BRIDGES

Build, Research, Invent, Design, Grow and Explore through Science

Project Book

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Our Mission:

The Salvadori Center *empowers students* and teachers to unlock the math and science embedded in the structures that surround us. We inspire students and teachers to use the wonder, beauty, and logic of our *built environment* as a foundation for learning *through collaborative, hands on, project-based learning.*

Introduction

About the Salvadori Center

For more than 35 years, the Salvadori Center has made a positive impact on students in all five boroughs of New York City. Through project-based math and science curricula, Salvadori programs address grade-specific learning objectives and National Common Core Standards. Long-standing partnerships with public schools, public housing community centers, and museums enable Salvadori to reach some of our most underserved communities.

Salvadori's curricula use the built environment – buildings, bridges, and structures from the communities that surround us – to improve STEM (Science, Technology, Engineering, and Math) education for America's students. The Salvadori approach enables students to achieve academic success through a team-based, hands-on approach to personal discovery and experimentation that promotes critical thinking, evidence-based analysis, and the effective presentation of ideas.

Salvadori Educators engage students and teachers in real-world design and construction activities, beginning with the local neighborhood and expanding to architectural icons worldwide. As students unlock the wonder, logic and beauty of the built environment through fun and engaging projects, they gain a personal understanding of the practical applications of math and science concepts.

Salvadori After-School: BRIDGES

Build, Research, Invent, Design, Grow and Explore through Science (BRIDGES) is an after-school STEM program for 8- to 12-year-olds. It is underwritten by the National Science Foundation and run in partnership with the New York City Housing Authority, the Housing Authority of New Haven, and the Bridgeport Housing Authority.

BRIDGES uses the built environment - landmarks, buildings, parks, etc. - as a means for students to explore science, engineering, math, and architecture, while learning about their communities. Students participate in engaging, collaborative, and hands-on project-based learning that allows every student can succeed. BRIDGES curriculum modules are linked to grade-specific learning objectives and National Common Core Standards and assess the change in students' comprehension of math and science concepts.

Salvadori Enrichment: BRIDGES

A new program developed for STEM-based in-school residencies, Salvadori Enrichment: BRIDGES is a 12-week module designed for 8- to 12-year-olds in extended class periods. The curriculum uses the built environment - bridges, buildings, parks, etc. - as a means for students to explore science, engineering, math, and architecture, while learning about their communities. Students participate in engaging, collaborative, and hands-on project-based activities that are linked to grade-specific learning objectives and National Common Core Standards. Collaborative planning sessions allow teachers to incorporate interdisciplinary connections, while developing a deeper understanding of how to expand their instructional approach with real-world applications to the built environment.

Salvadori In-Depth: GLOBE

The Salvadori Center's GLOBE program (Guided Learning through Our Built Environment) is an innovative partnership with New York city public schools. GLOBE uses the investigation of the built world as a springboard for learning in all disciplines. Salvadori Educators work onsite mentoring teachers, modeling lessons and developing curricula targeted to student needs.

Teachers learn strategies to engage and motivate learners and transform their classrooms into active environments for critical thinking and problem solving. Their students learn geometry by constructing bridges, physics by building simple machines, and ratio and proportion by making scale models of skyscrapers. Young people become skilled at working collaboratively, writing and persuasively, and presenting their ideas effectively. They understand the real-world applications of the concepts they've mastered as they explore their communities and the importance of civic involvement.

Salvadori projects align with local and national standards and with the scope and sequence of city- and state-mandated curricula. Through GLOBE, the Center provides effective learning conditions for educational success: teacher planning sessions, a year-round presence in schools, and a thorough evaluation.

Salvadori Starter: LEAD

The Salvadori Center's LEAD (Learning through Engineering, Architecture & Design) - an exciting 8-week in-school experience - is an excellent introduction to our work. Through simple experiments, hands-on activities, and model-making projects, students explore the real-world applications of math and science concepts such as forces, measurement, scale, and geometric shapes in the built environment. Programs are designed for students in grades K through 12, and include topics such as:

- My Community
- Bridges
- Skyscrapers
- The Built Environment of Ancient Greece

Each program package includes all curriculum outlines, consumable materials, a pre-planning session with participating classroom teachers, and weekly check-in meetings.

