grade Level
Third Grade

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See https://www.routledge.com/products/9781138804234 for more information about STEM Road Map: A Framework for Integrated STEM Education.
STEM Road Map Curriculum Module Overview

**STEM Road Map Module Theme and Grade Level**
Represented World – Third Grade
**Lead Discipline:** Science

**STEM Road Map Module Topic**
Recreational STEM: Playground Swing Set Makeover

**Module Summary**

In this module, students will examine the STEM aspects involved in constructing a new and improved swing set design. Science inquiry activities will allow students to explore the impact of balanced and unbalanced forces on motion and force. Students will gain a conceptual understanding of motion and force when they relate how the body moves to the objects explore, paying close attention to the forces each exerts and the positions maintained to keep balance. Students will identify geometric shapes, collect data using mathematical tools, and record and analyze data using line plots and bar graphs in order to explain and make predictions. Students will be challenged to apply this knowledge in the module’s final challenge, the Swing Set Makeover. Students will work collaboratively using the engineering design process (EDP) to sketch and develop a small scale model of their proposed design, using geometric shapes and precise measurements. (adapted from Capobianco, Parker, Laurier, & Rankin, 2015; see [https://www.routledge.com/products/9781138804234](https://www.routledge.com/products/9781138804234)).

**Established Goals/Objectives**
Students will be able to:

- Use the engineering design process (EDP) to create a new design for a swing set.
- Compare and contrast swing set designs as they improve upon or diminish a Fun Factor score on a survey.
- Recognize and describe gravity and friction as forces.
- Evaluate forces that interact with the body and swing set unit on the playground and associate these forces with design challenges.
- Evaluate and recommend alternative shapes and designs for the swing set.
- Design and implement an investigation around a testable question.
- Use data analysis as evidence to answer a question under investigation.
- Evaluate and implement safety features and materials of a swing set design.

**Challenge and/or Problem for Students to Solve**
Student teams will be challenged to survey existing playground equipment, compare and contrast different designs in light of safety concerns connected to the playground equipment and its environment, and then sketch and build a small scale model of their proposed design using geometric shapes and precise
measurements. Details of the swing set and evidence of its improvement upon existing play sets will be summarized in a poster.

Students will create swing set designs that will:

- include a swing or glider, a slide, and some sort of connecting partition
- be able to take advantage of features which maximize what they learned about force and motion
- utilize fun features they outlined in discussions while still maintaining high standards of safety.

**DRIVING QUESTION:** How can I use what I know about force and motion to create a plan and build a prototype of a swing set that is both fun and safe?

**CONTENT STANDARDS ADDRESSED IN STEM ROAD MAP MODULE**

**NEXT GENERATION SCIENCE STANDARDS**

**Physical Science Standards**

3-PS2-1: Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.

3-PS2-2: Make observations and/or measurements of an object’s motion to provide evidence that a pattern can be used to predict future motion.

**COMMON CORE MATHEMATICS**

**CCS. Math. Practices**

MP1: Make sense of problems and persevere in solving them.

MP2: Reason abstractly and quantitatively.

MP4: Model with mathematics.

MP5: Use appropriate tools strategically.

MP7: Attend to precision.

**CCS. Math. Content**

MD.A.1: Tell and write time to the nearest minute and measure time intervals in minutes. Solve word problems involving addition and subtraction of time intervals in minutes, e.g. by representing the problem on a number line diagram.

MD.A.2: Measure and estimate liquid volumes and masses of objects using standard units of grams (g), kilograms (kg), and liters (l). Add, subtract, multiply, or divide to solve one-step word problems involving masses or volumes that are given in the same units, e.g., by using drawings (such as a beaker with a measurement scale) to represent the problem.
MD.B.4: Generate measurement data by measuring lengths using rulers marked with halves and fourths of an inch. Show the data by making a line plot, where the horizontal scale is marked off in appropriate units – whole numbers, halves, or quarters.

MD.C.5: Recognize area as an attribute of plane figures and understand concepts of area measurement.

MD.C.6: Measure areas by counting unit squares (square cm, square m, square in, square ft., and improvised units).

MD.C.7: Relate area to the operations of multiplication and addition.

OA.D.8: Solve two-step word problems using the four operations. Represent these problems using equations with a letter standing for the unknown quantity. Assess the reasonableness of answers using mental computation and estimation strategies including rounding.

OA.D.9: Identify arithmetic problems (including patterns in the addition table or multiplication table), and explain them using properties of operations. For example, observe that 4 times a number is always even, and explain why 4 times a number can be decomposed into two equal addends.

COMMON CORE ENGLISH/LANGUAGE ARTS (ELA)

Reading Informational Text
RI.3.5: Use text features and search tools (e.g., key words, sidebars, hyperlinks) to locate information relevant to a given topic efficiently.

RI.3.7: Use information gained from illustrations (e.g., maps, photographs) and the words in a text to demonstrate understanding of the text (e.g., where, when, why, and how key events occur).

RI.3.8: Describe the logical connection between particular sentences and paragraphs in a text (e.g., comparison, cause/effect, first/second/third in a sentence).

Writing Standards
W.3.1: Write opinion pieces on topics or texts, supporting a point of view with reasons.

W.3.1a: Introduce the topic or text they are writing about, state an opinion, and create an organizational structure that lists reasons.

W.3.1b: Provide reasons that support the opinion.

W.3.1c: Use linking words and phrases (e.g., because, therefore, since, for example) to connect opinion and reasons.

W.3.1d: Provide a concluding statement or section.

W.3.2: Write informative/explanatory texts to examine a topic and convey ideas and information clearly.

W.3.2b: Develop the topic with facts, definitions, and details.
**W.3.3**: Write narratives to develop real or imagined experiences or events using effective technique, descriptive details, and clear event sequences.

**W.3.7**: Conduct short research projects that build knowledge about a topic.

**W.3.8**: Recall information from experiences or gather information from print and digital sources; take brief notes on sources and sort evidence into provided categories.

**Speaking and Listening Standards**

**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.3.1d**: Explain their ideas and understanding in light of the discussion.

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

**Presentation of Knowledge and Ideas**

**SL.3.4**: Report on a topic or text, tell a story, or recount an experience with appropriate facts and relevant, descriptive details, speaking clearly at an understandable pace.

**SL.3.5**: Create engaging audio recordings of stories or poems that demonstrate fluid reading at an understandable pace; add visual displays when appropriate to emphasize or enhance certain facts or details.

**SL.3.6**: Speak in complete sentences when appropriate to task and situations in order to provide requested detail or clarification.
## 21st Century Skills Addressed in STEM Road Map Module

<table>
<thead>
<tr>
<th>21st Century Skills</th>
<th>Learning Skills &amp; Technology Tools (from P21 framework)</th>
<th>Teaching Strategies</th>
<th>Evidence of Success</th>
</tr>
</thead>
</table>
| **Interdisciplinary Themes** | • Health & Safety  
• Environmental Literacy  
• Science  
• Mathematics  
• Engineering Design Process | A student survey will highlight the impact of the environment on safety and fun.  
Students will explore and document the connection of position and force on motion in a variety of activities.  
Lessons will culminate in an EDP challenge, the Swing Set Makeover, in which students design playground swing sets. | Students will interpret, organize, and present information from activities and research in an effective format that demonstrates understanding of force and motion. |
| **Learning and Innovation Skills** | • Creativity & Innovation  
• Critical Thinking & Problem Solving  
• Communication & Collaboration | Teach and facilitate creativity by encouraging students to think outside the box to solve problems.  
Facilitate group work and instruct students on Internet search procedures and strategies. | Students will record their EDP process thinking in multiple formats and work with their teams to share and improve upon their swing set models (sketches).  
Student will document and support their ideas with evidence in their science notebooks.  
Design teams will interact in activities that reinforce the importance of communication and collaboration. |
| **Information, Media and Technology Skills** | • Information Literacy  
• Media Literacy  
• ICT Literacy | Students use technology to conduct research to gain an understanding of playground swing set design and safety considerations associated | Student blogs includes evidence from research and classroom inquiry experiences. |
<table>
<thead>
<tr>
<th>21st Century Skills</th>
<th>Learning Skills &amp; Technology Tools (from P21 framework)</th>
<th>Teaching Strategies</th>
<th>Evidence of Success</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>with various designs.</td>
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<tr>
<td></td>
<td>Students use technology to share experiences and knowledge in a blog.</td>
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</tbody>
</table>
| Life and Career Skills | • Flexibility & Adaptability  
• Initiative & Self-Direction  
• Social & Cross-Cultural Skills  
• Productivity & Accountability  
• Leadership & Responsibility | Scaffold sketch-and-model through a series of inquiry activities and topical research projects.  
Use EDP to encourage flexibility (through redesign), time management, and goal setting in structured group work.  
Provide guidelines and practice opportunities for students to share, emphasizing being professional and inclusive of all team members. | Team projects are completed on time with evidence of participation of all team members.  
Students’ presentations include appropriate language and vocabulary.  
Students are able to respond to questions regarding their design process and teamwork. |

**Launch**

Students will engage in a group discussion about the swing sets throughout this module at school and/or their neighborhood park to activate prior knowledge, share personal experiences, and highlight their ideas of what components they enjoy most. After the discussion, teams will be given a picture of a swing set that they will use to generate a list of five to ten criteria to analyze the swing set for fun and safety factors on a scale of 1 to 5. After completing their table, the class will revisit the school playground play set and use the same rubric to determine its score on the survey.

Tell students that after they explore force and motion, their challenge in this module will be to act as mechanical engineers to create a model or prototype of a swing set that will meet their high standards for fun and safety. After they have developed their prototypes they will share their designs and defend their reasoning for design decisions online in a blog.
## Prerequisite Key Knowledge

<table>
<thead>
<tr>
<th>Prerequisite key knowledge</th>
<th>Application of knowledge</th>
<th>Differentiation for students needing knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Science Knowledge</strong></td>
<td><strong>Science Knowledge</strong></td>
<td><strong>Science Knowledge</strong></td>
</tr>
<tr>
<td>- Force is a push or pull.</td>
<td>- Students will experience, model, and describe gravitational force on an inclined plane utilizing a variety of angles and materials.</td>
<td>- Provide adequate scaffolding to allow students to make informed decisions when designing tests.</td>
</tr>
<tr>
<td>- Gravity pulls objects down (toward the earth).</td>
<td>- Students will see the impact of friction when testing a variety of materials on the ramp.</td>
<td>- Provide opportunities to work in teams as students draft sketches of their models and tests.</td>
</tr>
<tr>
<td>- Friction causes objects to slow down.</td>
<td>- Students will experience, model, and describe rotational force using a variety of types of pendulums.</td>
<td>- Provide opportunities to use language orally and written to describe scientific processes and principles.</td>
</tr>
<tr>
<td>- Squares and rectangles have a length and width measurements. These are added to find the perimeter and multiplied to find the area.</td>
<td>- Students will design a play set that demonstrates careful examination of materials and how the design is impacted by gravitational force.</td>
<td></td>
</tr>
<tr>
<td>- Scientists and Engineers solve problems in a similar fashion.</td>
<td>- Some spaces are public spaces.</td>
<td></td>
</tr>
<tr>
<td>- Some spaces are public spaces.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Inquiry Skills</strong></td>
<td><strong>Inquiry Skills</strong></td>
<td><strong>Inquiry Skills</strong></td>
</tr>
<tr>
<td>- Ask questions, make logical predictions, plan investigations, and represent data.</td>
<td>- Select and use appropriate tools and equipment to conduct an investigation.</td>
<td>- Model selection and use appropriate tools and simple equipment to conduct an investigation.</td>
</tr>
<tr>
<td>- Use senses and tools to make observations.</td>
<td>- Identify tools needed to investigate specific questions.</td>
<td>- Provide samples of a science notebook.</td>
</tr>
<tr>
<td>- Communicate and plan simple investigations.</td>
<td>- Maintain a notebook that includes observations, data, diagrams, and reflections.</td>
<td>- Scaffold student efforts to organize data into appropriate tables, graphs, drawings, or diagrams by providing step-by-step instructions.</td>
</tr>
<tr>
<td>- Communicate understanding of data using age-appropriate vocabulary.</td>
<td>- Analyze and communicate findings from multiple investigations of similar phenomena to reach a conclusion.</td>
<td>- Identify specific investigations that could be used to answer a particular question and identify reasons for this choice.</td>
</tr>
<tr>
<td>Prerequisite key knowledge</td>
<td>Application of knowledge</td>
<td>Differentiation for students needing knowledge</td>
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<tr>
<td><strong>Measurement Skills</strong></td>
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<td><strong>Measurement Skills</strong></td>
</tr>
<tr>
<td>- Measuring distance using standard and metric units.</td>
<td>- Students will measure distances using a tape measure with metric units.</td>
<td>- Provide students with opportunities to practice measuring distances using various units and measuring time.</td>
</tr>
<tr>
<td>- Measuring distance to the nearest inch, half-inch, and one-quarter inch.</td>
<td>- Students will calculate distances using methods developed through experimentation.</td>
<td>- Provide students with additional content, including textbook support, teacher instruction, and online videos for using stopwatches and explaining strategies for measuring time.</td>
</tr>
<tr>
<td>- Evaluating time to the nearest minute and second.</td>
<td>- Students will use stopwatches and other strategies to determine periods of motion.</td>
<td>- Provide instruction in use of a stopwatch and identifying the units as seconds and minutes.</td>
</tr>
<tr>
<td><strong>Numbers and Representation</strong></td>
<td><strong>Numbers and Representation</strong></td>
<td><strong>Numbers and Representation</strong></td>
</tr>
<tr>
<td>- Represent whole numbers up to and including 1000.</td>
<td>- Students will add, subtract, multiply, and divide numbers in order to analyze findings and make decision.</td>
<td>- Review and provide models of addition and subtraction up to 1000.</td>
</tr>
<tr>
<td>- Add and subtract whole numbers.</td>
<td>- Students will calculate distances and speeds and track the results in tables.</td>
<td>- Review multiplication and division using examples of distance and time.</td>
</tr>
<tr>
<td>- Multiply and divide whole numbers.</td>
<td>- Students will support their design decisions using numbers in tables and graphs (line plots).</td>
<td>- Utilize textbook support, teacher instruction, models, graphic organizers, and online videos to provide practice using tables and graphs.</td>
</tr>
<tr>
<td>- Create real data and represent findings in appropriately labeled tables.</td>
<td>- Students will calculate speeds in units they create as well as cm units over a period of time.</td>
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<tr>
<td>- Represent data using line plots.</td>
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<tr>
<td><strong>Geometry</strong></td>
<td><strong>Geometry</strong></td>
<td><strong>Geometry</strong></td>
</tr>
<tr>
<td>- Recognize and identify geometric shapes and patterns.</td>
<td>- Students will find geometric shapes and patterns in the play yard and playground sets.</td>
<td>- Review and provide tessellation models and manipulatives.</td>
</tr>
<tr>
<td>- Recognize that a plane is composed of geometric shapes and patterns.</td>
<td>- Students will experiment with geometric shapes as they design playground equipment.</td>
<td>- Put together intermediate level puzzles to get a sense of how shapes make up planes.</td>
</tr>
<tr>
<td>- Measure perimeter and area of geometric shapes.</td>
<td>- Students will consider the space that is available and the size of the apparatus they design (perimeter and area).</td>
<td>- Practice measuring shapes around the classroom.</td>
</tr>
<tr>
<td><strong>Reading</strong></td>
<td><strong>Reading</strong></td>
<td><strong>Reading</strong></td>
</tr>
<tr>
<td>- Use information gained from illustrations and words in print or digital text to build understanding of scientific concepts.</td>
<td>- Students will describe the relationship between a group of images and descriptions using language that describes where, when, why, and how as it pertains to playgrounds and safe versus unsafe conditions.</td>
<td>- Provide reading strategies to support comprehension of non-fiction texts, including using vocabulary notecards, creating graphic organizers, writing in the science notebook, and discussions.</td>
</tr>
<tr>
<td>- Use information gained from illustrations and words in print or digital text to build understanding of safe and</td>
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</tr>
<tr>
<td><strong>Prerequisite key knowledge</strong></td>
<td><strong>Application of knowledge</strong></td>
<td><strong>Differentiation for students needing knowledge</strong></td>
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<tr>
<td>--------------------------------------------------------</td>
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<td>--------------------------------------------------</td>
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<tr>
<td>dangerous conditions on a playground.</td>
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<tr>
<td><strong>Writing</strong></td>
<td>Writing</td>
<td>Writing</td>
</tr>
<tr>
<td>- Use science terms to inform and explain thoughts and</td>
<td>- Write informative and explanatory narratives to</td>
<td>- Provide a template for writing.</td>
</tr>
<tr>
<td>ideas about the topic.</td>
<td>convey ideas and information clearly.</td>
<td>- Provide writing organization</td>
</tr>
<tr>
<td>- Use key terminology as words and pictures.</td>
<td>- Write narratives to describe experiences using</td>
<td>worksheets to scaffold student work.</td>
</tr>
<tr>
<td></td>
<td>effective techniques, descriptive details, and clear</td>
<td>- Provide rubrics that have a consistent format</td>
</tr>
<tr>
<td></td>
<td>event sequences.</td>
<td>so students can measure their own writing.</td>
</tr>
<tr>
<td><strong>Communication Skills</strong></td>
<td>Communication Skills</td>
<td>Communication Skills</td>
</tr>
<tr>
<td>- Participate in collaborative conversations using</td>
<td>- Students will engage in a number of collaborative</td>
<td>- Scaffold student understanding of</td>
</tr>
<tr>
<td>appropriate language and skills.</td>
<td>discussions in which they will convey and support</td>
<td>communication skills by providing</td>
</tr>
<tr>
<td>- Effectively support scientific knowledge with</td>
<td>learning.</td>
<td>examples of appropriate language and</td>
</tr>
<tr>
<td>appropriate language and relevant, descriptive</td>
<td>- Students will write a blog to describe their play</td>
<td>presentation.</td>
</tr>
<tr>
<td>details.</td>
<td>set design and support it with scientific</td>
<td>- Provide worksheets and rubrics to support</td>
</tr>
<tr>
<td></td>
<td>reasoning.</td>
<td>organization of facts and use of relevant</td>
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<tr>
<td></td>
<td></td>
<td>descriptive details.</td>
</tr>
</tbody>
</table>

**Desired Outcomes and Monitoring Success**

<table>
<thead>
<tr>
<th><strong>Desired Outcome</strong></th>
<th><strong>Evidence of Success in Achieving Identified Outcome</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>- Students will be able to apply an understanding of</td>
<td><strong>Performance Tasks</strong></td>
</tr>
<tr>
<td>balanced and unbalanced forces and be able to predict</td>
<td>- Students will maintain science notebooks that will</td>
</tr>
<tr>
<td>the motion of unbalanced forces that are applied to an</td>
<td>contain graphic organizers with lab test data,</td>
</tr>
<tr>
<td>object.</td>
<td>sketches, research notes, evidence of collaboration,</td>
</tr>
<tr>
<td></td>
<td>and ELA related work.</td>
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<tr>
<td></td>
<td>- Students will design a prototype of a swing set.</td>
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<td></td>
<td>- N.A.</td>
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</table>
**Assessment Plan**

**Major Group Products**
- Modified ‘Fun Factor’ survey and data sheet that is developed by the students in Lesson 1 and applied to their school playground swing set or neighborhood park.
- Lab reports (Forces Push Back, Scavenger Hunt, Ramp and Pendulum Investigations)
- Jigsaw Poster Presentation (optional)
- Swing Set Makeover plan, sketch, write-up and model

**Major Individual Products/Deliverables**
- Personal ‘Fun Factor’ survey results, before peer engagement
- Science notebook (with research, lab notes, sketches, graphic organizers, and reflections).