Professional Development

Salvadori offers a variety of professional development opportunities for K-12 teachers. Workshops range from three-day Summer Institutes to customized workshops designed to meet specific School-based needs. In addition, Salvadori offers a series of graduate-level courses through the New York City Department of Education's After School Professional Development Program. Course topics include:

- Teaching Math Through the Structures Around Us
- Bridges
- Urban Planning & Design

All professional development sessions are designed to enhance teachers' ability to use hands-on, collaborative, project-based curricula to meet grade-specific learning objectives aligned with National-Common Core Standards.

Program Partners

New York City Housing Authority
(National Science Foundation)

Astoria | Long Island City, NY, 2010 - 2013
Beach 41 | Far Rockaway, NY, 2011 - 2013
Berry | Staten Island, NY, 2012 - 2013
Breevort | Brooklyn, NY, 2009 - 2013
Boulevard | Brooklyn, NY, 2012 - 2013
Butler | Bronx, NY, 2010 - 2013
Davidson | Bronx, NY, 2012 - 2013
Gun Hill | Bronx, NY, 2009 - 2013
Hammel | Far Rockaway, NY, 2009 - 2013
Highbridge | Bronx, NY, 2011 - 2013
Jackie Robinson | New York, NY, 2012 - 2013
Jacob Riis | New York, NY, 2010 - 2013
King Towers | New York, NY, 2009 - 2013
Lafayette Gardens | Brooklyn, NY, 2011 - 2013
Lehman Village | New York, NY, 2009 - 2013
Manhattanville | New York, NY, 2008 - 2013
Parkside | Bronx, NY, 2009 - 2013
Roosevelt | Brooklyn, NY, 2010 - 2013
Rutgers | New York, NY, 2011 - 2013
Sotomayor | Bronx, NY, 2008 - 2013
South Beach | Staten Island, NY, 2008 - 2013
Todt Hill | Staten Island, NY, 2012 - 2013
West Brighton | Staten Island, 2011 - 2013
Williamsburg | Brooklyn, NY, 2009 - 2013
Woodside | Woodside, NY, 2010 - 2013

Housing Authority of New Haven
(National Science Foundation)

Farnam Courts | New Haven, CT, 2013
Monterey Place | New Haven, CT, 2012
Westville Manor | New Haven, CT, 2013

Bridgeport Housing Authority
(National Science Foundation)

Gary Crooks Center | Bridgeport, CT, 2012 - 2013

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Program Partners (continued)

Sunnyside Community Services
(Time Warner Cable)

PS 150 **|** Sunnyside, NY, 2012
PS 199 **|** Sunnyside, NY, 2012

YouthBuild
(Time Warner Cable)

YouthBuild **|** New York, NY, 2012

New York City Housing Authority
(Time Warner Cable)

Mariner's Harbor **|** Staten Island, NY, 2013
Richmond Terrace **|** Staten Island, NY, 2013

Out of School Time (OST)

IS 141 **|** Astoria, NY, 2012
PS 151 **|** New York, NY, 2013

Sunnyside Community Services:
PS 150 **|** Sunnyside, NY, 2013
PS 199 **|** Sunnyside, NY, 2013

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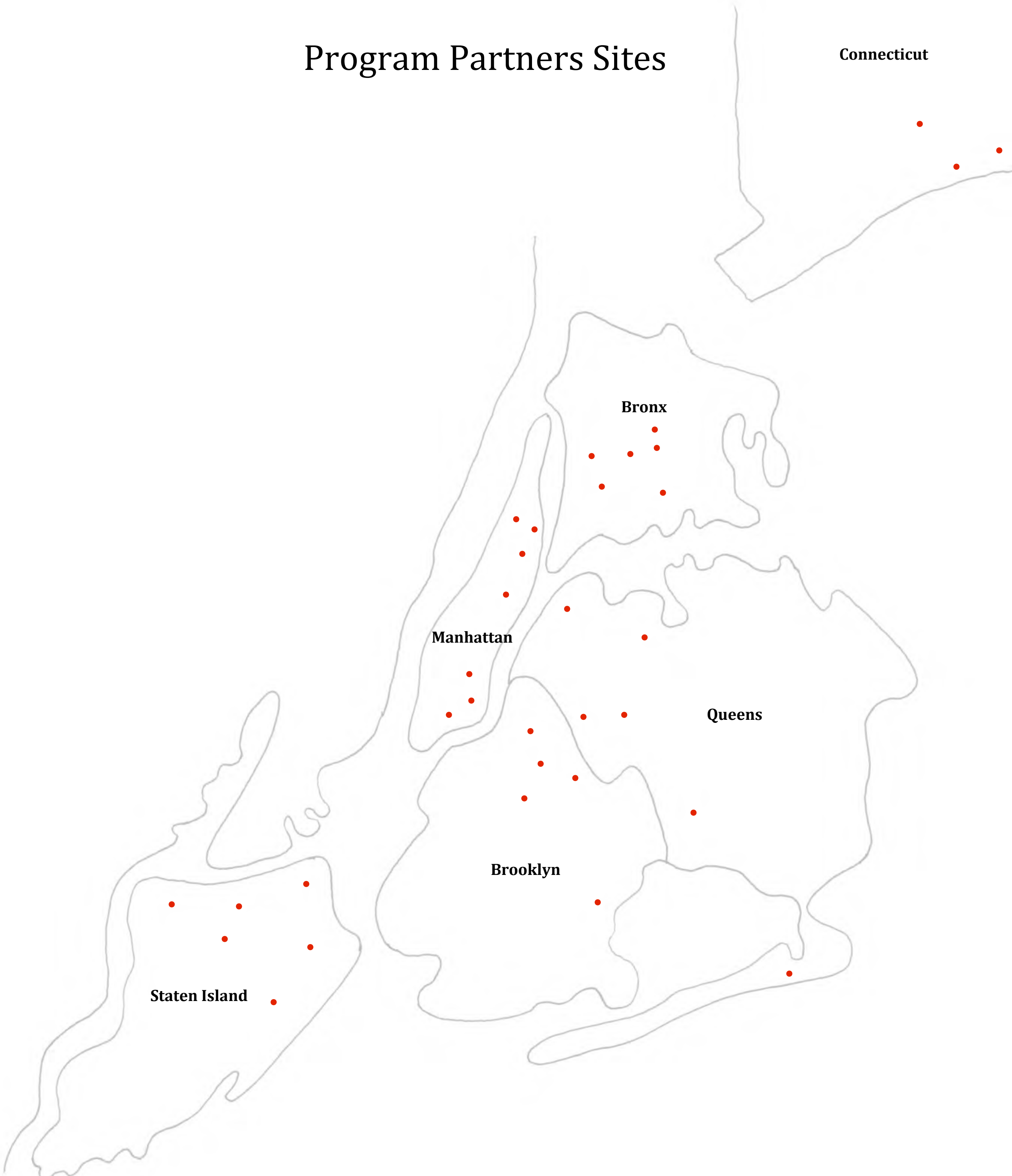
Program Partners Sites



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Skateparks

Skateparks

The *Skateparks* curriculum uses hands-on activities and design challenges to foster student learning and exploration of topics relating to skateparks - private versus public spaces, shape and form, scientific inquiry, friction, scale, energy, and materials. The curriculum consists of 12 Sessions: 8 hands-on sessions focused on background knowledge and 4 sessions dedicated to the final project: Designing a Skatepark.

The curriculum is aligned to the National Common Core Mathematics and English Language Arts Standards, and the New York State Standards for Math, Science, and Technology. The curriculum emphasizes important science and math skills including scientific inquiry, modeling and optimization, scale, measurement, and the effects of common forces.

This program was implemented in Fall 2010 and Spring 2013.

Included in this section are:

- *Skateparks* module outline
- Sample Lesson 3 of 12
- Photos

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Skateparks Module Outline

Session 1: Public Places and Spaces
Students will understand the difference between a public and private space and the importance of public spaces.