**Resources**

**School-based Individuals:** academic teachers, multi-media teacher, and librarian

**Technology:** Devices with Internet access.

**Community:** audience for presenting the prototype and for reading the blog/essay – school administrators, local newspaper journalist, engineers, parents, etc.; Guest speaker options include: park naturalist or volunteer, city planner, engineer, or journalist

**Materials:** materials lists are provided within each lesson.
### STEM Road Map Module Schedule Week One

<table>
<thead>
<tr>
<th>Day</th>
<th>Lesson</th>
<th>Activity Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 1</td>
<td>Lesson 1</td>
<td>Forces Push Back</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Access students’ prior knowledge about playgrounds and swing sets and introduce the module challenge. Students create individual and team Fun Factor scales and use these to analyze playground images and the school playground.</td>
</tr>
<tr>
<td>Day 2</td>
<td>Lesson 1</td>
<td>Forces Push Back</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Students complete Fun Factor scales. Introduce ramps and relate these to sliding boards. Students participate in the Ramp Experiment activity to identify forces.</td>
</tr>
<tr>
<td>Day 3</td>
<td>Lesson 2</td>
<td>Slippery Slide Design</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Introduce balanced and unbalanced forces. Students participate in Ramp Investigations activities.</td>
</tr>
<tr>
<td>Day 4</td>
<td>Lesson 2</td>
<td>Slippery Slide Design</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Introduce geometric shapes, area, perimeter, and scale. Students complete Geometry Scavenger Hunt.</td>
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<tr>
<td>Day 5</td>
<td>Lesson 2</td>
<td>Slippery Slide Design</td>
</tr>
<tr>
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<td></td>
<td>Introduce the engineering design process (EDP) and have students apply it to complete the Slide Makeover design challenge.</td>
</tr>
</tbody>
</table>

### STEM Road Map Module Schedule Week Two

<table>
<thead>
<tr>
<th>Day</th>
<th>Lesson 3</th>
<th>Activity Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 6</td>
<td>Lesson 3</td>
<td>Swinging Pendulums</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Introduce pendulums and relate these to swings. Students participate in Pendulum Investigations activity.</td>
</tr>
<tr>
<td>Day 7</td>
<td>Lesson 3</td>
<td>Swinging Pendulums</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Field trip to playground (see Extend/Apply section of Lesson 3). Note: This trip may be held on any day of lessons 3 or 4.</td>
</tr>
<tr>
<td>Day 8</td>
<td>Lesson 3</td>
<td>Swinging Pendulums</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Students complete the Swing Makeover design challenge.</td>
</tr>
<tr>
<td>Day 9</td>
<td>Lesson 4</td>
<td>The Swing Set Makeover Challenge</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Students create their prototypes for the Swing Set Makeover Challenge.</td>
</tr>
<tr>
<td>Day 10</td>
<td>Lesson 4</td>
<td>The Swing Set Makeover Challenge</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Students create and present their prototypes for the Swing Set Makeover Challenge.</td>
</tr>
</tbody>
</table>
Lesson Plan #1
Recreational STEM – Grade 3

Lesson Title
Forces Push Back

Lesson Summary
This lesson will introduce students to the module and the culminating challenge of the module, the Swing Set Makeover. A video, a field trip to the school playground, discussions, and graphing data will help students connect to the project and will excite their curiosity. Science activities will focus on motion, emphasizing inertia, gravity, and friction forces.

Essential Question(s)
- What forces are at work on a playground?
- How does the design and shapes in a swing set affect speed and motion?
- What is the relationship of inertia and other forces in playground play activities?
- How does the force called friction slow down or decrease gravity’s pull?
- What are some ways that friction slows down objects such as balls or Frisbees when nothing seems to be touching the object?
- How can what is learned about inertia, gravity, and friction be applied to a slide design?

Established Goals/Objectives
Student will be able to:
- Evaluate the impact of a swing set on its Fun Factor score.
- Recognize and describe gravity as a force.
- Recognize and describe friction as a force.
- Evaluate a variety of activities to identify the forces that impact motion.
- Recognize forces that interact with the body on the playground and associate these forces to swing sets and design challenges.

Time Required
2 days (90 minutes each)
NECESSARY MATERIALS

- Science notebooks (for each student),
- Access to Internet for showing swing set images and for student research
- Chart paper for a Know/Wonder/Learned chart [K-W-L]
- Optional: You may want to have pictures of swing sets, slides, ramps, pendulums, or other images on display to create excitement and for students to use for inspiration when creating the cover page.
- Paper and markers for creating notebook cover
- Materials to decorate the cover page of the science notebook (markers, colored pencils, scissors, glue stick, stickers, paper scraps, etc.)

Materials needed for activities within this lesson

Fun Factor Survey
- Four images of swing sets per team (see Appendix, Lesson 1)
- Fun Factor survey individual handout (for each student), located in Appendix, Lesson 1
- Fun Factor survey team handout (for each team), located in Appendix, Lesson 1
- Fun Factor Bar Graph handout – optional, provided for students who need help setting up the bar graph, located in Lesson 1 Appendix

Forces Push Back
- Sets of sports equipment – soccer ball, 2 jump ropes, wiffle ball bat and ball, basketball, hacky sack ball, Frisbee, volleyball, golf putter and ball, football, magnetic fishing game, badminton racket and birdie, etc.
- Clipboards (1 per group of 3-4 students)
- Pencils
- Timer (for teacher)
- Forces Push Back handout (for each team), located in lesson 1 appendix
CONTENT STANDARDS ADDRESSED IN STEM ROAD MAP MODULE LESSON

Next Generation Science Standards
3PS2-1; 3PS2-2

Common Core Mathematics
CCS.Math.Practices: MP1; MP2; MP4; MP5; MP7
CCS.Math.Content: MD.C.5; MD.C.6; MD.C.7; OA.D.9

Common Core English/Language Arts (ELA)
Reading Information Text Standards: RI.3.5; RI.3.7
Writing Standards: W.3.1; W.3.1a; W.3.1b; W.3.1c; W.3.1d; W.3.2; W.3.2b; W.3.3; W.3.7; W.3.8
Speaking and Listening Standards: SL 3.1; SL 3.1d; SL 3.3
Presentation of Knowledge and Ideas: SL 3.4; SL 3.6

21st Century Skills
Interdisciplinary Themes (health & safety, environmental literacy, science, mathematics, engineering design process); Learning and Innovation Skills; Information, Media, & Technology Skills; Life Skills

<table>
<thead>
<tr>
<th>Key Vocabulary</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>direction</td>
<td>the path a moving object follows</td>
</tr>
<tr>
<td>distance</td>
<td>the measure of how far an object has traveled</td>
</tr>
<tr>
<td>force</td>
<td>an energy that causes motion or a change in motion</td>
</tr>
<tr>
<td>friction</td>
<td>a force that causes moving things to slow down when one object rubs against another object</td>
</tr>
<tr>
<td>gravity</td>
<td>the force that pulls objects toward the center of the earth</td>
</tr>
<tr>
<td>inertia</td>
<td>the property of an object that keeps it resting when at rest or moving when in motion in the same straight line unless acted on by an outside force</td>
</tr>
<tr>
<td>motion</td>
<td>the act of changing place or position</td>
</tr>
<tr>
<td>pull</td>
<td>a force that moves something toward you</td>
</tr>
<tr>
<td>push</td>
<td>a force that moves something away from you</td>
</tr>
<tr>
<td>speed</td>
<td>how fast or slow an object is moving</td>
</tr>
</tbody>
</table>

TEACHER BACKGROUND INFORMATION

Engineering
In this module, students will act as mechanical engineers who use science and mathematics to design, build, and maintain equipment. Many students have experienced creating their own structures using 3D building blocks; consequently, the students will be familiar with using many of the same decision-making processes that engineers use. Mechanical engineers must understand scientific principles (physics), as well as have an
understanding of materials (chemistry). This lesson will help students understand that decisions about each component are made after careful deliberation and testing.

For this module you may wish to focus on what an engineer is and does. The following video provides an overview: https://www.youtube.com/watch?v=UiaXl0giP78.

**Newton’s First Law of Motion**

This lesson explores Newton’s first law of motion, which states that an object in motion will stay in motion unless acted upon by an outside force, and an object at rest will stay at rest unless acted upon by an outside force. This tendency to obey Newton’s Law is called inertia. This lesson will also provide opportunities for the students to explore the motion of an object and the forces that cause these changes, such as gravity, friction, and air resistance. Gravity pulls things down toward earth, friction slows motion by rubbing against moving objects. Air resistance, or friction with the air, also slows objects down.

**Everyday Application of Newton's First Law**

There are many applications of Newton's first law of motion. Consider some of your experiences in a car. You have to use a travel mug in a vehicle because a coffee cup that is filled to the rim while starting a car from rest or while bringing a car to rest from a state of motion "keeps on doing what it is doing." When you accelerate a car from rest, the road provides a force on the spinning wheels to push the car forward; yet the coffee (that was at rest) wants to stay at rest. While the car accelerates forward, the coffee remains in the same position causing the car to move out from under the coffee and the coffee spills in your lap. On the other hand, when braking the coffee continues moving forward with the same speed and in the same direction, ultimately hitting the windshield or the dash. Coffee in motion stays in motion.

A car that is braking is another good example. When the force of the road on the locked wheels creates a force to change the car's state of motion, there isn’t a force to change the passenger’s motion. Thus, the passenger of the car will continue in motion, sliding along the seat in a forward motion. A person in motion stays in motion with the same speed and in the same direction ... unless acted upon by the unbalanced force of a seat belt.

In Lesson 1 you will be setting up stations inside or outside with sports/recreation equipment. This provides a good basis for inquiry, since this equipment is readily available familiar to students. Adding a few other options can provide variety and you may wish to offer new activities that may interest students who have not participated in previous playground games.

**Science Notebook**

A science notebook will be maintained to serve as a place for students to organize their work throughout the module, record their thoughts, and track their progress throughout the EDP. All student work for the module should be kept in the notebook. This notebook may be maintained across subject areas, giving students the opportunity to see that although their classes are separated throughout the day, the knowledge is connected.
Journaling is as personal and unique as one’s teaching strategies. Many of the notebooking activities throughout this module will be based on Kellie Marcarelli’s interactive notebook strategy in which students create a portfolio of their work and thought processes through personal reflections, graphic organizers, and sketches. Feel free to substitute these activities with your own strategies; the suggestions are merely a guide as a springboard your own ideas. Creating a cover page for the notebook allows students to express their creativity and personalize their notebooks. You may wish to have students create a table of contents for their notebooks.

**Swing Sets**
Throughout this module the term “swing set” is used to refer to the type of playground equipment typically found in school playgrounds. The use of this terminology is intended to designate that swings are specifically incorporated into the playground equipment students will design, since modern playgrounds may or may not incorporate swings. Students’ designs will include slides, swings, and connectors between these pieces, but is otherwise limited only by students’ imaginations. Students may wish to incorporate various features such as climbing walls, music elements, and rope courses.

**LESSON PREPARATION**
Review the teacher background information provided and assemble the materials. Hang chart paper and have markers on hand for creating a K-W-L chart. Prepare group sets of swing set images for evaluating (3 each) or pre-set saved images from the provided websites. Set up the sport stations the Forces Push Back activity (with one sport or activity per station), either in a large indoor space or outdoors. Preview the links and videos in the Learning Plan.

Visit your local library to compile a collection of fiction books about visiting parks and books that show people or objects being moved by a variety of forces as well as a few nonfiction books about force. The librarian may put a collection together for you if you call ahead.

The students will be working in groups of about three students, called design teams throughout this module. Divide students into groups before passing out the swing set images during the ‘what do you know/wonder’ discussion in the introduction to the lesson. Provide students an opportunity to choose a group name and get acquainted if necessary.
LEARNING PLAN COMPONENTS

INTRODUCTORY ACTIVITY/ENGAGEMENT

1. Ask students to share their experiences on playground/park swing sets. Possible discussion questions include:
   - Do you play on the playground swing set on the school playground or neighborhood park?
   - What part of the playground swing set do you enjoy most?
   - Fill in the black: In order to be fun, a swing set or play set must have _____.
   - What makes the swing set swing move?
   - Why do you slide down a slide and not up?
   - What is that pull you feel when you are climbing up a rock wall or a ladder?

2. You may want to create a Know/Wonder/Learned chart [K-W-L] for swing sets.
   - What do you know about swing sets?
   - Do you have anything that the students are curious about? About the forces that impact motion on the swing set? About the design of a swing set? Are they curious about the shapes used for parts of the swing set or why ropes or chains are used and not a pole for the swing? Is it possible to go up and over the bar of a swing set or will gravity and other forces prevent this from occurring? What other things might the students be curious about?
   - Begin generating the final column, but remember this is a work in action. Students ought to be provided an opportunity each day throughout the module to make modifications to this chart.

3. Continue the discussion about swing sets and begin to weave questions about forces and resulting motions into the conversation.
   - Where are the forces being applied on a swing set? (Pumping feet, climbing ladder, sliding, etc.)
   - What happens when forces are applied? Students should conclude that forces cause motion, i.e. going up, going down, spinning, bumping, etc. all result from a force being applied.

Swing sets allow you to experience greater heights and sometimes greater speeds due to the forces that are pushing and pulling on our bodies. Swing sets allow you to test your strength and endurance as you work with and against gravitational forces. Explore the idea that a swing set offers opportunities for falling in a controlled manner – so gravity is an important consideration when planning swing set structures.

4. Show several images of swing sets with poorly placed or have a poor design sprinkled within the mix. Students can hold up markers to indicate designs that are a win or a fail. The following links include images of multiple swing sets:
   - www.swingsets.com/swing-sets

5. Ask students to share their thoughts about these playground play sets.
- Is this swing set fun? What qualities make this swing set fun/not fun?
- Is this swing set safe? What conditions cause this swing set to be unsafe?

6. Take time to add to the K-W-L chart if these images have sparked new ideas about what is known about forces.

**Activity/Investigation**

**Science Activity #1**

**What’s the Fun Factor?**

1. Pass out the Fun Factor Survey located in the appendix. The survey will help students to identify characteristics of fun that can apply to swing set designs.

2. Let each student assess his or her own perception of “fun” by filling out the survey to establish a baseline measurement. The children will record their personal preferences for fun in chart 1 by numbering the squares 1 to 5. Survey components include:
   - Speed: does the student like to go fast (not at all or moving as fast as a cheetah)?
   - Flight: fly through the sky, (a penguin cannot fly, a baby bird hops when it tries – but an eagle soars!).
   - Height: does the student like heights (prefer to stay close the ground or up in the clouds)?
   - Climb: preference for bridges with no climbing involved or climbing ladders or trees?
   - Spin: some students do not like spinning, others love to spin around and around.
   
   Fun Areas: spaces the student enjoys most, wide open spaces, spaces with puzzles or gadgets, or interconnected spaces forming a maze.

3. Now that students have individually identified their own personal standards for fun, tell the students they will work in design teams to begin evaluating swing set designs and imagining their own design for a swing set that will be fun and safe. Introduce the module challenge, the Swing Set Challenge. Tell students that they will design swings, slides, and other components to create a swing set that will have a high fun factor rating and will be safe. Once the students are divided into teams of three to four, encourage them to give their teams a name.

4. Encourage students to share their survey results with each team member. Are all the items numbered the same on each survey? How are they similar? Different?

5. Tell students they will need to create a common fun factor scale, based on each team members’ survey results. Let teams brainstorm to devise a strategy for selecting the order and create a team fun factor scale. Students may choose to average their individual scores or use compromise and negotiation to create their team scale.

6. Have each team share their fun factor scales with the class, and compare and contrast the teams’ scales. Ask students to share what types of things they considered when creating their scales and how they negotiated amongst team members to arrive at a common scale. Ask students to consider what might affect the scale for different people (prompt them to consider the user’s age, size, abilities, etc.).
7. Present swing set image #1, either from the images located in the appendix or one that you selected during the lesson preparation, and project the image. Walk students through the process of evaluating it using their teams’ fun factor benchmarks.
   - Allow time to add up the score and propose a suggestion for improving the swing set design.
   - Evaluate: Is the rubric working as it ought? Let the teams tweak their rubric if necessary.

8. Have teams evaluate swing set images #2, #3, and #4 in the same manner.

Take the class on a ‘field trip’ to the school playground. Have teams rate the playground using their fun factor scales. Ask students if they believe that the fun factor scale is useful for assessing the playground. Ask them to consider if the scale is missing anything or if they can think of ways to make the fun factor scale better. Give teams an opportunity to modify their scales or add categories to them.

**MATHEMATICS CONNECTION**

Bar Graph

1. Have students graph their team’s Fun Factor scores for the swing set images and the school playground on a bar graph. A handout is provided for students who need the extra help setting it up (see HO 1-2 in the appendix to this lesson).
   - Students will add all the scores for each swing set to get a total Fun Factor score.
   - Create a bar graph with values (0-30) on one side and the labels for each set of data.

Discuss with students that mathematics can be used to help make decisions. Guide students to analyze the results of their data. Which swing set received the top score? Why?

Many careers involve mathematics – careers kids may not suspect such as game developers, animators, robot engineer, and doctors and nurses use math. The career connections, you may want to introduce that relate to this lesson are:

a. **Statistician** – uses mathematics every day. They collect data from surveys and studies and analyze the data. They also help companies develop good business strategies to make them more effective.

b. **Geographer** – collects data about the earth’s landforms and environment and uses the data to make decisions about the effect the environment has on wildlife, weather, and climate patterns.

c. **Actuary** - looks at patterns in numerical data and applies theories to make predictions.

d. **Stockbroker** – uses mathematics to guide people who want to invest their money.

**ELA CONNECTION**

You may wish to have students write a paragraph (3-5 sentences) summarizing the What’s the Fun Factor activity in their notebooks that may be formatted as follows:

- Sentence 1: What did I do?
- Sentence 2: Why did I do this?
- Sentence 3: What did I find out?
- Sentence 4: How can I apply what I learned?

**Science Activity #2**

Students should understand the following points after completing this activity:
- a force is a push or a pull on an object that makes it move
- the greater the force applied to an object, the greater the change in speed or direction of the object

Place a soccer ball on the floor and stare at it. When students asks you what you are doing, tell them you are playing soccer. Hopefully this will arouse some sort of disagreement. Launch into a discussion about what else you need to do to play soccer.

Students will need to associate playing soccer to motion and understand that motion is the result of push and pull forces. In this case gravity and friction forces play a role in getting the ball to the net.

Show students the following video about forces and gravity (about 21 minutes long): [https://www.youtube.com/watch?v=ysrpUL8dASg](https://www.youtube.com/watch?v=ysrpUL8dASg). Ask students to watch for the following terms: inertia, gravity, and friction.

Afterwards have design teams work together to create a definition for each term. Then, lead a discussion and ask teams to share their definitions with the class and support their definitions with examples.

Guide the class to develop working definitions such as:
- **Inertia**: objects that are not moving will continue not to move unless a force is applied to them; an object moving in a straight line will continue to move in a straight line unless an outside force is applied to it.
- **Gravity**: the downward pull that keeps things on the ground, or causes objects to fall to the ground
- **Friction**: (a pull) the rubbing force that causes objects to slow down when in motion

**Forces Push Back**

Students will engage in the Forces Push Back activity using what they have learned from the discussions and the video to identify the push and pull forces in the sports stations.