Session 2: Shapes and Forms
Students will understand how shapes can be manipulated to create various forms.

Session 3: Skatepark Science: Investigating Inclined Planes
Students will understand how the characteristics of a ramp impact forces and movement along the ramp.

Session 4: Skatepark Science: Exploring Friction and Work
Students will understand how friction impacts movement, and how scientists calculate the amount of work being done.

Session 5: Exploring Scale
Students will understand how architects use scale drawings to represent real-life objects.

Session 6: Layout and Flow
Students will understand that there are different ways of organizing space, and how this affects movement within the space.

Session 7: Mapping
Students will understand how mapping symbols and scale can be used for navigation.

Session 8: Skatepark Design and Materials
Students will learn about the different structures used in skatepark design and build them to scale.

Session 9: Introduction to the Design Challenge
Students will understand that the design process includes brainstorming, sketching, presenting their ideas to others, and incorporating the feedback of others into their final plan.

Sessions 10 and 11: Designing a Skatepark
Students will understand how to collaborate on a scale model design and presentation.

Session 12: Final Presentations
Students will understand how to conduct a collaborative oral presentation.

Name: ______________________________________

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Skateparks

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Session 3 Skatepark Science: Investigating Inclined Planes

Lesson Theme

Students will understand how the characteristics of a ramp impact forces and movement along the ramp.

Objectives	Students will be able to:

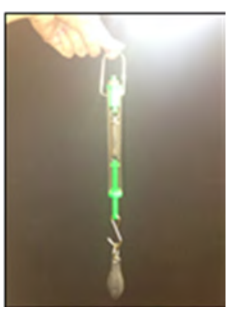
1. measure force using a spring scale
2. compare the force needed to lift a load vertically with the force needed to lift a load using an inclined plane
3. describe how the length of an inclined plane impacts the force needed to lift a load
4. design, build, and test a ramp with given materials and specifications

35 min.	Re-Cap: Measuring Force on an Inclined Plane

➢ Guiding the discussion:

Last week we learned about shapes and forms – raise your hand if you can remind us what the difference between a shape and a form is. Today we're going to learn about a three-dimensional form that is used in the design of skateparks – a ramp.

First we need to make sure everyone is familiar with the words we'll be using in our experiment today. You might even remember some of these words from other lessons we've done in BRIDGES. Does anyone remember what a force is? [a push or a pull] *In what units do we measure force?* [Newtons] *Today we're going to measure forces along a simple machine known as an inclined plane (another name for a ramp).* [Pass around pictures of inclined planes examples: stairs, slides, ladders, wheelchair ramps, truck ramps.]



Our experiment will test which requires the least amount of force to lift a load: a straight vertical distance, a long ramp, or a short ramp. In other words, does the length of a ramp impact how much force is needed?

Let's start by learning (or practicing) how to use a measurement tool called a spring scale. A spring scale measures the force of an object in Newtons – that's why there's a big N *at the top.*

Demonstrate attaching a weight onto the spring scale, then use a dry erase marker on the poster to explain how to read the measurement.

Distribute to each group a spring scale, a 2-ounce weight, and a 4-ounce weight. Have them practice measuring the force of each weight, then record their findings on the laminated spring scale poster as a check for accuracy.

Lesson Prep

✓ Post charts/pictures:
1. Salvadori Student Agreement
2. Inclined plane pictures to pass around
3. Measuring Force with a Spring Scale

✓ Calibrate spring scales to 0 Newtons

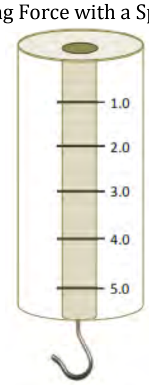
Materials

- ☐ stickers, pencils, student activity books
- ☐ chart paper, markers
- ☐ *Inclined Plane* materials (per group)
  - ☐ cardboard ramp templates (4"×24")
  - ☐ spring scale
  - ☐ 12" ruler
  - ☐ masking tape (4 pieces)
  - ☐ total of 12 ounces of weights
  - ☐ plastic baggie
- ☐ *Ramp Challenge* materials (per group)
  - ☐ scissors
  - ☐ masking tape
  - ☐ newspaper (e.g., Metro)
  - ☐ 12" ruler
  - ☐ wooden ball

Vocabulary

- ☆ ramp
- ☆ force
- ☆ Newton
- ☆ simple machine
- ☆ inclined plane
- ☆ load
- ☆ hypothesis
- ☆ conclusion
- ☆ scientific method

Measuring Force with a Spring Scale



Re-Cap (cont.)