1. Before class, set up eight to ten sports stations, each of which represent a different sporting event or playground activity. These can be set up outdoors or in a large indoor space. Each team should have a clipboard, pencil and the Forces Push Back handout located in the appendix at the end of Lesson 1.
2. Explain the procedure for the learning center stations to the students:
   - Write the name of the sport in the left column of the table.
   - Use the equipment to play the sport for 3 minutes.
   - While playing, pay attention to the forces used to play.
   - Write down on the handout if a push or pull force was being used, or both, and explain your reasoning. For example, a baseball is a push because your hand and the bat push on the ball to make it move.
   - Complete the sentence thread to identify the forces that were used [see teacher explain section below].
   - Go to the next station (It may be helpful to number stations). There should be an agreed signal that will indicate that it is time to move on.

3. Send the students to the stations and use the timer to allow 3 minutes for exploring. Then use a signal (ring a bell or blow a whistle if you are outside) to get students to stop playing and begin writing about their experiences. Allow one minute for writing.

4. Signal to indicate that teams move to the next station and begin again until everyone has been to every station.

5. When each team has been to every station, clean up and have students return to the classroom.

6. Chart class findings on the board and discuss the results. Questions may include:
   - What observations did you make about the role of inertia in the sports you played?
   - What observations did you make about the role of gravity and friction in the sports you played?
   - How can you apply this information to playing on a swing set?
   - How will what you know about inertia, gravity and friction impact your design decisions when you design your swing set?

Optional: Have students write a 2 paragraph summary in your science notebook. Describe your thoughts and Aha moments during the investigations in paragraph one. Explain your conclusions and use evidence to support them in paragraph two.

**ELA Connection**

1. Students may design a cover page for their science notebooks. Ask them to use the title, “Swing Set Makeover.” Allow students to use art materials, add pictures they have printed, word art, or even hand-drawn cartoon images. The cover will show what part of this module excites the student most.

2. Create vocabulary cards for the terms inertia, gravity, and friction.

3. Students should add the title to the Table of Contents in the front of their notebook.

4. You may want to use this opportunity to launch a discussion about Tables of Contents that are present in non-fiction texts while noticing that fiction stories do not have one.

**Suggested literature connections**

|-------------------------|---------------------------|---------------------------|


**EXPLAIN**

**SCIENCE**

**Prototypes**

Students should understand that prototypes are small-scale models of a product that are used for repeated testing so that improvements can be made. Students will be making annotated sketches throughout the module that they may use to build a prototype during the final challenge.

**Fun Factor Survey**

Being self-aware and flexible are key learning goals for the Fun Factor Survey activity. The self-assessment helps students to become self-aware before being influenced by peers. This self-assessment will also be considered when teams build their swing set prototypes.

**Force**

A force is anything that tends to change the state of rest or motion of an object. Forces cause changes in the speed or direction of the motion of an object; the greater the force placed on an object, the greater the change in motion. The more massive an object is, the less effect a given force will have upon its motion. The activities in this lesson are based on a working definition for force. A *working definition* is one that is determined by students. It may or may not be completely accurate; however, it should be used and corrected by the students as they gain more experience with and gain understanding of the concept. The advantage of a working definition is that it is an indicator of student understanding and can be used by the teacher to guide future experiences.

Explain to students that there are invisible forces including gravity and friction. They are like the wind. We can't see these forces, but we know they are there because we can see their effect. We can’t see gravity, but we know it is there because the natural tendency of objects is to fall down. We can’t see friction, but we know it is there by watching the way things move. Friction helps things stay in one place.

The chart below contains examples of push and pull forces in sports and recreational activities that you may wish to use as examples in the Forces Push Back activity.
## Sports and Activities with Pushing Forces

<table>
<thead>
<tr>
<th>Activity</th>
<th>Action</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseball/ Racquetball</td>
<td>Hand pushes ball, bat pushes ball</td>
<td>Inertia causes the moving ball to move in a straight line until a person’s hand/the wall or the bat/racket stops it or air pressure slows it down (friction) and gravity pulls it to the ground.</td>
</tr>
<tr>
<td>Kickball / soccer</td>
<td>Foot pushes ball</td>
<td>Inertia causes the moving ball to move in a straight line until a person’s foot causes it to change direction (push) or a person’s arms or friction (from the ground) and gravity slow it down.</td>
</tr>
<tr>
<td>Football</td>
<td>Hand pushes ball, foot pushes ball</td>
<td>Inertia causes the moving ball to move in a straight line until a person's arms causes it to stop or air pressure (or the ground) slows it down (friction) gravity slow it down and makes it fall to the ground.</td>
</tr>
<tr>
<td>Basketball</td>
<td>Hand pushes ball</td>
<td>Inertia causes the moving ball to move in a straight line until gravity pulls it down into the basket or the ball hits something that deflects it somewhere else.</td>
</tr>
<tr>
<td>(Dribbling)</td>
<td></td>
<td>Force is applied to push the ball to the ground and it bounces back up as the result of the elasticity of the basketball material.</td>
</tr>
<tr>
<td>A stacked balls demonstration can be shown to explain elastic force to the curious students using a demonstration such as that depicted in Physics Girl.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frisbee</td>
<td>Hand pushes Frisbee</td>
<td>Inertia causes the moving Frisbee to move in a straight line until the air slows it down (friction) and lets gravity take over, pulling it to the ground. Alternatively, the Frisbee may be stopped by a hand or other body part.</td>
</tr>
<tr>
<td>A Frisbee simultaneously experiences lift (like an airplane) and spin. Curious students may wish to view A Moment of Science to get a better understanding of the gyroscopic force that is actually occurring.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hacky sack</td>
<td>Foot pushes sac</td>
<td>The hacky sack is constantly under the influence of gravity pulling it to the ground, but the force exerted by a body part pushing it up can temporarily overcome gravity.</td>
</tr>
</tbody>
</table>

## Sports and Activities with Pulling Forces

<table>
<thead>
<tr>
<th>Activity</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tug-of-War</td>
<td>Hand pulls on rope</td>
</tr>
<tr>
<td>Two groups are pulling, which is a force in itself, but gravity is helping too as people use their body weight to exert more pull; friction comes into play as well since it prevents feet from moving – or slows them down.</td>
<td></td>
</tr>
</tbody>
</table>
### Playground Sports and Activities the Push and Pull

<table>
<thead>
<tr>
<th>Activity</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jump Rope</td>
<td>The rope is being pulled as the jumper swings it around and gravity is always exerting a force (as noted when the jumper slows down the swing). Friction is involved as the rope moves through the air (you can hear its whistle). It also impacts the rope as it hits the ground when the jumper’s arms are extended downward, thus slowing it down. A body that jumps into the air will always come back down because gravity is pulling on it (on earth).</td>
</tr>
<tr>
<td>Climbing (monkey bars/ladders)</td>
<td>The body overcomes gravity as it pulls on the bar and pushes up with the feet. Friction is occurring where the climber’s shoes touch the bar; the tread on the shoe prevents the foot from slipping on the bar as the climber pushes off.</td>
</tr>
<tr>
<td>Archery</td>
<td>Inertia makes the arrow move in a straight line at a constant speed until friction through the air slows it down and gravity begins pulling it down to the ground... or the arrow strikes something and it stops.</td>
</tr>
<tr>
<td>Swimming</td>
<td>The swimmer is pushing and pulling to create the forward motion and inertia keeps the swimmer moving forward. Even with buoyancy force acting to keep the swimmer afloat, gravity is pulling the body down (some bodies more than others) and the water is creating friction as it rubs against the body. The effect of friction on speed is significant enough that swimmers will sometimes shave the hair off their bodies to gain speed and purchase special swimming wear (caps and suits) to reduce friction – there are some garments that cause a swimmer to be disqualified from an event because they offer the swimmer too much advantage.</td>
</tr>
<tr>
<td>Hockey</td>
<td>Inertia causes the puck to keep moving forward in a straight line from when it is struck until a stick stops it or pushes it in a different direction. Friction occurs as the puck rubs across the ice, causing it to slow down. Gravity’s pull keeps the puck on the ice.</td>
</tr>
</tbody>
</table>

### Mathematics Connection

**Graphing**

The steps in creating a bar graph are emphasized in the rubric, but it may be helpful to brainstorm the parts of a bar graph with students before beginning and record them on a large sheet of paper to display throughout the module. The steps include:

A. Decide on a title for your graph.
B. Draw the vertical and horizontal axes.
C. Label the horizontal axes (swing set scores).
D. Write the names of the swing sets where the bars will be.
E. Label the vertical axes (number of Fun Factor points).
F. Decide on the scale. Explain that you should consider the least and the greatest number shown on the graph. Discuss what range of numbers should be shown on this bar graph (Begin at 0 and count by 5s to 30).

G. Draw a bar to show the total for each item.

**ELA Connection**

In third grade students are able to begin exploring a variety of genres in their reading. Students will begin reading more broadly in the swing set module and a quick reference guide may be helpful in helping the students to recognize the genre more easily as they experience more nonfiction books in their classroom reading assignments. Creating a flipbook to compare and contrast fiction and nonfiction literature may provide a helpful reference throughout the year.

<table>
<thead>
<tr>
<th>FICTION</th>
<th>NONFICTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Read for enjoyment</td>
<td>Read for information</td>
</tr>
<tr>
<td>A story that is created from your imagination</td>
<td>A true story about people or events</td>
</tr>
<tr>
<td>Poems, stories, fairy tales, plays, comic books,</td>
<td>Newspaper, cookbook, biography, pet care, textbook,</td>
</tr>
<tr>
<td>Not actual events</td>
<td>Actual events</td>
</tr>
<tr>
<td>Story talk</td>
<td>Fact talk</td>
</tr>
<tr>
<td>Read to enjoy</td>
<td>Read to learn</td>
</tr>
<tr>
<td>Read in order</td>
<td>Read in any order</td>
</tr>
<tr>
<td>Pictures</td>
<td>Photos, charts, graphs</td>
</tr>
<tr>
<td>Beginning, middle, end</td>
<td>Table of Contents</td>
</tr>
<tr>
<td>Problem, solution</td>
<td>Index, Glossary, Labels</td>
</tr>
<tr>
<td>Has characters</td>
<td>True Information</td>
</tr>
</tbody>
</table>

**EXTEND/APPLY KNOWLEDGE**

**SCIENCE**

Challenge students to look for applications of inertia, gravity, and friction interactions in other activities, such as picking up a book, carrying an item from one point to another, riding in a car, etc.

**MATHEMATICS CONNECTION**

After students have created a bar graph with their team’s data, they can create a line plot with each group’s data to determine a class mean score for each swing set design.
**ELA Connection**

Create a section in the science notebook to write about the book students read about force and motion, swing set design, and engineers. Have students write the name of the book and indicate if the book is fiction or nonfiction then respond to a reading response question.

**Assessment**

**Performance Tasks**
- Fun Factor Survey
- Forces Push Back Lab Participation
- Bar Graph

**Other Measures**
- Engagement in class activities and discussions
- Involvement in group work and discussions
- Writing exercises
INTERNET RESOURCES

Helpful Teacher Tools

Book: Wednesday, A Walk in the Park by Phyllis Del Greco, Jaclyn Roth, and Kathryn Silverio
Can be downloaded for free from ChildrenBooksPDF.com

Book: Teaching Science with Interactive Notebooks by Kellie Marcarelli

20 Ideas for teaching Citizenship
- http://www.kellybear.com/TeacherArticles/TeacherTip27.html

Research Support for Using Interactive Notebooks

Interactive Notebook explained
- http://wastatelaser.org/Science-Notebooks/home

Vocabulary Strategies w/ Interactive Notebooks

Examples of Interactive Notebooks on Pinterest
- https://www.pinterest.com/explore/interactive-science-notebooks/

Dinah Zike Foldables
- http://www.csun.edu/~krowlands/Content/Academic_Resources/Foldables/Basic%20Foldables.pdf
- https://www.pinterest.com/kmp444/foldables/
- https://wvde.state.wv.us/strategybank/DirectionsForFoldedBooks.html
- http://cmase.pbworks.com/w/page/6923144/Foldables

Mel and Gerdy Interactive Notebook blog post –

Classroom Science blog by Jill Grace, “Taking the Interactive Science notebook plunge”

Career Exploration

- Queens University, Aboriginal Access: http://www.aboriginalaccess.ca/adults/types-of-engineering
- Science Kids
  http://www.sciencekids.co.nz/sciencefacts/engineering/typesofengineeringjobs.html
- eGFI Prezi http://www.egfi-k12.org/
- Engineering for Kids 20125 Labs - https://www.youtube.com/watch?v=UiaXl0giP78
Images of Swing Sets for Introduction
- Wood play sets - http://www.swingsets.com/swing-sets
- King Swings - http://www.kingswingsets.com/products/vinyl-swing-sets
- Slide Innovations - http://www.slideinnovations.com/
- Home Depot slides - http://www.homedepot.com/b/Playsets-Recreation-Parks-Playsets-Playhouses-Playsets-Swing-Sets/N-5yc1vZc5p2
- Backyard Adventure series - http://www.backyardadventures.com/

Videos of Slides to help inform student’s designs
WATER SLIDE
- https://www.youtube.com/watch?v=hhk2uqz5umA

STRAIGHT SLIDE
- https://www.youtube.com/watch?v=r56AHblQvlo
- https://www.youtube.com/watch?v=jmtWo9nRLEE
- https://www.youtube.com/watch?v=iio5zXVgiUI
- https://www.youtube.com/watch?v=eRh4DVbMcNY
- https://www.youtube.com/watch?v=jM3WqbY3glY
- https://www.youtube.com/watch?v=U-q_Qvn0iTc

SPIRAL SLIDE
- https://www.youtube.com/watch?v=KeLpPljQCK4
- https://www.youtube.com/watch?v=TXdMsib3v4
- https://www.youtube.com/watch?v=15oG0yU8kcU

TUNNEL SLIDE
- https://www.youtube.com/watch?v=JA8iBapiQRo
- https://www.youtube.com/watch?v=KBP7LMfhB6k

INFLATABLE SLIDES
- https://www.youtube.com/watch?v=vnrkYF-ED44
- https://www.youtube.com/watch?v=C1jANN8d6b8

Force and Motion Links
- Newton’s First Law of Motion:
  http://archive.ncsa.illinois.edu/Cyberia/VideoTestbed/Projects/NewPhysics/newtons_1.html
- Gravity, Force, and Work -
  https://www.youtube.com/watch?v=LEs9J2IQlZY&list=PLpDa1bdUqe2cehXhqW52hKcJRalqxfulh
- Extreme Adventure: http://www.tryscience.org/tsadv/world/home.html
- Sport Science: http://www.exploratorium.edu/sports/
- Soaring Science: The Aerodynamics of Flying a Frisbee (lesson extension):
  http://www.scientificamerican.com/article/bring-science-home-frisbee-aerodynamics/

Park Research Aids
- Playgrounds! Lots of them on this Find a Playground near you –
  https://www.playlsi.com/en/commercial-playground-equipment/playgrounds?Age-Range=5to12years&page=1
- National Recreation and Park Association: http://www.nrpa.org/Tools-Resources/
- America’s State Parks locator - http://www.americasstateparks.org/Find-A-Park
- Center for City Park Excellence - http://www.tpl.org/center-city-park-excellence
- Parks and Recreation in the US – Local Park Systems document -
- Every Kid in a Park – Get into any park in the US for FREE! - https://www.everykidinapark.gov/
- Locate a park near you - http://www.discovertheforest.org/?m=1#map

YouTube Support
- Physical Science for Children, All about Forces and Gravity
  https://www.youtube.com/watch?v=ysrpUL8dASg
- Bill Nye and Force & Motion: https://www.youtube.com/watch?v=8iKhLGK7HGk
- A Moment in Science: https://www.youtube.com/watch?v=IJPaVi2Fxhc
- Physics Girl – Stacked Balls demonstration:

Interactive websites
- Push and Pull: http://www.bbc.co.uk/schools/scienceclips/ages/5_6/pushes_pulls_fs.shtml
- Force and Movement:
  http://www.bbc.co.uk/schools/scienceclips/ages/6_7/forces_movement_fs.shtml
- Inclined Plane: http://www.bbc.co.uk/schools/scienceclips/ages/8_9/friction_fs.shtml
- Materials and Movement: http://www.bbc.co.uk/schools/scienceclips/ages/8_9/friction_fs.shtml
- Weights & Parachutes: http://www.bbc.co.uk/schools/scienceclips/ages/8_9/friction_fs.shtml
APPENDIX, LESSON 1

Playground swing set images for group work.

Swing Set Image #1
Swing Set Image #3
**Fun Factor Survey**

Name _______________________________  Team Name _______________________________

Fill in this survey to identify your own standards for FUN. Use the numbers 0 (not fun) to 5 (most fun) to create a rubric for yourself. When you are done you will compare your rubric to those of others on your team.

### My Personal Fun Factor Scale

<table>
<thead>
<tr>
<th>Standard</th>
<th>Nope, not me (sloth)</th>
<th>Move at a very slow pace (koala)</th>
<th>Move at a walk, slow &amp; easy (panda)</th>
<th>Move at a quicker pace (giraffe)</th>
<th>Move fast, but not scary fast (gazelle)</th>
<th>Move so fast my heart races (cheetah)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed</td>
<td>Rate 0-5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flight</td>
<td>Fly like a penguin</td>
<td>Hop like a baby bird</td>
<td>Hop like a grasshopper</td>
<td>Fly like a chicken</td>
<td>Fly like a bumblebee</td>
<td>Soar like an eagle</td>
</tr>
<tr>
<td>Rate 0-5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Height</td>
<td>Best on the ground</td>
<td>No higher than a chair</td>
<td>As high as a step stool</td>
<td>As high as a bunk bed</td>
<td>As high as a telephone pole</td>
<td>High up in the clouds</td>
</tr>
<tr>
<td>Rate 0-5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Climb</td>
<td>Cross bridges</td>
<td>Up ramps</td>
<td>Up stairs</td>
<td>Up a ladder</td>
<td>Up trees</td>
<td>Up steep cliffs</td>
</tr>
<tr>
<td>Rate 0-5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spin</td>
<td>Nope, not me</td>
<td>Turn sideways (1/4 turn)</td>
<td>Turn to look backwards (1/2 turn)</td>
<td>Turn a full circle (1 turn)</td>
<td>Turn around one direction</td>
<td>Spin around &amp; around</td>
</tr>
<tr>
<td>Rate 0-5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fun Spaces</td>
<td>Wide, open spaces</td>
<td>Square areas, like a box</td>
<td>Spaces with windows &amp; doors</td>
<td>Tunnels</td>
<td>Spaces with gadgets &amp; puzzles</td>
<td>Mazes</td>
</tr>
<tr>
<td>Rate 0-5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Did everyone on your team create the same rubric? __________

Why are your rubrics so similar/so different? ____________________________________________________________

The team will create a rubric that will be used to measure the Fun Factor of swing sets. Your team will need to agree on a method for evaluating the importance of each criteria. How would you decide which criteria is most valuable?