- Have students open their activity books to *Measuring Force on an Inclined Plane*. Review the scientific method for conducting experiments, explaining that students should begin by forming a hypothesis – an educated guess – and documenting it at the top of their activity sheets before they begin.
- Distribute to each group the following materials:
  - ✓ pre-bent cardboard ramp, 12 ounces of weights, baggie
  - ✓ spring scale, 12" ruler, 4 pieces of masking tape

Activity steps: (students can divide up tasks within group)

1. Hook the baggie of weights to the spring scale and record the direct downward force of the 12-ounce weight in Newtons. [approx. $3\frac{2}{5}$ N]
2. Bend the base of the ramp under and tape it to the table. Bend the cardboard along the other fold and tape the far end to the table to form an inclined plane. *Handle with care!*
3. Use the ruler to measure the length of the ramp in inches. [16"]
4. Use the spring scale to measure the force needed *when pulling the baggie up the ramp at a steady rate*. [approx. 2 N]

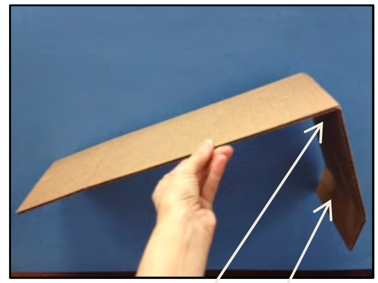
   Note that the vertical height of the ramp is also 6 inches, so the baggie of weights is being lifted to the same height as before.
5. Remove the tape from the end of the ramp, and bend the ramp completely under to form a shorter inclined plane, then tape it down. Repeat step 3 [12"] and step 4 [approx. $2\frac{1}{2}$ N].
6. Write a conclusion that answers the question in the hypothesis: *Which requires the least amount of force?* [The longer ramp requires the least amount of force.]

- Call on student volunteers to share their observations and/or what they wrote for their conclusion statement. Questions for discussion:
  - Which requires the least amount of force to "lift" the load up to a height of six inches? Why do you think that is?
  - When you lift the weight along a ramp rather than vertically, how does the force change?
  - How does the force needed on the longer ramp compare to the force needed on the shorter ramp?
- Summary: *Machines don't reduce the energy you need to move things, but they can reduce the force you need. They do this by increasing the distance through which you exert your force. There is a trade-off between force and distance: the longer the distance of the inclined plane, the less force is needed.*

10 min.	Intro to Primary Activity

- Collect the materials from the re-cap activity before moving on to the primary activity. Students may keep their rulers for the next activity.

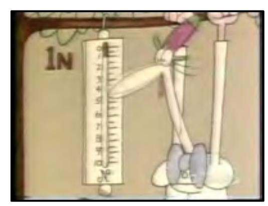
Pre-bent cardboard ramp



Bend only at the 8" and 2" marks. Students will bend the final piece during the experiment.

✪ Lesson Resource ✪

The *Eureka!* cartoons are a fun series designed to teach concepts of physical science to elementary and middle-school students. To learn more about INCLINED PLANES, Google "Eureka episode 11." [length: 4:53]



✪ Book Resource ✪

Roll, Slope, and Slide: A Book about Ramps ... From skateboard parks, to highway ramps, to ramps on moving vans, this book takes a look at the many ways we use ramps every day.

Intro to Primary Activity (cont.)

- Collect the materials from the re-cap activity before moving on to the primary activity. Students may keep their rulers for the next activity.
- Describe the challenge and the materials that will be provided:

  Now that you've seen how loads can move up a ramp, we're going to see what it takes to move a load down a ramp. You and your group must work together to construct a ramp using only newspaper and masking tape.

  The ramp must meet the following conditions:

  a) *It must be at least 10 inches high at its highest point.*
  b) *It must carry a wooden ball the entire length of the ramp without being touched after it is first released. (i.e., you cannot hold the ramp up at any point while the ball is in motion)*
  c) *It must cause the wooden ball to change direction at least once.*

  The scissors and ruler may not be used as part of the ramp. You will not receive extra paper – once you use it up, it's gone!

40 min. — **Primary Activity: Ramp Challenge**

- Distribute to each group the following materials:
  - ✓ scissors (2)
  - ✓ masking tape (about four 6" strips)
  - ✓ newspaper
  - ✓ wooden ball
- Circulate around the room to distribute additional tape as needed.
- Each group takes a turn demonstrating that their ramp meets the conditions (i.e., releasing the wooden ball and letting it finish the course), then explaining their design process to the class.

5 min. — **Wrap-up**

- In preparation for next week's experiment, ask students to pay attention in the coming week to the different types of surfaces they interact with, to look for *intentional changes* in surfaces, and to consider why those changes happen. For example:
  - ✓ why the yellow edge of a subway platform has raised bumps, while the rest of the platform is smooth tile or concrete
  - ✓ why stair treads – made of materials such as sandpaper, carpet, or rubber – are often added to staircases


Inclined Plane Examples



✪ Lesson Resource ✪

The ADA Accessibility Guidelines state that for every 1 foot in height, the ramp must be at least 12 feet long. This gives an incline ratio of 1:12. While this is the maximum incline allowed, many times it is better to double that number to 1 foot of height for 24 feet of length. This works better for elderly or weaker users.

Source: www.accessibleconstructionblog.com

Session 3 Vocabulary

Force	a push or pull exerted on an object; measured in Newtons
Newton	the unit used for measuring force
Inclined Plane	a flat surface that makes an angle with the plane of the horizon
Ramp	a sloping floor, walk, or roadway leading from one level to another
Load	any force that acts upon a structure; weight
Hypothesis	an idea or theory that is not proven but that leads to further study or discussion
Observation	the act of becoming aware of an object or event by using any of the senses to identify properties
Conclusion	a final decision reached by reasoning
Scientific Method	the rules and procedures for the pursuit of knowledge involving the finding and stating of a problem, the collection of facts through observation and experiment, and the making and testing of ideas that need to be proven right or wrong

Session 3 Standards Addressed

New York State: Math, Science, and Technology Standards

Standard 1 Analysis, Inquiry, and Design

Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions.

ENGINEERING DESIGN, ELEMENTARY: *Key Idea 1*

Engineering design is an iterative process involving modeling and optimization (finding the best solution within given constraints); this process is used to develop technological solutions to problems within given constraints.

- T1.1 Describe objects, imaginary or real, that might be modeled or made differently and suggest ways in which the objects can be changed, fixed, or improved
  - ☆ T1.1b Identify features of an object that help or hinder the performance of the object
  - ☆ T1.1c Suggest ways the object can be made differently, fixed, or improved within given constraints
- T1.3 Generate ideas for possible solutions, individually and through group activity; apply age-appropriate mathematics and science skills; evaluate the ideas and determine the best solution; and explain reasons for the choices
  - ☆ T1.3a List possible solutions, applying age-appropriate math and science skills
  - ☆ T1.3b Develop and apply criteria to evaluate possible solutions
  - ☆ T1.3c Select a solution consistent with given constraints and explain why it was chosen
- T1.4 Plan and build, under supervision, a model of the solution, using familiar materials, processes, and hand tools
- T1.5 Discuss how best to test the solution; perform the test under teacher supervision; record and portray results through numerical and graphic means; discuss orally why things worked or didn't work; and summarize results in writing, suggesting ways to make the solution better
  - ☆ T1.5a Determine a way to test the finished solution or model
  - ☆ T1.5b Perform the test and record the results, numerically and/or graphically
  - ☆ T1.5c Analyze results and suggest how to improve the solution or model, using oral, graphic, or written formats

MATHEMATICAL ANALYSIS, ELEMENTARY: *Key Idea 3*

Critical thinking skills are used in the solution of mathematical problems.