________________________________________________________________________________________

________________________________________________________________________________________

No create a team Fun Factor Scale that your team will use to score swing sets.
# Our Team Fun Factor Scale

<table>
<thead>
<tr>
<th>Standard</th>
<th>Rate 0-5</th>
<th>Rate 0-5</th>
<th>Rate 0-5</th>
<th>Rate 0-5</th>
<th>Rate 0-5</th>
<th>Rate 0-5</th>
<th>Rate 0-5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Speed</strong></td>
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<td>Move fast, but not scary fast (gazelle)</td>
<td>Move so fast my heart races (cheetah)</td>
<td>0-5</td>
</tr>
<tr>
<td><strong>Rate</strong></td>
<td>Fly like a penguin</td>
<td>Hop like a baby bird</td>
<td>Hop like a grasshopper</td>
<td>Fly like a chicken</td>
<td>Fly like a bumblebee</td>
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<tr>
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<tr>
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<td>Turn a full circle (1 turn)</td>
<td>Turn around one direction</td>
<td>Spin around &amp; around</td>
<td></td>
</tr>
<tr>
<td><strong>Fun Spaces</strong></td>
<td>Wide, open spaces</td>
<td>Square areas, like a box</td>
<td>Spaces with windows &amp; doors</td>
<td>Tunnels</td>
<td>Spaces with gadgets &amp; puzzles</td>
<td>Mazes</td>
<td></td>
</tr>
<tr>
<td><strong>Rate</strong></td>
<td>0-5</td>
<td>0-5</td>
<td>0-5</td>
<td>0-5</td>
<td>0-5</td>
<td>0-5</td>
<td></td>
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</tbody>
</table>
## Swing Set #1

<table>
<thead>
<tr>
<th>Standard</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Score</th>
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</thead>
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<td>Speed</td>
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<td>Fun Spaces</td>
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</tr>
</tbody>
</table>

**Total Score**

Does this swing set meet your high standards for fun? ______________ Please, offer a suggestion for improving Fun Factor score __________________________________________________________________________________________

Maybe you want to change your rubric. Use this space to change it if you wish. Evaluate swing set #2.

## Swing Set #2

<table>
<thead>
<tr>
<th>Standard</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Score</th>
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<td>Speed</td>
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<td>Spin</td>
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<td>Fun Spaces</td>
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</tbody>
</table>

**Total Score**

Does this swing set meet your high standards for fun? ______________ Please, offer a suggestion for improving Fun Factor score __________________________________________________________________________________________

Evaluate swing set #3.
## Swing Set #3

<table>
<thead>
<tr>
<th>Standard</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Score</th>
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<tbody>
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<td>Speed</td>
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</tbody>
</table>

**Total Score**

Does this swing set meet your high standards for Fun? ______________

Suggestion for improving Fun Factor score______________________________________________

_____________________________________________________________________

## Swing Set #4

<table>
<thead>
<tr>
<th>Standard</th>
<th>0</th>
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</tbody>
</table>

**Total Score**

Does this swing set meet your high standards for Fun? ______________

Suggestion for improving Fun Factor score______________________________________________

_____________________________________________________________________
## School Playground Swing Set

<table>
<thead>
<tr>
<th>Standard</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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<th>Score</th>
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</tr>
</tbody>
</table>

**Total Score**

Does this swing set meet your high standards for Fun? ______________

Suggestion for improving Fun Factor score______________________________________

___________________________________________________________________________

HO1-2 Fun Factor Survey
**Forces Push Back**

Fill out the table. Write the sport or activity in the first gray box and circle the force that is being used (push, pull, or both). Write a sentence explaining how inertia, gravity, and friction interact. Circle the forces you identified.

<table>
<thead>
<tr>
<th>Force(s) involved</th>
<th>Gravity</th>
<th>Friction</th>
<th>Inertia</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Push</td>
<td>Pull</td>
<td>Both</td>
<td></td>
</tr>
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<td></td>
<td></td>
<td></td>
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</tbody>
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</thead>
<tbody>
<tr>
<td></td>
<td>Push</td>
<td>Pull</td>
<td>Both</td>
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<tbody>
<tr>
<td></td>
<td>Push</td>
<td>Pull</td>
<td>Both</td>
<td></td>
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<td>Other</td>
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What roles do inertia, gravity, and friction play in keeping an object in motion? ___________________________
LESSON PLAN #2
Recreational STEM – Grade 3

LESSON TITLE
Slippery Slide Design

LESSON SUMMARY
The students will be investigating Newton’s Laws of Motion and apply their learning to make a ramp or slide. This learning activity will be directly connected to the final challenge in which students will build a prototype of the slide they design during this lesson. Students will consider the effects of balanced and unbalanced forces as they relate to swing sets. As a mathematics connection, students will record and graph data. They will also note the geometric shapes on swing sets, taking measurements as an introduction to area measurements.

ESSENTIAL QUESTION(S)
- How can the geometric shapes of the swing set be altered to minimize/maximize the effect of unbalanced forces?
- How do the balanced and unbalanced forces on a ramp impact an object?
- How does the incline of a plane impact the speed of an object?
- What materials work best to overcome friction on a ramp?
- What would you recommend to improve the fun factor of a slide design?
- What are some of the safety concerns when developing a slide design?

ESTABLISHED GOALS/OBJECTIVES
Student will be able to:
- Identify the geometric shapes that appear in a swing set.
- Evaluate and recommend alternative shapes and designs for the swing set.
- Design and implement an investigation around a testable question.
- Use data analysis as evidence to answer a question under investigation.
- Relate the angle and length of a ramp to increased/decreased speed.
- Calculate the area of a surface.
- Explain that friction causes work (energy) to be wasted when objects go down the slide.
- Compare and contrast materials and angles to make decisions for a new slide design.
- Critique slide designs of classmates in order to provide constructive feedback.

TIME REQUIRED
3 days (90 minutes each)

Necessary Materials
- Science notebooks, 1 per student
- Access to Internet for showing video clip and student research
- K-W-L chart from last week
- Magnifying glasses (1 per group)
- Marbles (1 per group)
- Drinking straws (1 per student)
- Optional: Amazon offers a number of Bill Nye’s videos. The Imagineering series may offer support to helping students understand some of the concepts in this module (i.e., Newton’s Laws of Motion, gravity, friction, and design and models)

Inclined Plane
- Ramp Investigation handouts (for each team), located in lesson 1 appendix
- Engineering Design Cycle visual, located in lesson 2 appendix
- 1 pencil (for demonstration)
- 1 ball (for demonstration)
- 1 block (for demonstration)
- Ramp materials (per team) – strips of foam board about 5 inches wide x 20 inches long
- Wooden blocks, plastic containers, or books to build up ramps (per team)
- Materials to use on ramp for friction testing (rough sandpaper, cardboard, shelf liner, wax paper, aluminum foil, plastic cling wrap, etc.)
- 1 small wooden block (about 2-3 inches long) per team
- 1 marble (per team)
- 1 toy car/truck per team
- 1 roll masking tape (per team)
- 1 tape measure (per team)
- 1 stopwatch (per team)
- 1 calculator (per team)

Slide Makeover
- Slide Makeover handouts
- EDP diagram
- Graph paper
- Pencils
- Rulers
Geometry Scavenger Hunt
- Geometry Scavenger Hunt handout, located in lesson 2 appendix
- Paper for anchor chart (per student)
- Clipboard (1 per team)
- Pencil (per team)
- Tape measure (per team)
- Calculator (per team)

CONTENT STANDARDS ADDRESSED IN STEM ROAD MAP MODULE LESSON

Next Generation Science Standards
3-PS.2-1

Common Core Mathematics
CCS.Math.Practice: MP1, MP2, MP4, MP5, MP7
CCS.Math.Content: MD-A.1, MD-A.2, MD-B.4; C.5

Common Core English/Language Arts (ELA)
Reading Information Text Standards: RI.3.5, RI.3.7
Writing Standards: W.3.1, W.3.1a, W.3.1b, W.3.1c, W.3.1d, W.3.2, W.3.2b, W.3.3, W.3.7, W.3.8
Speaking & Listening Standards: SL.3.1, SL.3.1d

21st Century Skills
Interdisciplinary Themes (health & safety, environmental literacy, science, mathematics, engineering design process); Learning and Innovation Skills; Information, Media, & Technology Skills; Life Skills

<table>
<thead>
<tr>
<th>Key Vocabulary</th>
<th>Definition</th>
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<tbody>
<tr>
<td>balanced force</td>
<td>two forces equal in strength being pushed or pulled in opposite directions</td>
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<tr>
<td>direction</td>
<td>the path a moving object follows</td>
</tr>
<tr>
<td>distance</td>
<td>the measure of how far an object has traveled</td>
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<tr>
<td>force</td>
<td>an energy that causes motion or a change in motion</td>
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<tr>
<td>friction</td>
<td>a force that causes moving things to slow down when one object rubs against another object</td>
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<tr>
<td>gravity</td>
<td>the force that pulls objects toward the center of the earth</td>
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<tr>
<td>inertia</td>
<td>the property of an object that keeps it resting when at rest or moving when in motion in the same straight line unless acted on by an outside force</td>
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<tr>
<td>mass</td>
<td>a measure of how much matter is in an object; on earth mass equals weight</td>
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### Newton’s Law of Motion
An object at rest stays at rest and an object in motion stays in motion with the same speed and in the same direction unless acted upon by an unbalanced force.

### Pull
A force that moves something toward you

### Push
A force that moves something away from you

### Speed
How fast or slow an object is moving

### Unbalanced Force
Two forces pushing or pulling in opposite directions where one force is stronger than another

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**Teacher Background Information**

In Lesson 1, students were introduced to inertia, gravity, and friction and their relationship to motion. In Lesson 2, students will associate these concepts to Newton’s First Law of Motion, specifically balanced and unbalanced forces. Newton’s first law states:

An object at rest stays at rest and an object in motion stays in motion with the same speed and in the same direction unless acted upon by an unbalanced force.

A force can give energy to an object causing that object to start or stop moving, or change its direction. This occurs because forces occur in pairs that are either balanced or unbalanced. When the forces are balanced (equal) no motion will occur. The forces are equal in size and opposite in direction, like a tug-of-war match in which both teams have equal strength. Unbalanced forces always cause a change in motion. They are not equal and are opposite. The greater force will push or pull the object in opposition to the lesser force.

**Balanced and Unbalanced Forces**

Balanced forces occur when two forces are pushing in opposite directions, resulting in no movement. When forces have different strengths (unbalanced), then there is movement in the direction of the greater force.

Other examples of balanced and unbalanced forces include:

<table>
<thead>
<tr>
<th>Balanced Forces</th>
<th>Unbalanced Forces</th>
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</thead>
<tbody>
<tr>
<td>1. Two people hugging.</td>
<td>1. Arm wrestling, one person is stronger than the other.</td>
</tr>
<tr>
<td>2. Scale with 2 items of equal weight pushing down on the plate.</td>
<td>2. Soccer ball flying through the air after being kicked.</td>
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<tr>
<td>3. Book setting on a table – equal force pushing up and down to make it sit still.</td>
<td>3. Seesaw, going up and down requires one person kicking off and creating more force than the weight of the child on the other end.</td>
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<td>4. Two dogs pulling on a rope when they are equally matched.</td>
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New science vocabulary which can be visualized by watching the video *Balanced and Unbalanced Forces* at [www.youtube.com/watch?v=YyJSlclbd-s](http://www.youtube.com/watch?v=YyJSlclbd-s).
The Engineering Design Process
The engineering design process is a series of steps that engineers follow when they are trying to solve a problem. The solution often involves designing a product (like a machine or a computer code) that needs to meet certain criteria and/or accomplish a particular task.

The steps of the engineering process are:
- **ASK:** Define the problem. What is the problem, how have others approached it, identify the requirements
- **IMAGINE:** brainstrom possible solutions, choose the best solution.
- **PLAN:** Do research, list materials needed, identify steps you will take.
- **CREATE:** Follow your plan and build a prototype.
- **TRY IT OUT:** Test the prototype. What works, what doesn’t? What could you improve?
- **IMPROVE:** Redesign to solve problems that came up in testing and retest.
- **SHARE:** Present it to others and let them give you feedback. After it has been critiqued, it often has to go back to the drawing table and be reconfigured and a new prototype is fashioned. Don’t be discouraged if this happens. It is part of the process.

Engineers do not always follow the engineering design process steps in order. It is very common to design something, test it, find a problem, and then go back to an earlier step to make a modification or change the design entirely. This way of working is called iteration.

There are many kinds of engineers, who design and build many different kinds of things. [Science Kids](http://www.scholastic.com) introduces students to 15 different branches of engineering and this is not all of them!

<table>
<thead>
<tr>
<th>Civil Engineering</th>
<th>Mechanical Engineering</th>
<th>Electrical Engineering</th>
<th>Chemical Engineering</th>
<th>Aerospace Engineering</th>
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<tr>
<td>Structural Engineering</td>
<td>Genetic Engineering</td>
<td>Biomedical Engineering</td>
<td>Computer Engineering</td>
<td>Software Engineering</td>
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<td>Military Engineering</td>
<td>Nuclear Engineering</td>
<td>Forensic Engineering</td>
<td>Reverse Engineering</td>
<td>Environmental Engineering</td>
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**Sharing Your Opinion in Writing**
Optional: Students will use the “OREO” strategy to develop an argument or opinion about their slide design in this lesson. This strategy prompts students to state an opinion ("O") followed by a reason ("R") and an example (“E”), followed by a restatement of their opinion (“O”). Genia Connell wrote a fantastic blog for Scholastic on opinion writing for third graders that can be found at [www.scholastic.com/teachers/top-teaching/2015/03/graphic-organizers-opinion-writing](http://www.scholastic.com/teachers/top-teaching/2015/03/graphic-organizers-opinion-writing).
Reviews are one of the most common types of opinion content on the Internet. When buying a product, many people look for the reviews on Amazon or multiple other sites. The most common reason people look for product reviews are to:
- learn about the pros and cons of a given product
- find out the quality of the product and if it is easy to use
- discover if there is a cheaper, yet compatible substitute
- learn about other peoples’ experiences with the item

**LESSON PREPARATION**

Review the teacher background information provided, assemble materials for the lesson and preview videos included within the Learning Plan Components.

Read through the Geometry Scavenger Hunt to make sure the questions can all be answered as written. Modifications may be necessary to customize the activity to the playground equipment available at your school.
LEARNING PLAN COMPONENTS

INTRODUCTORY ACTIVITY/ENGAGEMENT

ELA CONNECTION


- Ask, “What is a slope? What is happening on the cover? Has anyone been on a skateboard before or watched someone on a skateboard? Do you see any ramps on the cover? What makes them ramps? What are ramps used for?”
- As you read, ask the students to look for ramps. Point out examples of how ramps are used to make tasks easier.
- Probe further by asking, “If you could go skateboarding like the boy in the story, would you rather ride on a steep ramp or one that is less steep? Why?”

SCIENCE

Review the concept that there is almost always more than one force acting on an object (for example, when dropping a ball, gravity and wind resistance or friction act upon the ball).

Some forces act when they come into direct contact with an object, such as when a box is moved. Other forces don’t need to come into contact with an object to act. For example when a skydiver jumps from a plane, gravity pulls him toward the ground without physically touching him or her.

Have students draw a T-chart with Contact and No Contact headings. Have them provide one or two examples of each in the appropriate columns.

Review friction (a force that occurs when surfaces rub together). Different surfaces can apply more or less friction. A clue to the amount of friction they will provide is how rough they are. Have students feel a variety of surfaces (paper, cardboard, kitchen tile). Sort the surfaces into smooth and rough surfaces. Have the students use a magnifying lens to look at surfaces explored, then other surfaces around the room. We need to control friction in some instances to make things work, or to make things more safe.

Have students make a list of types of surfaces that increase friction (treads on gym shoes, sand on roads) and things done to surfaces to decrease friction (add oil to gears, smooth out the ice before a hockey game).

Roll a ball gently across the room. Ask student to observe what happens to it (it slows and stops). Tell students that objects that are moving keep moving unless a force acts on them. Ask students what force acted on the ball to stop it (friction). Tell students that engineers use what they know about moving objects and forces such as friction to design safer cars, buildings, and even swing sets.

The following video can help describe some of the forces of nature that are balanced and unbalanced: www.youtube.com/watch?v=YyJSlClbd-s.
Discuss the meaning of the word **balanced** and contrast this with **unbalanced**. Associate these terms with forces. Have students draw a cartoon showing how balanced and unbalanced forces interact. One example might be a picture of a canoe with a person in the center and a large dog swimming beside the canoe, then draw a second picture of this same canoe with the dog riding inside the boat and the boat sinking lower in the water where the dog is sitting. Encourage the kids to be creative. Have the students share their pictures with their team and explain what is happening.

**Balanced and Unbalanced Forces**
Review the concepts of balanced and unbalanced forces. Lead students to describe balanced forces as forces acting on an object so that the object’s speed and direction do not change. This can mean that an object moves at a constant speed and direction or an object remains still. Unbalanced forces are forces acting on an object so that the object’s speed and/or directions changes either by speeding up or slowing down.

1. Have student teams place marble on the desk or table. Have them draw a diagram in their notebooks that shows all of the forces acting on the marble. Have them label the diagram as showing balanced or unbalanced forces.
2. Have one student use a drinking straw to blow air on the marble. The marble should move, but stay on the tabletop. Instruct students to draw another diagram, showing all of the forces acting on the marble. Have students label the diagram as showing balanced or unbalanced forces.
3. Next have each student in the group use a drinking straw to blow on the marble, balancing the force of the air so that the marble does not move. Again, instruct students to draw and label a diagram of forces acting on the marble and again, label the diagram as showing balanced or unbalanced forces.

**ACTIVITY/INVESTIGATION**

**Ramp Investigations**
Ask students to identify kinds of ramps they have seen (for example skateboard ramps, wheelchair ramps, highway exits, slides, moving truck ramps, stairs, escalators, etc.).

Next, show students a simple ramp and three items: a ball, a pencil, and a block.

Discussion Questions:
- Which of these would move fastest down a ramp? (Let students make prediction and then test)
- Were the results as expected?
- How does each of these items represent ways that a person travels down a ramp? (for example, ball-rolling somersaults down a hill; pencil- log rolling down a hill; block – sliding down a sliding board)
- Most students will agree the block is the slowest. Ask students why they think this is, and ask for ideas to make the block slide faster (guide students to understanding that the block will slide faster with less friction). Ask students for ideas about how friction can be reduced on the block? (for example, putting wheels under it like a roller coaster car; making the surface more slippery with water like a water slide, etc.)
Students will investigate balanced and unbalanced forces using “vehicles” on a ramp to help them make better decisions for their slide design.

Ask students to brainstorm with their design team what they want to investigate in this lab to help them make the best decision when they create their slide design. [Guide students to address at least three principle concerns: a) What would be the best incline? b) What would be the best surface? and c) What safety concerns should be considered?]

**Ramp Investigation #1 - Incline**

Each team will need the following: Ramp Investigation handout (located in the appendix), ramp, 3 “vehicles” (toy car, wooden block, marble), tape measure, stopwatch, and items for lifting one side of the ramp at a variety of heights (wooden blocks, books, etc.).

1. Have students complete the first two pages of the handout
   - Define the problem and propose their ideas about the outcome
   - List the materials
   - Create a plan (along with a picture of the setup)
   - Create a data collection table
   - STOP to get approval before moving on
2. After they have received approval, students can gather their materials, set up the ramp, and begin testing.
3. Students will be testing to determine the best incline for their slide. [They should conclude that steeper inclines allow the vehicle to move faster, but too steep an incline will cause the vehicle to drop off, which is not safe.]

**Ramp Investigation #2 - Surface**

Each team will need the following: Ramp Investigation handout (found in the appendix), ramp, 3 “vehicles” (toy car, wooden block, marble), masking tape, a tape measure, stopwatch, and a variety of materials to cover the ramp (i.e., cardboard, paper, fabric, sandpaper, aluminum foil, waxed paper, or others).

1. Use the same procedure as before, students will complete the Ramp Investigation lab sheet:
   - Define the problem and propose their ideas about the outcome
   - List the materials
   - Create a plan (along with a picture of the setup)
   - Create a data collection table and then STOP to get approval before moving on.
2. After they have received approval, students can gather their materials, set up the ramp, and begin testing.
3. Students will test to determine the best surface for their slide. [They should conclude that the materials that are the most slippery (wax paper, aluminum foil, etc.) are typically chosen since these materials afford the greatest amount of speed in the descent. The problem with metals, of course, is that they get very hot in the heat of the summer and very cold in the winter.]

**Ramp Investigation #3 – Combining Incline and Surface to Maximize Speed/Distance**
Each team will need the following: Ramp Investigation handout (found in the appendix), ramp, 3 “vehicles” (toy car, wooden block, marble), masking tape, a tape measure, stopwatch, and a single type of material with which to cover the ramp.

1. Use the same procedure as before, students will complete the Ramp Investigation lab sheet:
   - Define the problem and propose their ideas about the outcome
   - List the materials
   - Create a plan (along with a picture of the setup)
   - Create a data collection table and then STOP to get approval before moving on.

2. After they have received approval, students can gather their materials, set up the ramp, and begin testing.

3. Students will create a ramp with the height and material that will cause their toy car to travel the greatest distance.

**Slide Makeover Design Challenge** (Note: students should complete the geometry scavenger hunt [see Mathematics Connection below] before completing this activity)

In this activity, students will use the engineering design process (EDP) to design a slide for part of their Swing Set Makeover challenge. They will not build the slide during this activity, but will create a drawing and choose materials for the slide. The goal is to draw a sketch for a slide that they will build as part of their challenge and that will have a high ranking on the Fun Factor metric.

Ask students to brainstorm about who they think designs and builds playground equipment and swing sets. Record their answers. Introduce the idea that engineers are people who design and build things to solve problems or fulfill human needs. Students should understand that there are many different kinds of engineers (see Teacher Background section for an overview) and that these engineers do different kinds of work.

Remind students that they will be engineers in this module as they design and build a swing set. In order to assume the role of an engineer, they will need to solve problems and use a process called the engineering design process, or EDP, to do their work. Show the following video to introduce the steps of the EDP: https://www.youtube.com/watch?v=fxJWin195kU

After the video, show student the EDP graphic (in the appendix at the end of Lesson 2) and tell them that they will use this process as they work in groups to solve their swing set Makeover design challenge. Tell students that they will have the chance to practice using the steps of the EDP now and to put into action what they’ve learned about ramps.

In this activity, students will revisit the Fun Factor survey from the launch and will be challenged to use what they learned from the ramp investigations and integrate their decisions from the survey to create a new slide design that would be practical for the playground, yet is fun and safe. At this stage, students will brainstorm and draw their designs. This drawing may be tweaked later, but the important thing is to get their ideas out and on paper.
If students need help to get ideas flowing, you may wish to have them view some of the links in the Internet Resources section.

- What is the Fun Factor rating of the slide?
- What variable (angle or surface covering) had the most effect on the overall score?
- How could we cause the vehicle to move faster (or slower if that is the teams’ wish)?
- What features might we add that could make it even better?

Students will use the EDP to create a plan for a new slide with the Swing set Makeover handout, located in the appendix. A chart with the EDP has also been provided for your convenience in the appendix to this lesson. The output from the plan should be an annotated sketch of the slide on graph paper. The design should include the following:

- a title with a catchy name for your swing set
- a scale to identify the measurement of each block
- the preferred angle of the slide
- the length and width of the slide
- the material the slide will be made of
- any additional notes that will help when building the slide
- 

The findings from the ramp investigations combined with their geometry scavenger hunt should be combined in a proposal for the team’s slide design concept.

As the design teams create the sketch, have them begin to create a materials list. Explain that they will be operating with a budget, but in the brainstorming and planning stage the budget is not a huge consideration.

Students should present their sketches of their slide designs to another team. Students should provide feedback on the slide design (What do they like about the design? Does it look fun? Do they think it will be safe? What improvements can they imagine?)

**Mathematics Connection**

*Geometry Scavenger Hunt*

In this activity, students will search for various geometric shapes in playground equipment. Students may also apply the understanding of measurement and scale they gain from this activity in their slide makeover activity in this lesson.

Introduce geometric shapes using the 3D shapes and 2D shapes image attached in the appendix to this lesson. Tell students that playground equipment uses many of these types of shapes and that they can increase the Fun Factor of a swing set or playground. Ask students to consider how these shapes might be used in swing sets.
Introduce the concepts of area and perimeter and scale (see Explain section for more information). Acute, obtuse, and right angles are also a part of the scavenger hunt so you may wish to review these concepts with students.

For this activity, student teams will need the Geometry Scavenger Hunt handout (in the appendix), copies of the 3D and 2D shapes image, a clipboard, pencil, tape measure, and calculator. You may wish to have students complete this activity in the school playground or incorporate it with a field trip to another playground.

An additional option is to have student teams take photographs of the geometric shapes they find in and around the playground. You may wish to assign various teams various types of shapes to photograph.

ELA Connection

1. Students may write reflections and conclusions in their science notebooks throughout this lesson. The science activity has students writing conclusions and analyzing results, and applying their results when designing a new slide. In mathematics, the students write about what they learned in the scavenger hunt and explain how it applies to the upcoming Swing set Makeover project.

2. Create vocabulary cards for the terms: balanced forces, unbalanced forces, speed, and direction.

3. Explain that the students will create a poster about their swing set after they build their prototype. The poster will try to convince people that swing set they designed is the most fun and is the safest. To create their persuasive argument, students will use the “OREO” method of stating their opinions. Ask the students if they have ever eaten an Oreo cookie. Tell them to remember OREO to help them write an opinion paper. Pass out the handout, ‘Writing the Oreo Way’ to review the components of an opinion. Remind students there is no right or wrong opinions, but it is important that opinions be supported with reasons.

4. Help students to find online swing set reviews – based on the reviews, ask students to choose a design they would definitely purchase. Ask students to point out elements of the “OREO” method in the reviews.
**EXPLAIN**

**SCIENCE CLASS**

**Ramp Investigations**
- Check to make sure the students release the vehicle from the top of the ramp in the same spot every time. You may suggest that as a control, they put a piece of masking tape at the place they will begin the trial each time (approximately 5 cm from the top).
- Students should not push the vehicle.
- The ramp should be lifted with uniform intervals to enable the team to make reasonable predictions about the results (i.e., lift using 5 cm intervals – or two books).

Emphasize the importance of collaboration in projects (you may wish to refer to engineers and how they work):
- Individual accountability – being prepared, communicating with other team members, and completing individual tasks.
- Team participation – making a contribution to the team’s work, helping to solve problems the team encounters, giving feedback to other team members, volunteering to help others when they need help.
- Professionalism and respect – being polite and respectful to others and being respectful of other team members’ ideas.

**MATHEMATICS CLASS**

Understanding area and perimeter and keeping the terms straight in their minds can be difficult for students. Students can create a graphic organizer called an anchor chart for the terms, area and perimeter and keep it inside their science notebook. Divide a piece of paper into three columns. Label the columns: “is,” “can,” and “looks like” as in the following example:
Column 1: Define the term according to a mathematics book definition, then define it again using student’s own words.

Column 2: How can this area be used in everyday life outside of the mathematics classroom? Students provide two or more examples.

Column 3: Student creates a mathematics problem and shows how to solve the mathematics equation visually.

You may wish to introduce the idea of scale to students so that they can scale their swing set designs to fit a designated area. Introduce to students that scale is a way to represent large geographic areas in a small space. The simplest way to represent scale for this activity may be to establish a standard scale such as 5 graph paper blocks = 1 foot. Tell students that engineers use scale to draw their designs before they build them. The house plan attached in the appendix to this lesson may be useful to help students understand the concept of scale.
**Geometry Scavenger Hunt**

Some of the shapes may not be found on the playground. Read through the Scavenger Hunt to make sure the questions can all be answered as written. Modifications may be necessary to customize the activity to the swing set and play sets available at your school.

Identifying acute, obtuse, and right angles is a part of the scavenger hunt. You may want to review these concepts with students before beginning the scavenger hunt. You may wish to introduce these types of angles in a simplistic manner by having students compare the square edge of a piece of notebook paper to the angle they see, matching up the straight edge of the paper to one straight edge of the angle. If the other part of the angle falls inside the paper then the angle is acute; if it falls outside the paper it is an obtuse angle; if it matches the edge of the paper it is a right angle.

**ELA Connection**

It may be helpful for students if you provide a template for writing opinions the OREO way. A template is provided in the appendix at the end of Lesson 2.

**CRITERIA FOR QUALITY OPINION WRITING THE OREO WAY**

- **O=** Write an introduction – clearly state your *opinion*.
- **R=** Give 2-3 *reasons* why you hold this opinion.
- **E=** Provide 2-3 *examples* to support these reasons, providing details.
- **O=** *Opinion* is restated your conclusions WITH ENTHUSIASM

**Suggested literature connections:**

- *I want a dog: My opinion essay* Darcy Pattison [ASIN: B00PMEAYTQ]
**EXTEND/APPLY KNOWLEDGE**

**SCIENCE**
Students can make a list of ramps they see in their neighborhood and on their way to school and identify how the ramps are used.

Students can use foam pipe insulation (cut in half), card stock, clay or another flexible material to determine that twisted slides allow a slide to be able to increase the angle and distance of the slide (hence the speed of the vehicle) in a smaller footprint.

**MATHEMATICS CONNECTION**
Students can practice the concept of scale by measuring the furniture in a room of their home and creating an annotated map of the room on graph paper.

**ELA CONNECTION**
You can choose some of your favorite books and read Amazon reviews about it (positive and negative). Ask the students to share their ideas via a think/pair/share activity: first, students should reflect individually on their ideas about how the review affects how people perceive this product; next, students should pair with a partner to share these ideas. Ask them to share whether the review would influence their own purchasing decision.

**ASSESSMENT**

**Performance Tasks**
Ramp Investigation Activities
Slide Makeover, sketch
Geometry Scavenger Hunt
OREO Opinion Handout

**Other Measures**
Engagement in class activities and discussions
Involvement in group work and discussions
INTERNET RESOURCES

Teacher Resources
- **Roll, slope, and slide: a book about ramps** by Michael Dahl  
- Test bank:  [http://www.helpteaching.com/questions/Forces_and_Motion/Grade_3?pageNum=3](http://www.helpteaching.com/questions/Forces_and_Motion/Grade_3?pageNum=3)
- G. Connell’s Writing Opinions blog -  
  [http://www.scholastic.com/teachers/top-teaching/2015/03/graphic-organizers-opinion-writing](http://www.scholastic.com/teachers/top-teaching/2015/03/graphic-organizers-opinion-writing)
- Force and Motion activity sheet -  

Engineering
- The Fuse School (Global Education channel) -  [https://www.youtube.com/watch?v=YyJS1clbd-s](https://www.youtube.com/watch?v=YyJS1clbd-s)
- Crash Course in EDP -  [https://www.youtube.com/watch?v=fxJWin195kU](https://www.youtube.com/watch?v=fxJWin195kU)
- EDP NASA style -  
  [https://www.youtube.com/watch?v=wE-z_TJyzil&list=PL-2CXCHR1_JwcLMcQ_hIo6jq82_C7vL](https://www.youtube.com/watch?v=wE-z_TJyzil&list=PL-2CXCHR1_JwcLMcQ_hIo6jq82_C7vL)
- Robotics Academy’s take on the EDP -  [https://www.youtube.com/watch?v=pSmz1r3ltE](https://www.youtube.com/watch?v=pSmz1r3ltE)
- What is an Engineer and What does an engineer do?  [https://www.youtube.com/watch?v=UiaXl0giP78](https://www.youtube.com/watch?v=UiaXl0giP78)

Interactive websites
- Motion Games – Friction Ramp | Learning Games for Kids -  
- Phet: Forces and Motion basics:  

Social Studies Support
- Congress for Kids –  [http://www.congressforkids.net/citizenship_intro.htm](http://www.congressforkids.net/citizenship_intro.htm)
APPENDIX, LESSON 2
3D SHAPES

SPHERE  CUBE  TRIANGULAR PRISM  CONE

CYLINDER  PYRAMID  RECTANGULAR PRISM

2D SHAPES

CIRCLE  SQUARE  TRIANGLE  RHOMBUS
Geometry Scavenger Hunt

Name ________________________________  Team ________________________________

Assign the following roles to team members:
• Measurer (hold the tape measure and call out the measurements to the recorder)
• Recorder (have clipboard which documents the answers that will be turned in)
• Mathematician (hold the calculator and make any calculations needed for the team)
• Quality Control (read question to the team, help the measurer, and double-check answers)

Your team will need a clipboard, a pencil, a tape measure, and a calculator for this activity.

Be sure to make precise measurements as you answer the questions (1”, ½”, ¼”. 1/8”). The answers will provide important information for you when you create your swing set later.

Distance and Area of the Playground
1. Measure the edge of the playground to find the distance around it. __________________________

2. This is called the **perimeter**. Using mathematics you can find the perimeter in an easier way. What is the number sentence for finding the perimeter? Write it out and replace the letters with the numbers you have found when measuring the length and width. [If you do not know the number sentence for perimeter, you can “Google It!”] ________________________________________________________________________________________________

3. Do you get the same answer? yes no (circle your answer)

4. Multiply the length of the playground by its width (l x w) to find the **area** of the playground. __________________________________________________________________________

5. What is the length and width of the playground equipment? length ______________ width ______________

6. Use these numbers to find the area and perimeter of the swing set.

   area ____________________________  perimeter ____________________________

Exploring Shapes
7. What shapes do you see on the playground equipment?

   __________________________________________________________________________
   __________________________________________________________________________

8. Do you see a __________________________________________________________________________

9. Can you find a triangular prism? What is it? __________________________________________________________________________

10. Is there a cylinder on the playground? What is it? __________________________________________________________________________
Swing Measurements
11. What are the measurements of one rectangle you see on the swing set?

<table>
<thead>
<tr>
<th>length</th>
<th>width</th>
<th>height</th>
</tr>
</thead>
</table>

12. What is the area of the rectangle on the top? \((length \times width)\) ________________________________

13. How long is the chain on the swing? ______________________

14. How far off the ground is the swing? ______________________

Slide Measurements
15. Is there a slide? What is the height of the slide? ________________________________

16. Circle the type of angle that is used for a slide. acute angle right angle obtuse angle

17. Explain why you think slides use this kind of angle. ________________________________

18. Take some more measurements: how long is the bed of the slide? ________________________________

19. How wide is the slide? ________________________________

20. How long is the straight part at the end of the slide? ______________________

21. How far off the ground is the end of the slide? ______________________

22. Locate and name 2 angles on the slide. (acute angle, obtuse angle, or right angle)
   Angle #1: ________________________________
   Angle #2: ________________________________

Motion Mysteries
23. Which ride lets you move vertically (up and down)? ________________________________

24. Which ride lets you move horizontally (sideways)? ________________________________

25. Which ride lets you move in a straight line? ________________________________

26. Which ride lets you move in a curved path (a circle)? ________________________________
Ramp Experiment 1 – Incline, Page 1

You will do an experiment that will help you understand the motion and forces of an object moving down a ramp using your three vehicles (wooden block, toy car, and marble). The questions you will answer should help you design an extremely fun slide that is also safe.

**Materials:** a ramp, a vehicle, stopwatch, tape measure, masking tape, and classroom materials for lifting one end of the ramp at different heights.

Length of your slide (from top to bottom in inches): __________________________________________

**Procedure:**

1. Record the length of your slide above.
2. Record the height of the top of your slide in the first column of the data table below.
3. Mark a starting spot on your slide with masking tape. Be sure to start your vehicle at the same place each time.
4. Send your wooden block down the ramp and time it from the starting point until it reaches the floor. Record the time on the data table.
5. Repeat step 3 for the toy car and marble.
6. Circle which vehicle was fastest; if the vehicle fell off the slide before it reached the floor, place an X next to it.
7. Elevate the top of your ramp. Record the new height
8. Repeat steps 3-7 for 4 new heights.

<table>
<thead>
<tr>
<th>Height of the top of the slide from the ground (inches)</th>
<th>Vehicle – <strong>Circle</strong> which vehicle is fastest for each height of the slide. If the vehicle falls off the slide, place an X next to it.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wooden Block</td>
<td>Toy Car</td>
</tr>
<tr>
<td>Time: ________</td>
<td>Time: ________</td>
</tr>
<tr>
<td>Wooden Block</td>
<td>Toy Car</td>
</tr>
<tr>
<td>Time: ________</td>
<td>Time: ________</td>
</tr>
<tr>
<td>Wooden Block</td>
<td>Toy Car</td>
</tr>
<tr>
<td>Time: ________</td>
<td>Time: ________</td>
</tr>
<tr>
<td>Wooden Block</td>
<td>Toy Car</td>
</tr>
<tr>
<td>Time: ________</td>
<td>Time: ________</td>
</tr>
</tbody>
</table>

HO 2-2 Ramp Experiments 1, 2, 3
What happened to the speed of the vehicles as the ramp became steeper?

________________________________________________________________________

What was the fastest vehicle?

________________________________________________________________________

What was the safest vehicle (least likely to fall off the ramp)?

________________________________________________________________________

Is a steeper slide always a more fun slide? Why or why not?

________________________________________________________________________
You will do an experiment that will help you understand the motion and forces of an object moving down a ramp. You will use the wooden block for this experiment.

**Materials:** a ramp, wooden block, masking tape, tape measure, stopwatch, and four different materials to cover the surface of the ramp. Consider your goal – do you want to go faster or slower?

Length of your slide (from top to bottom in inches): ________________________________

Height of the top of your slide from floor (in inches): ________________________________

**Procedure:**

1. Record the length and height of your slide above.
2. Mark a starting point on the slide with a piece of masking tape. Be sure to start your vehicle at this point each time.
3. Send your vehicle (the wooden block) down the slide with no covering and use the stopwatch to time its trip. Record the time.
4. Send your vehicle down twice more, recording the time for each trial.
5. Calculate the average time by adding together time 1 + time 2 + time 3 and dividing the total by the number of trials (3).
6. Repeat steps 3-5 for the four different materials. Be sure to record what material you are using in the “Material” column of the data chart.

<table>
<thead>
<tr>
<th>Material</th>
<th>Time 1</th>
<th>Time 2</th>
<th>Time 3</th>
<th>Average Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Covering</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Ramp Experiment 3 - Distance

Name ____________________________ Team ____________________________

This time you will design a ramp that will cause the vehicle (the toy car) to travel the greatest distance. You will decide the best height and material to use on the ramp. Once you have built your ramp, you will have three trials; the design team whose vehicle travels the greatest \underline{average} distance is the winner. Good Luck!

**Materials:** a ramp, a car, a tape measure, classroom materials for lifting one end of the ramp at different heights, and ONE type of material for covering the ramp.

Length of your slide (top to bottom in inches): __________________________________________________________

Height of the top of your slide from the floor (in inches): ____________________________________________________

Slide material: _________________________________________________________________

Trial 1 distance: ________________________________

Trial 2 distance: ________________________________

Trial 3 distance: ________________________________

Average distance: ________________________________
### Slide Makeover!

Name: ___________________________________________  Design Team: ___________________________________________

Now it is time to begin thinking like an engineer! Use the following blocks as you work through the problem like an Engineer. You will need four pieces of paper. Put the pages together and fold them in half, like a book. Give it a title, then turn the page and begin.

**Dream Big Engineers!**

**Task 1: Define the Problem.  Find the Important Parts.**

<table>
<thead>
<tr>
<th>Description</th>
<th>Fun Factor Strong Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the role of a slide on the swing set?</td>
<td>What Fun Factor elements are met by a slide’s role?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Safety</th>
<th>Other Things to Consider</th>
</tr>
</thead>
<tbody>
<tr>
<td>What safety rules apply to slides?</td>
<td>What other limits might be important? : size limits, ages of children</td>
</tr>
</tbody>
</table>

**Task 2: Imagine It!  – Brainstorm possible solutions.**

<table>
<thead>
<tr>
<th>Ideas to Add Function</th>
<th>Ideas for Fun</th>
</tr>
</thead>
<tbody>
<tr>
<td>How can you change the slide to add new ways to play on it?</td>
<td>What can you do to the slide to make it more fun?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Safety Pointers</th>
<th>More Ideas to Improve the Slide</th>
</tr>
</thead>
<tbody>
<tr>
<td>How could you make the slide even safer?</td>
<td></td>
</tr>
</tbody>
</table>
Task 3: Plan It! – Research, list materials, and identify the next steps.

<table>
<thead>
<tr>
<th>Functions - Research It!</th>
<th>Fun - Research It!</th>
</tr>
</thead>
<tbody>
<tr>
<td>What have others done to add functions to the basic slide design? (Cite your resources.)</td>
<td>How have others made the slide more fun? (Cite resources.)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Safety - Research It!</th>
<th>More Ideas - Research It!</th>
</tr>
</thead>
<tbody>
<tr>
<td>What are some of the rules for safe slide designs?</td>
<td>What else did you learn when you were conducting your research?</td>
</tr>
</tbody>
</table>

Task 4: Sketch It! – Follow your plan and draw your slide design

After filling out this information, make a sketch with your ideas. After drawing your sketch, meet with your team to get more ideas that you might want to change or add. Once your design is perfect, trace your sketch in black ink and color it, then begin adding notes using labels or stickers or post-its or anything else that you want to use to make it clear to you later.

Remember – label EVERYTHING – list the materials for each part, the size of each part (using metric is extra points, but using standard measurement is fine to), and, of course, the name of each part.

Finally, make a supply list for your prototype. Be thorough, you don’t want to have to hold up the process while you wait on shipping to get your parts in.

Task 5: Share It! Engineers know they must share their ideas and use feedback.

At least one team member must sign the back of your book. They will write 2 sentences that provide feedback to make your slide better. The sentences should look something like this:

This slide uses a good design. I like ________________________________________________________________
This slide could be better if ________________________________________________________________
<table>
<thead>
<tr>
<th><strong>Opinion</strong></th>
<th>Give your opinion.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Reason</strong></td>
<td>State the reason for having this opinion.</td>
</tr>
<tr>
<td><strong>Example</strong></td>
<td>Give an example that supports your opinion.</td>
</tr>
<tr>
<td><strong>Reason</strong></td>
<td>State a second reason for having this opinion.</td>
</tr>
<tr>
<td><strong>Example</strong></td>
<td>Give a second example that supports your opinion.</td>
</tr>
<tr>
<td><strong>Opinion</strong></td>
<td>Restate your opinion.</td>
</tr>
</tbody>
</table>
ASK: Identify the problem

IMAGINE: Brainstorm possibilities, choose the best

PLAN: Research, list needs, plan steps

CREATE: Follow your plan and build a model

TEST: Try it out. What works? What doesn’t?

IMPROVE: Redesign to solve problems that came up

SHARE: Show it to others and get feedback.

Engineering Design Process (EDP)
Lesson Plan #3

Recreational STEM – Grade 3

Lesson Title
Swinging Pendulums

Lesson Summary
This lesson will continue the module theme of exploring forces acting on common swing set equipment and the motion that results. Science activities will focus on balanced and unbalanced forces as demonstrated by pendulums. Lessons learned from measuring pendulum motion will be applied to observations of swings and gliders. These observations will, in turn, be used to design the swing or glider component of the swing set. Mathematics activities will include measuring pendulum motion as well as ranking design alternatives using the team’s Fun Factor rubric. A field trip to a playground can be incorporated as part of this lesson.

Essential Question(s)
- What forces are at work on a playground swing or glider?
- How does the design of the swing or glider unit affect speed and motion?
- How do gravity and inertia affect the “Fun Factor” of a swing or glider?
- How do materials used in a swing or glider unit affect the cost and/or performance of the unit?
- What safety features are part of the design of a swing or glider?

Established Goals/Objectives
Students will be able to:
- Recognize and describe gravity and inertia’s influence on pendulum motion.
- Analyze the circular motion of a pendulum to make predictions.
- Predict and evaluate the impact of design and materials on the swing’s “Fun Factor” rating.
- Evaluate the safety features and materials of a swing design.
- Design a swing or glider for the Swing Set Makeover Design Challenge.

Time Required
3 Days (90 minutes each)
Necessary Materials
- Science notebooks, one per student
- Access to the Internet for showing video clips and student research
- K-W-L chart from previous weeks
- Optional: pictures of swing sets with swings and other forms of pendulums

Pendulum Investigations
- Pendulum Investigations lab sheet (1 per team), located in Lesson 3 appendix
- Pendulum Investigations lab sheet (1 per team), located in Lesson 3 appendix
- Pendulum Investigations lab sheet (1 per team), located in Lesson 3 appendix
- Swing Makeover Plan, located in Lesson 3 appendix
- Pendulum Investigation Rubric (1 per team), located in Lesson 3 appendix
- Engineering Design Cycle, (per team), located in Lesson 3 appendix
- Four full length pencils
- Four pieces of string – approx. 30cm; 45cm; 60cm; and 75cm
- Roll of masking tape approx. 1 inch wide
- Ten large washers, identical in size and mass – approx. 3 cm outside diameter (a pipe cleaner will be wrapped around the washers to hold them together in groups)
- Pipe cleaners (or chenille stem)
- Meter sticks
- Stopwatches
- Calculators
- Colored markers or pencils – one each of four different colors. Each station is identified by its color.

Jigsaw Research Activity
- Jigsaw Activity, (per team), located in Lesson 3 appendix
- Access to the Internet
- Chart Paper or Poster Board
- Markers
Content Standards Addressed in STEM Road Map Module Lesson

**Next Generation Science Standards**
3-PS2-1; 3-PS2-2

**Common Core Mathematics**
CCS.Math.Practices: MP1; MP2; MP4; MP5; MP7
CCS.Math.Content: MD.C.5; MD.C.6; MD.C.7; OA.D.9

**Common Core English/ Language Arts (ELA)**
Reading Informational Text Standards: RI.3.5; RI.3.7
Writing Standards: W.3.1b; W.3.2; W.3.2b; W.3.3
Speaking & Listening Standards: SL.3.1; SL.3.1d; SL.3.4
Presentation of Knowledge and Ideas: SL.3.4; SL.3.6

**21st Century Skills**
Interdisciplinary Themes (health & safety, environmental literacy, science, mathematics, engineering design process); Learning and Innovation Skills; Information, Media, & Technology Skills; Life Skills
<table>
<thead>
<tr>
<th>Key Vocabulary</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>arc</td>
<td>an unbroken part of a circle or other curved line</td>
</tr>
<tr>
<td>balanced force</td>
<td>two forces equal in strength being pushed or pulled in opposite directions</td>
</tr>
<tr>
<td>bob</td>
<td>the weight at the end of the pendulum</td>
</tr>
<tr>
<td>circle</td>
<td>a line that is curved so that its ends meet and every point on the line is the same distance from the center</td>
</tr>
<tr>
<td>direction</td>
<td>the path a moving object follows</td>
</tr>
<tr>
<td>distance</td>
<td>the measure of how far an object has traveled</td>
</tr>
<tr>
<td>energy</td>
<td>the ability of a body or system to do work or produce a change; a power exerted with force</td>
</tr>
<tr>
<td>force</td>
<td>a push or pull on an object</td>
</tr>
<tr>
<td>gravity</td>
<td>the force that pulls objects toward the center of the earth</td>
</tr>
<tr>
<td>inertia</td>
<td>the property of an object that keeps it resting when at rest or moving when in motion in the same straight line unless acted on by an outside force</td>
</tr>
<tr>
<td>mass</td>
<td>a measure of how much matter is in an object; on earth mass equals weight</td>
</tr>
<tr>
<td>motion</td>
<td>the act of changing place or position</td>
</tr>
<tr>
<td>path</td>
<td>the way or track in which something moves</td>
</tr>
<tr>
<td>pendulum</td>
<td>a weight hung from a point so as to swing freely back and forth under the action of gravity</td>
</tr>
<tr>
<td>rotate</td>
<td>to turn around a center line or center point</td>
</tr>
<tr>
<td>speed</td>
<td>how fast or slow an object is moving</td>
</tr>
<tr>
<td>stall</td>
<td>to bring to a standstill by stopping an object's motion</td>
</tr>
<tr>
<td>unbalanced force</td>
<td>two forces pushing or pulling in opposite directions where one force is stronger than another</td>
</tr>
<tr>
<td>velocity</td>
<td>how fast an object moves in a given direction</td>
</tr>
</tbody>
</table>
Teacher Background Information

Students will be applying learning from previous lessons throughout the module in this lesson. You may wish to review the principles of force and motion covered in Lessons 1 and 2, particularly the concepts of gravity and inertia. This lesson includes a pendulum lab that will give students experience with a new type of motion that does not conform to the straight line inertia concept covered in Lesson 2. Students will also be using the criteria they incorporated in the Fun Factor metric as they design a swing unit for their playground makeover.

The Pendulum

A pendulum is a weight (called a bob) hung from a fixed point so that the weight can swing freely back and forth under the action of gravity. In this unit, students will explore the motion of simple pendulums and compare that motion to that of playground swings.

Science owes much of its understanding about pendulum motion to one of the fathers of the study of physics, Galileo. Legend has it, that when he was eighteen years old, Galileo noticed something unusual about large lamps he observed while sitting in the cathedral of Pisa. These lamps hung from the ceiling and would often swing back and forth when moved by the lamplighter or a gust of wind. It seemed to the young student that lamps that hung the same distance from the ceiling seemed to move in the same rhythm. Galileo used his own pulse to time the swings of the lamps and discovered that the time a pendulum takes to make one complete swing (there and back again) is always the same, even when the pendulum has lost energy and the swings aren’t nearly so large. In further experiments, Galileo discovered that different length pendulums swing in predictable rhythms. Longer pendulums have lower frequency (swings per minute). Shorter pendulums have higher frequency. He discovered that he could change the length of a pendulum until it swung exactly 60 times in a minute. This discovery led to the development of pendulum clocks, often referred to as grandfather clocks.

As students work through the pendulum lab, they will use the same size bob on pendulums of various lengths. Their data will consist of the mass of their bob (the number of washers used), the length of the pendulum, and the number of swings they count in each of four minutes from the time the bob is dropped, until it nearly comes to rest four minutes later. Casual observation of the pendulum makes it clear that each swing is a little smaller than the one before. This is because air resistance converts a portion of the pendulum’s kinetic energy to heat, thereby reducing the energy available to make the climb on the upswing. A common misconception is that there will be fewer swings in minute #2 than in minute #1 because the pendulum seems to be going so much slower. By making a line plot, students should see the surprising fact that their counts are very consistent, at least over the first three minutes. It is possible that the pendulum could come to rest in minute four or shortly thereafter since the washers used as a bob have fairly high air resistance. When the class data is combined in a large line plot, students are likely to be surprised that the other teams who used bobs of more or less mass (from one to four washers) counted swing counts similar to theirs on pendulums with the same length. This is the ‘aha’ we are looking for: while the pendulum keeps swinging, swing count per minute is consistent for pendulums of the same length where the bobs have equivalent air resistance.

In classic pendulum studies, the length of the pendulum is defined as the distance from the top of the string to the center of gravity of the bob. In the case of this lab, the center of gravity is near the center of the washers.
You may determine that measuring to the center of the washers is too difficult for your students. In that case, simply have students measure from top of the string to the bottom of the washers when the pendulum is hanging at rest.

The University of Colorado has a great online pendulum simulator on its PhET website at http://phet.colorado.edu/en/simulation/pendulum-lab. This simulator allows the user to explore pendulum motion by varying any or all of four factors: gravity, friction (air resistance), mass of the bob, and length of the pendulum. A few different trials illustrate the fact that mass of the bob does not affect the time of the swings. On earth, the main drivers of variation to the time of a single swing are the length of the pendulum and the friction encountered by the bob as it moves through the air. One limitation of the simulation as an extension for this lesson’s lab is that the mass cannot be set lower than .1 kg. This is the equivalent of about six washers – more than any of the groups will use.

**Jigsaw Teamwork Learning**

Optional: The Jigsaw Method is a way for students to become experts on a particular research topic that is part of a larger study. Each student can become an expert for their team by researching a topic with a member of each of the other design teams. Ideally, each expert team should include one representative from each design team. While researching, the student will complete the graphic organizer in the appendix, and the group will compile their findings on poster board or chart paper. This poster will serve as a visual with which they will share their knowledge with the class. For more information on the Jigsaw Method see the Explain section of this lesson and an online overview at https://www.jigsaw.org/overview.

Suggested topics for this lesson are below.

**Research Topic 1: Motion**

Applying pendulum principles to swing design requires student to solve an important problem; how to keep the swing going when the natural behavior of the pendulum is to slow and eventually stop. Students will need to devise a propulsion system in order to fulfill one of the design requirements, “…[design] a swing or glider that adds to the Fun Factor score for the proposed playground.” Each team should appoint a member as a propulsion expert. This person should participate with peers from other teams in the propulsion portion of a jigsaw learning team.

Observation of a trapeze video, https://vimeo.com/143478380, gives students a clue that thrusting a rider’s weight in the direction of the movement of the swing will add additional energy to the swing. Repeated application of additional energy can propel the rider higher and higher. This method of propulsion makes sense for a trapeze rider, but is not practical for most swing configurations.

On a conventional swing, the rider adds energy by rapidly extending the lower legs, a motion commonly called pumping. A rider can add even more energy by leaning back and forth so much that the chains (or ropes) that hold the swing actually go from straight to bent, with the bend happening where the hands grasp the chains. This minor deflection of the chain lifts the body upwards against gravity. This lift, added repeatedly at the
correct part of the swing, increases the speed of the swing since the body is falling from a slightly higher location. The video https://youtu.be/UXo6WvHRs_I from the University of Nottingham illustrates this idea.

A video about a wheelchair swing, https://www.youtube.com/watch?v=ZOzEJrdv1V4, offers a different propulsion alternative. The rider adds energy to the swing by pulling on a stationary rope. Notice that this fulfills the classic definition of force as a push or a pull. Whether by displacing weight, adding a push or a pull, or some other imaginative technique, your students will have fun designing a swing or glider for the Swing Set Makeover.

**Research Topic 2: Safety**

As with any object used by or in contact with living things, safety is an important concern. In designing a swing or glider, your budding engineers will need to consider the safety of the riders as well as the safety of bystanders. Each team should appoint a member as a safety expert. This person should participate with peers from other teams in the safety portion of a jigsaw learning team. The definitive resource for public playground safety guidance is the *Public Playground Safety Handbook* published by the U.S. Consumer Product Safety Commission that can be found at [http://www.cpsc.gov/PageFiles/122149/325.pdf](http://www.cpsc.gov/PageFiles/122149/325.pdf). Students should focus on the “Playground Injuries” and “Playground Hazards” portions of this publication.

**Research Topic 3: Materials**

The swing unit is a large object. One important design consideration is the materials that will be used for the structure. Most children have experience with a wide variety of playground equipment and will be familiar with many kinds of material: wood, metal, plastic, concrete, etc. Each team should appoint a member as a materials expert. This person should participate with peers from other teams in the materials portion of a jigsaw learning team. There are numerous commercial resources on the Internet for playground materials. A directory of playground suppliers may be found at [http://www.playgroundprofessionals.com/equipment/playground/independent-play](http://www.playgroundprofessionals.com/equipment/playground/independent-play). This site includes links to websites where students can get ideas for materials. The *Public Playground Safety Handbook* published by the U.S. Consumer Product Safety Commission found at [http://www.cpsc.gov/PageFiles/122149/325.pdf](http://www.cpsc.gov/PageFiles/122149/325.pdf) also provides information about materials and surfacing.

**Research Topic 4: Accessibility**

The Americans with Disabilities Act (ADA) requires that all public facilities, including playgrounds, be accessible to individuals with disabilities. This means that public playgrounds must be designed in order to ensure that children with a range of disabilities can access playground components. This includes accessible routes, ground surfaces, and entry points and seat. The *Guide to ADA Accessibility Guidelines for Play Areas* at [http://www.playgroundregs.com/resources/ADA%20guide.pdf](http://www.playgroundregs.com/resources/ADA%20guide.pdf) provides information about these playground features (pages 19-37).

**Career Connections**

**Materials Scientist**
The design challenge for this module has a special focus on materials. When you hear the word material, students might think of fabric used to make clothes. When an engineer talks about materials, she means the stuff things are made of more generally. Materials can be plastics, metals, ceramics, or some other substance. Materials scientists are people who study and design materials to solve special problems. If you like science and enjoy working in a laboratory, you might enjoy being a materials scientist. The following website provides more information about this career: www.sciencebuddies.org/science-engineering-careers/engineering/materials-scientist-and-engineer

**Landscape Architect**

This module’s design focus is a swing set or playground. The design of the outdoor surroundings of the playground is just as important as the playground itself. Landscape architecture is the design of planned changes to the land, especially in areas where people live, work, and play. A landscape architect might work on many different kinds of projects such as parks, gardens, playgrounds, monuments, city design, etc. If you enjoy being outdoors and making places beautiful and organized, you might enjoy being a landscape architect. The following is a link to the Harvard University alumni page about a woman knew she wanted to make parks when she was only 11 years old: [http://alumni.harvard.edu/stories/cornelia-oberlander](http://alumni.harvard.edu/stories/cornelia-oberlander).

**Lesson Preparation**

Review the teacher background information provided, assemble materials for the lesson and preview videos included within the Learning Plan Components. Students will be assessed on their collaboration, their team swing unit designs, their presentations of proposed designs, and the discussions surrounding the choice of a winning design. You may wish to review the associated rubrics (attached at the end of this lesson).

The science centerpiece of this lesson is the pendulum lab. You may wish to conduct this lab on your own prior to working with students since proper setup of the apparatus is essential to its function. It will be helpful if you have a clear idea for setting up the pendulums so students have plenty of room for swinging the pendulum without hitting team members. The longest string is approximately 30 inches. See the Activity/Investigation section for details about setting up this activity.
Learning Plan Components

Introductory Activity/Engagement

ELA CLASS

Read the poem “The Swing” by Robert Louis Stevenson (from A Child’s Garden of Verses) to the class:

THE SWING
By Robert Louis Stevenson

How do you like to go up in a swing,
Up in the air so blue?
Oh, I do think it the pleasantest thing
Ever a child can do!

Up in the air and over the wall,
Till I can see so wide,
Rivers and trees and cattle and all
Over the countryside –

Till I look down on the garden green,
Down on the roof so brown –
Up in the air I go flying again,
Up in the air and down!

Let students share their own ideas about swinging.

- How did it make you feel listening to this poem?
- Have you had similar feelings when you were swinging on a swing?

This story allows students to experience the girl’s imagination soaring, but it also does a good job of showing students the pumping action that is necessary for moving the swing and may help to inform them as they need to consider how to imitate this action without actually moving their feet.

Give students an opportunity to add to the K-W-L chart to add specific details about swings.

SCIENCE

Watch videos that depict different kinds of swings. Remind students that a change in motion is always the result of a push or a pull. Encourage them to look for pushes and pulls in these videos.

Wheelchair swing video: https://www.youtube.com/watch?v=ZOzEJrdv1V4
Trapeze practice video: https://vimeo.com/143478380
Discuss the videos and allow students a second opportunity to add to the KWL chart. Ask the following lead in questions to help stimulate ideas:

- What were the people in the videos doing?
- What part of a playground is similar to the devices in the videos?
- How did the riders make their swings go higher?
- How does a person on a common swing set make a swing go higher?
- Where in the path of the swing does the rider add energy?

**Activity/Investigation**

**SCIENCE**

**Pendulum Investigations**

Observe that without the addition of more energy, a pendulum will gradually slow down and its swings will be shorter and shorter. Make use of observations to propose ways to add energy to a swing ride. The activity can be conducted using stations. Each station has a different length pendulum. Each group has a set of washers that they use for their pendulum weight at each station. The goal of the activity is to observe the behavior of each pendulum and compare that behavior to the pendulums with different string length. Each team has a different number of washers for their weight, but they don’t necessarily know that the other teams’ weights are different.

To set up four learning centers for the pendulum investigations gather the following materials:

- Four full length pencils
- Four pieces of string – approx. 30cm; 45cm; 60cm; and 75cm
- Roll of masking tape approx. 1inch wide
- Ten large washers, identical in size and mass – approx. 3 cm outside diameter (a pipe cleaner will be wrapped around the washers to hold them together in groups)
- Four pipe cleaners (or chenille stem)
- Four meter sticks
- Four stopwatches
- Pendulum Investigation handouts (see Appendix, Lesson 3)
- Four colored markers or pencils – one each of four different colors. Each station is identified by the color of its graph.

Design teams members will be performing one of the following jobs (have students switch jobs as they switch stations):

- Technician – holds the bob and drops the bob to start the pendulum.
- Statistician – counts the number of full swings (there and back again) in a specific period of time.
- Crew Chief – Runs the stop watch, calls the start, and calls out each minute.
- Quality Control (optional – add this job if groups of 4 students are used)– does the measuring and makes sure the tests are fair. Quality control will make sure the bob begins at the same
point and the record times are consistent. Quality control will also count the number of full swings of the pendulum.

**Teacher set up:** Prepare the four pendulum stations

a. Tape a pencil to the table with the eraser end hanging off the front of the table by several centimeters.
b. Make a loop in one end of the string to provide a place to attach the bob to the string.
c. Fasten one end of string to the end of the pencil so that the bob can swing freely. Leave enough room to hang the bob below the loop at the end of the string. The goal here is to have several different stations each with a different length of string. If tables are short, the range of the string lengths will need to be adjusted accordingly, or you may wish to stack books to create a higher surface.
d. Place a line plot recording sheet at each station. Students will use them in the first station, and then carry the graph with them to each station they are able to visit. Each station will have a different color marker for recording their results.

The empty line plot should have:
- The vertical axis should be “number of swings” with a scale from 0 to 100 in increments of 5.
- The horizontal axis will be number of minutes (1-4).
e. Make a pendulum bob to use to demonstrate the procedure for marking a location for the drop and the proper way to drop the bob (see Explain for details).

**Teacher Demonstration**

a. Show students how to set the bob along the edge of the table even with the pencil. Stretch the string until it is tight and lined up along the edge of the desk.
b. Use a piece of tape to mark the place on the desk where the washer is lying. This will be the drop point mark. Explain that to create a fair experiment, this drop point needs to be the same for every test.
c. Show students to proper way to begin the swing, by sliding the washer gently off the edge of the desk and letting it swing freely.
d. Once you are sure students know how to safely begin the swing, pass out the pendulum handouts and a different number of washers to each design team. Group 1 will receive 1 washer, group 2 will receive two washers, group 3 will receive three washers, and group 4 will receive four. Modify the number of total washers if necessary.

**Student set up:** Build the Pendulum Bob

a. Assemble a washer pack by stacking the washers together.
b. Thread a pipe clear through the center of the washers.
c. Twist the pipe cleaner together to hold the washers tightly. Leave enough pipe cleaner to fasten to the pendulum loop at the end of the string.
d. This washer pack is called the pendulum bob. The same bob will be used throughout the entire activity.

e. Record the number of washers used for your bob.

**Student Process:** When you arrive at each station, do the following:

1. Fasten the bob to the loop at the end of the string by twisting the loose ends of pipe cleaner together through the loop.
2. Mark the drop point on the desk as was demonstrated.
3. Measure the length of the pendulum from the pencil to the bottom of the bob when it is resting on the desk.
4. Draw a sketch of the pendulum (with measurements labeled) on the lab handout.

**Activity #1: Identify the Pendulum Path**

Encourage the students to “see the circle” in the pendulum and to transfer that same idea to swings on a typical swing set. This will help them identify the footprint of the swing path in order to identify the safety zone needed to provide clearance for a swing.

1. Raise the pendulum washer even with the edge of the desk and place the bob on the drop point mark. The string should be tight along the edge of the desk.
2. The technician will gently move the bob up and over to the table top on the opposite side of the pencil keeping the pendulum’s string tight through the entire movement.
3. Ensure that the technician continues to hold the string firmly as the bob moves along its entire path until it returns to the starting point. Someone should be watching to make sure the string remains tight through the entire movement and the other two team members should be watching to identify the path of the bob. What shape is being formed?
4. Add information to the sketch in your notebook showing the path observed as you moved the washer around the pencil. Label any interesting locations on the path such as the drop point, the highest point, the lowest point, and so on.
5. Label the length of the pendulum.

**Activity #2: Pendulum Motion**

Encourage students to predict what they think will happen when they begin work with a pendulum of a different length. They will be asked to make predictions (see Pendulum Motion Activity handout in the appendix) about the pendulum swing and length.

1. Place the pendulum bob on the drop off point mark that was marked earlier. The string should be straight and tight along the edge of the table.
2. Drop the pendulum bob. Students will observe its motion for 3 minutes.
   a. Count the number of full swings (there and back again) in minute 1 (from start till the crew chief calls “one.”)
   b. Count the number of full swings in minute 2 (until the crew chief calls “two.”)
   c. Count the number of full swings in minute 3 (until the crew chief calls “three.”)
3. Make a sketch of the path of the pendulum path from the drop point to the place where it would come to rest. Label the parts of the path, and the pendulum length. Indicate balanced and imbalanced forces on different sides of the swing.

4. Record the number of full swings for each minute of the three trials.

5. At each station, plot the swing counts on your team’s line plot with columns from 0 to 100 in increments of 5. Use the colored marker from the station to distinguish counts from the different stations.

Activity #3: Free Weight Motion

Performed after the last activity.

1. When completing the third set of times at the last station, remove the bob from the pendulum.

2. Raise the bob to the drop point mark.

3. On the crew chief’s command, drop the washer bob.
   - Observe the path of the washer until it comes to rest.
   - Using the stopwatch, measure the time from the drop until the washer comes to rest.

4. Make a sketch of the path of the free weight washer from the drop point to the place where it came to rest.

Swing Makeover Design Challenge

The Swing Makeover is the engineering portion of the lesson and is the second component of the final challenge, the Swing Set Makeover. Up until now, students have been concerned with swinging motion as illustrated in a simple pendulum. The design challenge requires that students add a new dimension - propulsion. The trapeze and wheelchair videos from the Introductory/Engagement section illustrated two very different propulsion systems: thrusting the body to add momentum and pulling on a rope to move the swing. In addition to these methods, students are familiar with the motion of pumping the legs to add momentum. In this section, students should be encouraged to imagine a swing design that incorporates any or all of these propulsion methods or something entirely different.

Since the Swing Set Makeover Challenge is focused on creating a new design for the school playground, the design should fit within the size constraints of the playground measurements that were identified in the Lesson 2 Geometry Scavenger Hunt. Students should be free to use their imaginations and not be expected to solve mechanical problems in this challenge. The output is a design drawing showing the primary features of the proposed solution.

Students should connect the pendulums they observed in the activities with this activity by considering the following:

- If this pendulum was a ride at the playground, what would be its Fun Factor rating?
- What variable (mass or pendulum length) has the most effect on the Fun Factor score?
3rd Grade Recreational STEM Module

- How could you improve the pendulum’s Fun Factor rating?

1. Use the engineering design process (EDP) to create a plan for a new swing design. The output from the plan should be an annotated sketch of the swing design on graph paper and a written description of the design highlighting its features. The design should include the following:

- TITLE (begin thinking about a creative name for the swing set that will be designed next week)
- SCALE to identify the measurement of each block on the grid paper
- LABELS for the center point of the swing arc, the preferred height of the swing above ground, and the width of the swing seat
- FOOTPRINT of the swing arc is marked with a dotted line to indicate the clearance required for safety
- MATERIALS are labeled to show where they are used in the various components of the swing
- NOTES indicating the propulsion system for the swing unit

2. Students will present their sketches of their swing designs to another team. Students should give feedback (What do they like about the design? How would they rate the Fun Factor for the swing? Is it safe? What could be improved?)

**MATHEMATICS CONNECTION**

**Swing Set Makeover**
The team should use mathematics to determine critical specifications for the design of the swing.

1. Using measurements from Activity #1, model the size of the safety zone required for the swing so that bystanders are safe.
2. Create guidelines for materials to be used for the swing based on the combined mass of the swing and the riders.

**ELA CONNECTION**

1. Vocabulary Cards: pendulum, bob, arc; stall; radius; circle; center; footprint
2. Optional: Students will research various topics about playgrounds using a jigsaw strategy. The Teacher Background section provides details about topics, resources, and strategies.

In addition to applying pendulum principles to the design of their swing rides, students will be research four topics which serve as constraints to their designs: motion/propulsion, safety, materials, and
accessibility. To tackle these important problems, employ the jigsaw method of grouping students. The jigsaw method involves dividing students into small groups (called expert groups) to investigate one factor of a larger phenomenon. Students then present these findings to the larger group so that, together, the class forms an overview of the various factors, using the presentations to put them together, much like a puzzle is constructed. For this lesson, each expert group will be charged with investigating one of the factors affecting playground design. You should ensure that each design team has a member on each of the expert teams, so that the design team has an “expert” on each factor represented and the number of expert groups should match the number of members on each design team as closely as possible.

Each expert group should research their assigned topic using the resources suggested in the Teacher Background section. A graphic organizer is included in the appendix to this lesson. After they have completed their research, students should record their findings on chart paper or poster board and groups will share their findings with the class using this poster as a visual aid.

**Explain**

**SCIENCE**

Activity #1 helps students recognize that the path of an object with a fixed center point and fixed distance (radius) between the object and the center point is a circle. In the real world, a pendulum follows an arc, which is a part of the circle, having its center point at the point of the circle closest to the earth. Once students start to see this circular pattern for motion, they will see circles everywhere: the motion of a swinging arm, the path of bicycle pedals, the arc of a door, etc. The pendulum’s path is an arc at the bottom of the circle. As the energy of the pendulum is diminished by friction, the arc gets smaller and smaller.

Activity #2 is done by rotating students through different stations. Each station has a pendulum set up with a different length string. Only the string length changes from station to station as the student teams will be using a consistent bob weight throughout all their trials. The measurement they make is the number of full swings (there and back again) made during specific intervals: minute 1, minute 2, etc. Activity #2 helps students to see the effect of forces acting on the pendulum bob:

- gravity, pulls the bob down
- inertia, keeps the bob moving
- friction, in the form of air resistance, slows it down
- pull of the string, opposes gravity so the pendulum can keep repeating its cycle because of inertia

Draw the students’ attention to places in the pendulum swing where some or all of the forces are balanced. Ensure that the students see that forces working together and in opposition result in different motions of the pendulum bob.

- At rest all of the forces are balanced - no movement
At the top of the swing on each side (the stall point), all forces are balanced for an instant before the pendulum changes direction.

As the pendulum falls, gravity and inertia worked together, opposed only by friction, and the pendulum picks up speed.

As the pendulum rises, inertia is opposed by gravity and friction working together to slow the pendulum until it stops at the top of one side or the other.

Friction is at work on both sides of the swing, dissipating energy from the system.

The force of the string pulling against gravity enables inertia’s effect to repeat over and over again.

Activity #3 should be done at the end of the last station that students will cycle through. It stands in stark contrast to the long-running motion of the pendulum. The free falling bob has the same starting energy as the falling pendulum; however its motion ends moments later when all of the forces come into balance. As mentioned earlier, the force of the string enables the pendulum to defy gravity and swing up the opposite side of the arc. This is similar to the effect that a kite string has in holding the kite surface against the pressure of wind resulting in an object that floats in the sky, also defying gravity.

**Mathematics Connection**

The Swing Makeover design challenge provides an opportunity to calculate areas and perimeters using the size of the proposed swing design, called *footprint*. In mechanical engineering, an object’s footprint is the size and shape of the surface that the object covers. Guide the teams as they project the swing’s total horizontal movement down onto the ground. This is the footprint and should be enlarged to establish a safety zone for bystanders. Guide the students into determining how big of a buffer is needed around the swing’s footprint - possibly an arm’s length?
Extend/Apply Knowledge

**SCIENCE**

You may wish to incorporate a field trip to a playground during this lesson. During this field trip you may wish to incorporate some of the following learning activities:

- Have students use their team Fun Factor scales to determine a Fun Factor rating for the playground.
- Have students identify points in the playground where forces influence the Fun Factor and have students identify the playground feature and the force at work.
- Have students consider how the various elements of the playground are connected and note ideas about how they might connect the elements of their design in the Swing Set Makeover challenge.
- Have students use their science notebooks to identify and sketch features of the playground they may want to incorporate into their Swing Set Makeover designs.
- Have students search for geometric shapes and note where they find them or, alternatively, photograph a range of shapes.
- Have students identify safety features of the playground and note these in their science notebooks or take photographs of the features.
- Have students measure the footprint of the playground and create a scale drawing of the playground on graph paper.

This online simulation from the University of Colorado shows forces in action on pendulums: http://phet.colorado.edu/en/simulation/pendulum-lab. The simulation user can vary friction or gravity to zero and see how a pendulum behaves when it does not lose energy to friction or gravity.

**MATHEMATICS CONNECTION**

This is an excellent time to introduce the concept of strength of materials. The string used in the pendulum lab is adequate to hold a few washers, but would hardly suffice to hold something heavy like a bowling ball or a person. Similarly the tape on the desk is adequate to secure the pencil used to suspend the pendulum above the ground. Neither the tape nor the pencil would adequately support anything very heavy. Guide the students to propose alternatives that could support the required load without being overkill. These will be based on the total load that the equipment is expected to carry: swing hardware plus rider plus a reasonable safety factor.

**Assessment**

**Performance Tasks**

- Pendulum Investigation Activities
- Swing Makeover, sketch
- Jigsaw Poster Presentation

**Other Measures**
Engagement in class activities and discussions
Involvement in group work and discussions

Internet Resources

Teacher Resources
- Flickr image in the Jigsaw Puzzle handout LuMaxArt Linkware freebie image provided by Scott Maxwell [https://www.flickr.com/photos/lumaxart/262682758/](https://www.flickr.com/photos/lumaxart/262682758/)
  - Jigsaw Teamwork Learning [https://www.jigsaw.org/overview/](https://www.jigsaw.org/overview/)

Videos
- Flying in the Mountains: [https://vimeo.com/132779884](https://vimeo.com/132779884)

Best for showing the motions used to add energy
- Trapeze video: [https://vimeo.com/143478380](https://vimeo.com/143478380)
- Wheelchair Video: [https://www.youtube.com/watch?v=ZOzEJrdv1V4](https://www.youtube.com/watch?v=ZOzEJrdv1V4)
- Swing motion video: [https://youtu.be/UXo6WvHRs_I](https://youtu.be/UXo6WvHRs_I)

Simulations
- Pendulum Simulation from the University of Colorado [http://phet.colorado.edu/en/simulation/pendulum-lab](http://phet.colorado.edu/en/simulation/pendulum-lab)

Materials of the Playground
Appendix, Lesson 3
Pendulum Path - Activity 1

You will perform a test to help you better understand the path of an object moving on a pendulum. This experiment will help you see the footprint of the swing’s path so you can find the safety zone you will need when you plan your swing set.

Materials: a pencil, piece of string, masking tape, washers, a pipe leaner, meter stick, and stopwatch.

Procedure:

1. Attach your pendulum bob to the end of the string at your station.
2. Measure your pendulum (from where the string is attached to the pencil to the bottom of your bob).
3. Lift the bob to the level of the pencil and stretch the string tight along the edge of the table.
4. Mark this spot with tape – you will begin your pendulum swing from this spot each time.
5. Gently slide the bob off the edge of the table and observe it.
6. Make a diagram of the path your pendulum takes. Label the points along the pendulum’s path, including:
   a. the highest point
   b. the lowest point
   c. the drop point
   d. what shape is being formed
   e. the number of washers in your bob.
7. Label the length of your pendulum.
Pendulum Motion - Activity 2

You will watch and record the motion of the pendulum with the number of washers (the bob) that you have been given. Everyone will have a different size bob. You will get to try it 4 times testing different lengths of string on the pendulum at various stations. Before you begin, consider what your team would like to find out and what you expect you will see. Be sure to use the science words you have learned when you tell about the forces that are acting on the pendulum.

Materials: 4 full length pencils, 4 different lengths of string, masking tape, washer bob, pipe cleaners, meter stick, 4 colored markers or pencils, stopwatch.

Predict:
- Does a longer pendulum mean more swings before coming to rest?
- Does a longer pendulum mean more swings per minute?

Procedure:
1. Place the pendulum bob on the drop off point mark that was marked earlier. The string should be straight and tight along the edge of the table.
2. Drop the pendulum bob. Observe its motion for 4 minutes.
   a. Count the number of full swings (there and back again) in minute 1 (from start till the crew chief calls “one.”)
   b. Count the number of full swings in minute 2 (until the crew chief calls “two.”)
   c. Count the number of full swings in minute 3 (until the crew chief calls “three.”)
   d. Count the number of full swings in minute 4 (until the crew chief calls “stop.”)
3. Make a sketch of the path of the pendulum path from the drop point to the place where it would come to rest. Label the parts of the path, and the pendulum length. Indicate balanced and imbalanced forces on different sides of the swing.
4. Record the number of full swings for each minute of the three trials on the data chart.
5. At each station, plot the swing counts on your team’s line plot with columns from 0 to 100 in increments of 5. Use the colored marker from the station to distinguish counts for the different string lengths at the different stations.
### Pendulum Motion (Page 2)

#### Data Chart

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<th></th>
<th>Minute 1</th>
<th>Minute 2</th>
<th>Minute 3</th>
<th>Minute 4</th>
<th>Total of swings in Minutes 1-3</th>
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<tr>
<td>(45 cm string) Trial 1</td>
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<tr>
<td>(60 cm string) Trial 1</td>
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<td></td>
</tr>
<tr>
<td>(75 cm string) Trial 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

After you have visited all the stations, answer the following:

1. How do the number of swings in minute 1 compare to the number of swings in minute 2?

   ________________________________________________________________

   In minute 3?____________________________________________________

   In minute 4?_____________________________________________________

2. What happened to the pendulum arc as time passed?__________________________

3. Look at the predictions you made before you began this activity. Are they correct? If not, what was different than what you predicted?

   ________________________________________________________________

4. What forces worked on the pendulum?_____________________________________

   ________________________________________________________________

HO3-2 Pendulum Test 2
Free Weight Motion - Activity 3

Name _______________________________  Team _______________________________

Sometimes objects fall and they do not fall like a pendulum. Explore how a free fall compares to a pendulum swing. Consider the forces that act on a pendulum and the forces on the free weight. Are they the same? What is the difference?

Predict:

What path do you think your bob will take when you drop it and it is not attached to the pendulum?

____________________________________________________________________________________

How long do you think it will take for the bob to reach the floor?

____________________________________________________________________________________

Procedure:

1. When completing the third set of times at the last station, remove the bob from the pendulum.
2. Raise the bob to the drop point mark.
3. On the crew chief’s command, drop the washer bob.
   - Observe the path of the washer until it comes to rest.
   - Using the stopwatch, measure the time from the drop until the bob comes to rest.
4. Make a sketch of the path of the free weight washer from the drop point to the place where it came to rest.

How long did it take the bob to come to rest?__________________________________________

____________________________________________________________________________________

HO3-3 Pendulum Test 3
Your group sent you to get ideas about a problem they are trying to solve. Get together with other experts for this topic and learn things that only experts know!

<table>
<thead>
<tr>
<th>Main Idea #1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Main Idea #2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Main Idea #3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>
Swing Makeover!

Name: __________________________  Team: ______________________________________

Our Playground Name is: ________________________________________________________

Now it is time to begin thinking like an engineer! Use the following blocks as you work through the problem like an Engineer. You will need four pieces of paper. Put the pages together and fold them in half, like a book. Give it a title, then turn the page and begin.

Dream Big Engineers!

Task 1: Define the Problem.  Find the Important Parts.

<table>
<thead>
<tr>
<th>Description</th>
<th>Fun Factor Strong Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the role of a swing on the swing set?</td>
<td>What Fun Factor elements are met by a swing’s role?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Safety</th>
<th>Other Things to Consider</th>
</tr>
</thead>
<tbody>
<tr>
<td>What safety rules apply to swing?</td>
<td>What other limits might be important? (for example, size limits, ages of children, etc.)</td>
</tr>
</tbody>
</table>

Task 2: Imagine It!  – Brainstorm possible solutions

<table>
<thead>
<tr>
<th>Ideas to Add Function</th>
<th>Ideas for Fun</th>
</tr>
</thead>
<tbody>
<tr>
<td>How can you change the swing to add new ways to play on it?</td>
<td>What can you do to the swing to make it more fun?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Safety Pointers</th>
<th>More Ideas to Improve the Swing</th>
</tr>
</thead>
<tbody>
<tr>
<td>How could you make the swing even safer?</td>
<td></td>
</tr>
</tbody>
</table>
Task 3: Plan It! – Research, list materials, and list the next steps.

<table>
<thead>
<tr>
<th>Functions - Research It!</th>
<th>Fun - Research It!</th>
</tr>
</thead>
<tbody>
<tr>
<td>What have others changed the design of a swing? (Cite your resources.)</td>
<td>How have others made the swing more fun? (Cite resources.)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Safety - Research It!</th>
<th>More Ideas - Research It!</th>
</tr>
</thead>
<tbody>
<tr>
<td>What are the rules for safety that every swing must have?</td>
<td>What else did you learn when you were doing your research?</td>
</tr>
</tbody>
</table>

Task 4: Create It! – Follow your plan and draw your swing design

After filling out the information above, make a sketch with your ideas. Meet with your team to get more ideas. Make at least one change to improve your design. Document the change you made in the booklet you made for this project. When you are done, trace your sketch in BLACK INK and color it. Add notes using labels or stickers or post-its or anything else that you want to use to make it clear to you later.

Remember – label EVERYTHING – list the materials for each part, the size of each part (using metric is extra points, but using standard measurement is fine too), and, of course, the name of each part.

Finally, make a supply list for your prototype. Be thorough, you don’t want to have to hold up the process while you wait on shipping to get your parts in.

Task 5: Share It! Engineers know they must share their ideas and use feedback.

At least one team member must sign the back of your book. They will write 2 sentences that provide feedback to make your slide better.

The sentences should look something like this:

This swing uses a good design. I like ____________________________________________________________

This swing could be better if ______________________________________________________________
LESSON

Recreational STEM – Grade 3

LESSON TITLE
Swing set Makeover

LESSON SUMMARY
This lesson serves as the capstone of the module and challenges students to complete the Swing Set Makeover. Students will use the EDP to build a prototype of their proposed design, including the slide and swing they designed in previous lessons as well as connectors and other features students choose to include. Students will also create a poster highlighting the features of their swing set, focusing on materials, safety, and accessibility. Note: the poster element of the project may be omitted to permit students more time to create their prototypes or models.

ESSENTIAL QUESTION(S)
- How can we use what we know about forces to improve the design of the school’s playground swing set?
- What safety features need to be considered when designing swing sets?
- What arguments can be used to prove to others that the swing set designed by my team is an improved design?

ESTABLISHED GOALS/OBJECTIVES
Students will be able to:
- Build a prototype for a new swing set that considers shapes, materials, and forces to improve its rating on the Fun Factor Survey.
- Build a prototype for a new swing set that has safety features which integrate safety research.
- Effectively utilize shapes, materials, and measurements to impact speed, aesthetics, and safety on a new swing set design.

TIME REQUIRED
2 days (90 minutes each)
NECESSARY MATERIALS

Prototype
Measuring and Building devices (per team)
- Ruler and/or meter stick
- Scissors
- Assortment of tools to work with modeling clay (plastic knives, toothpicks, etc.)
- Foam display boards – 1 per team (20 x 30)

Possible Building Materials include:
- Modeling clay
- Cardboard
- Straws
- Pipe cleaners
- Wooden dowels
- Craft sticks
- Plastic drinking straws
- Note cards
- String
- Rubber bands
- Foam pipe insulation, cut in half (possible slide material)

Possible Fastening Materials include:
- String
- Masking tape
- Elmer’s Craft Glue or Tacky Glue
- Wire
- Glue gun and hot glue
CONTENT STANDARDS ADDRESSED IN STEM ROAD MAP MODULE LESSON

Next Generation Science Standards

3PS2-1; 3PS2-2

Common Core Mathematics

CCS.Math.Practices: MP1; MP2; MP4; MP5; MP7
CCS.Math.Content: MD.C.5; MD.C.6; MD.C.7; OA.D.9

Common Core English/Language Arts (ELA)

Reading Informational Text Standards: R.I.3.5; RI.3.7; R.I.3.8
Writing Standards: W.3.1; W.3.1a; W.3.1b; W.3.1c; W.3.1d; W.3.2; W.3.2b; W.3.3
Speaking and Listening Standards: SL 3.1; SL 3.1d; SL 3.3
Presentation of Knowledge and Ideas: SL 3.4; SL 3.6

21st Century Skills

Interdisciplinary Themes (health & safety, environmental literacy, science, mathematics, engineering design process); Learning and Innovation Skills; Information, Media, & Technology Skills; Life Skills
<table>
<thead>
<tr>
<th>Key Vocabulary</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>arc</td>
<td>an unbroken part of a circle or other curved line</td>
</tr>
<tr>
<td>balanced force</td>
<td>two forces equal in strength being pushed or pulled in opposite directions</td>
</tr>
<tr>
<td>bulb</td>
<td>the weight on a pendulum</td>
</tr>
<tr>
<td>direction</td>
<td>the path a moving object follows</td>
</tr>
<tr>
<td>distance</td>
<td>the measure of how far an object has traveled</td>
</tr>
<tr>
<td>energy</td>
<td>the ability of a body or system to do work or produce a change; a power exerted with force</td>
</tr>
<tr>
<td>footprint</td>
<td>the area on a surface covered by something</td>
</tr>
<tr>
<td>force</td>
<td>an energy that causes motion or a change in motion</td>
</tr>
<tr>
<td>friction</td>
<td>a force that causes moving things to slow down when one object rubs against another object</td>
</tr>
<tr>
<td>gravity</td>
<td>the force that pulls objects toward the center of the earth</td>
</tr>
<tr>
<td>inertia</td>
<td>the property of an object that keeps it resting when at rest or moving when in motion in the same straight line unless acted on by an outside force</td>
</tr>
<tr>
<td>mass</td>
<td>a measure of how much matter is in an object; on earth mass is equal to weight</td>
</tr>
<tr>
<td>motion</td>
<td>the act of changing place or position</td>
</tr>
<tr>
<td>Newton's Law of Motion</td>
<td>An object at rest stays at rest and an object in motion stays in motion with the same speed and in the same direction unless acted upon by an unbalanced force</td>
</tr>
<tr>
<td>path</td>
<td>the way or track in which something moves</td>
</tr>
<tr>
<td>pendulum</td>
<td>a weight hung from a point so as to swing freely back and forth under the action of gravity</td>
</tr>
<tr>
<td>rotate</td>
<td>to turn around an center line or center point</td>
</tr>
<tr>
<td>speed</td>
<td>how fast or slow an object is moving</td>
</tr>
<tr>
<td>stall</td>
<td>to bring to a standstill by stopping an object’s motion</td>
</tr>
<tr>
<td>unbalanced force</td>
<td>two forces pushing or pulling in opposite directions where one force is stronger than another</td>
</tr>
</tbody>
</table>

**Teacher Background Information**

**Science/Mathematics**

The teacher support material for taking the 2D sketches from Lessons 2 and 3 and converting them into a 3D model has been provided as a document in the appendix as a teacher resource (Prototype Procedure). You may wish to copy this for student use.

**Lesson Preparation**

Review the teacher background information provided, assemble materials for the lesson and preview videos included within the Learning Plan Components.
Students will apply the learning they have accumulated throughout the module in this lesson. Assemble the materials for the swing set prototype before the class begins building. Students should have their slide and swing sketches on hand.

**LEARNING PLAN COMPONENTS**

**INTRODUCTORY ACTIVITY/ENGAGEMENT**

*Science*

Tell students that they will spend the next two class periods creating a model or prototype for the Swing Set Makeover challenge. Remind students that they have already created a plan for a slide and a swing, so that now they will consider what other features they want to include (connectors between the pieces, additional features such as climbing walls, ropes courses, etc.). Allow student teams to look at the materials available to them for the prototype and brainstorm ideas for their completed design. Teams should create sketches of the final designs.

**ACTIVITY/INVESTIGATION**

Review with the students that the goal of the Swing Set Makeover project is to create a model, or prototype, of a swing set that will meet their high standards for fun and safety. After their prototype is developed, the students will share their designs and highlight its features in a poster, emphasizing safety, materials, and accessibility.

*Science / Mathematics*

In previous weeks, the design teams drew sketches for a swing and a slide design. Now is the time for each team to convert these designs into a physical model or prototype.

- Model: a small, physical copy of something
- Prototype: a rough model used to refine a final design

Each team should take their sketch for the slide and swing and devise a way to integrate these two units into a single playground unit. This may require an additional design, probably in the form of a connecting climber or tower. Refer to the Prototype Procedure in the appendix for instructions about the workflow to produce a model.

There are two handouts included in the Appendix to support students’ progress in using the EDP. You may choose to use either or both of these to facilitate student work.

**Here are guidelines for the models:**

- The full size swing set; swing, slide, and connector should be designed so that the real-life object would fit in the site determined in Lesson 2.
- The prototype should be built on foam display boards.
- The model need not be fully functional but should include the primary features of the full size swing set.
- It is OK if, in building the prototype, the teams need to vary their original designs for the swing or slide. Solving design problems is one of the purposes of building a prototype.
- If the swing or slide designs are modified in the prototyping stage the original sketches should be revised to match the prototype.
- If a connecting unit is designed to join the swing and slide units, a design sketch should be prepared for it, similar to the one prepared for the swing and the slide.

**EXPLAIN**

**SCIENCE/ MATHEMATICS**

The teacher support material for taking the 2D sketches from Lessons 2 and 3 and converting them into a 3D model has been provided as a document in the appendix as a teacher resource (Prototype Procedure).

Building the 3D model may seem daunting to the students. Remember that many of them are familiar with building models using 2D instructions provided in 3D building sets. The fact that their sketches lack detail (or precision) shouldn’t be viewed as a hindrance. The objects they have designed exist in their imagination in surprising detail. The prototype building procedure (see appendix) can help add structure to the process of turning their vision into a 3D model.

A frustration with model making is that realism is difficult. Encourage students to understand that a model is just an abstraction, and need not have all the details of real life.

See Prototype Building Procedure in the Lesson 4 Appendix for instructions for building the model.

**EXTEND/APPLY KNOWLEDGE**

**SCIENCE**

Display the models for other students to view. Have students rate each other’s designs on their Fun Factor scales.
ASSESSMENT

Performance Tasks
Model for the Swing Set Makeover
Poster highlighting swing set features (safety, materials, accessibility) [optional]

Other Measures
Engagement in class activities and discussions.
Involvement in group work and discussions.
**INTERNET RESOURCES**

**Book:** Up, Up in a Balloon (NSTA Kids I Wonder Why Series)

**Blogging Articles**
- Blogging? It’s Elementary My Dear Watson!
- Edutopia on blogging in the classroom
- Edutopia on Elementary Blogging
- Center for Teaching Quality - Blogging Resources
  [http://www.teachingquality.org/content/blogs/bill-ferriter/blogging-resources-classroom-teachers](http://www.teachingquality.org/content/blogs/bill-ferriter/blogging-resources-classroom-teachers)
- Ten Ways to Use Your Edublog
  [http://edublogs.org/10-ways-to-use-your-edublog-to-teach/](http://edublogs.org/10-ways-to-use-your-edublog-to-teach/)

**Social Studies Map**
- Find a National Park Service Map
  [http://www.nps.gov/hfc/cfm/carto.cfm](http://www.nps.gov/hfc/cfm/carto.cfm)

**Materials of the Playground**
- Materials
APPENDIX, LESSON 4
Swing Set Makeover ---- Planning

Name___________________________  Team Name ________________

Step 1: State the problem. What are you trying to do?

Step 2: What solutions can you and your team imagine?

Step 3: What features and functionality will make your swing set fun and safe?

Step 4: Do your design documents tell the most important ideas about your proposal?

Step 5: How did it work? Could it work better?

Step 6: This is your chance to make changes! What did you change?

Step 7: What is your swing set fun factor rating?

What design features of your swing set do you want to highlight in your blog? Think about what makes it fun, safe, and appealing to your readers.

_______________________________________________________________
### Task 1
Your team’s design should achieve high Fun Factor ratings while being safe. Use the Swing Set Makeover graphic organizer to gather information for your design planning.

### Task 2
What features and functionality will make yours a winning design? Combine these ideas into a sketch and proposal that will describe what your unit will do and how it will work.

### Task 3
Use your sketch and notes to make a model of the swing set you have imagined. Your materials list helped you have everything you need!

### Task 4
Show your design documents and model to family members and fellow students. Does it convince them that your ideas for the

### Task 5
Did you get any ideas about how you could make your swing set better? Make changes to improve your model. These changes should be shown on your sketch too!

### Task 6
It’s done! Share your ideas for a swing set makeover with the public in a blog post!
Building A Prototype

The design challenge in this lesson is to build a prototype of the team’s concept for a new and improved swing set. The general steps for building this prototype are listed below. Encourage teams to photograph the project frequently as it comes together. These photos can be used later to illustrate the stages of the project for team blogs or newspapers.

1. Lay out the playground site on graph paper the same size as the construction platform (foam board or cardboard).
2. Plan the arrangement of the swing set sections (slide, swing, climber or tower) on the playground site.
3. Identify the major parts of each section of the swing set.
4. Choose materials that will be used to build the major parts.
5. Build the major parts of the swing set.
6. Assemble the major parts into the swing set model.
7. Add details and finishing touches to the model.

Encourage the teams to approach each of these steps like a mini EDP. Each step has a problem (ASK), different possible solutions (IMAGINE), a plan (PLAN), an implementation (CREATE), trial and error (TEST), refinement (IMPROVE), get feedback (SHARE). The seven prototyping steps and a possible solution for each are detailed below. Use judgment on how much of the solution to give the teams. Team devised solutions give students ownership of the project and empower them for future projects.

Problem 1. Lay Out the Playground Site

1. Fasten multiple sheets of graph paper together to make a sheet the same size as the construction platform. Make sure the sheets are cut and joined so the lines and spaces match.
2. Determine the scale as follows:
   - Count a single line of squares across the length of the graph paper. If you are using a 15”x20” board, this will be about 80.
   - Count a single line of squares down the width of the graph paper. If you are using a 15”x20” board, this will be about 60.
   - If the site is over 80 ft. long or 60 ft. wide, use 1 square = 2 ft. .
   - If the site is between 40 ft. long and 79 ft. long, use 1 square = 1 ft.
   - If the site is between 20 ft. long and 39 ft. long, use 2 square = 1 ft.
   - If the site is between 10 ft. long and 19 ft. long, use 4 square = 1 ft.
3. Sketch the site on the graph paper
4. Hot glue or double-stick tape the graph paper site drawing to the construction platform ensuring that the lines of the graph paper run parallel with edges of the platform.

Problem 2. Plan the Arrangement of the Swing Set Sections

1. On separate pieces of graph paper, draw the footprint of each section of the swing set.
   - Use the same scale as determined for the site layout.
   - The lines of the graph paper should run the same way as the main feature of the section.
2. Label and cut out the footprint drawings
3. Arrange the footprint drawings of the sections on the site layout
4. Move the footprint drawings around to find the best fit for a high Fun Factor score.
5. Ensure that there are adequate safety zones around each section. Reposition if necessary.
Problem 3. Identify the Major Parts of Each Swing Set Section

1. Make a list of the major parts of each section. These might include such things as
   - Swing unit frame, seat, chains, etc.
   - Slide deck, steps, ladder, etc.
   - Connector sides, steps, etc.
2. On separate pieces of graph paper, draw the major parts.
   - Use the same scale as determined for the site layout.
   - The lines of the graph paper should run the same way as the main feature of the part.

Problem 4. Choose Materials for Each Major Part

1. Different parts will require different materials:
   - Cardboard or clay can be used for walls and platforms.
   - Cardboard can be used for decks.
   - Straws or craft sticks can be used for beams or bars.
   - String can be used for rope or chains.
   - Pipe cleaners can be used for fittings and fasteners.
   - Glue and tape can be used for fasteners.
2. Choose the materials for each major part.

Problem 5. Build the Major Parts of the Swing Set

1. As far as possible build the different parts separately.
2. Modify the design of major parts if necessary.
3. Build the major parts, maintaining scale as indicated by the sketches from Problem 3.

Problem 6. Assemble Major Parts into the Swing Set

1. Using the arrangement determined in Problem 2, arrange the main sections in place on the construction platform.
2. Once fit is established, fasten the sections in place and assemble the sections.
3. Join the sections to each other if the swing set is intended to be a continuous unit.

Problem 7. Add Details and Finishing Touches

1. Embellish the swing set structure as desired.
2. Add a project label to the construction platform where it can be clearly seen - usually near the front edge.
   - Project Name
   - Team Name
   - Date
   - Scale
3. Add any other desired finishing touches such as shrubs, ground cover, etc.
References