- M3.1 Explore and solve problems generated from school, home, and community situations, using concrete objects or manipulative materials when possible
  - ☆ M3.1a Use appropriate scientific tools, such as metric rulers, spring scale, pan balance, graph paper, thermometers [Fahrenheit and Celsius], graduated cylinder to solve problems about the natural world

MATHEMATICAL ANALYSIS, INTERMEDIATE: *Key Idea 3*

- M3.1 Apply mathematical knowledge to solve real-world problems and problems that arise from the investigation of mathematical ideas, using representations such as pictures, charts, and tables
  - ☆ M3.1a use appropriate scientific tools to solve problems about the natural world

Standards Addressed

SCIENTIFIC INQUIRY, ELEMENTARY: *Key Idea 1*

The central purpose of scientific inquiry is to develop explanations of natural phenomena in a continuing, creative process.

- S1.1 Ask "why" questions in attempts to seek greater understanding concerning objects and events they have observed and heard about
  - ☆ S1.1a Observe and discuss objects and events and record observations
  - ☆ S1.1b Articulate appropriate questions based on observations
- S1.2 Question the explanations they hear from others and read about, seeking clarification and comparing them with their own observations and understandings
  - ☆ S1.2a Identify similarities and differences between explanations received from others or in print and personal observations or understandings

SCIENTIFIC INQUIRY, ELEMENTARY: *Key Idea 2*

Beyond the use of reasoning and consensus, scientific inquiry involves the testing of proposed explanations involving the use of conventional techniques and procedures and usually requiring considerable ingenuity.

- S2.3 Carry out their plans for exploring phenomena through direct observation and through the use of simple instruments that permit measurement of quantities, such as length, mass, volume, temperature, and time.
  - ☆ S2.3a Use appropriate "inquiry and process skills" to collect data
  - ☆ S2.3b Record observations accurately and concisely

SCIENTIFIC INQUIRY, ELEMENTARY: *Key Idea 3*

The observations made while testing proposed explanations, when analyzed using conventional and invented methods, provide new insights into phenomena.

- S3.2 Interpret organized observations and measurements, recognizing simple patterns, sequences, and relationships
  - ☆ S3.2a State, orally and in writing, any inferences or generalizations indicated by the data collected
- S3.3 Share their findings with others and actively seek their interpretations and ideas
  - ☆ S3.3a Explain their findings to others, and actively listen to suggestions for possible interpretations and ideas
- S3.4 Adjust their explanations and understandings of objects and events based on their findings and new ideas
  - ☆ S3.4a State, orally and in writing, any inferences or generalizations indicated by the data, with appropriate modifications of their original prediction/explanation
  - ☆ S3.4b State, orally and in writing, any new questions that arise from their investigation

SCIENTIFIC INQUIRY, INTERMEDIATE: *Key Idea 3*

The observations made while testing proposed explanations, when analyzed using conventional and invented methods, provide new insights into phenomena.

- S3.2 Interpret the organized data to answer the research question or hypothesis and to gain insight into the problem.

Session 3	Standards Addressed

Standard 4 The Physical Setting

Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

PHYSICAL SETTING, ELEMENTARY, *Key Idea 5*

Energy and matter interact through forces that result in changes in motion.

- 5.1 Describe the effects of common forces (pushes and pulls) of objects, such as those caused by gravity, magnetism, and mechanical forces.
  - ☆ 5.1b The position or direction of motion of an object can be changed by pushing or pulling
  - ☆ 5.1d The amount of change in the motion of an object is affected by friction
  - ☆ 5.1f Mechanical energy may cause change in motion through the application of force and through the use of simple machines such as pulleys, levers, and inclined planes

PHYSICAL SETTING, INTERMEDIATE, *Key Idea 5*

Energy and matter interact through forces that result in changes in motion.

- 5.2 Observe, describe, and compare effects of forces (gravity, electric current, and magnetism) on the motion of objects
  - ☆ 5.2c Machines transfer mechanical energy from one object to another
  - ☆ 5.2d Friction is a force that opposes motion
  - ☆ 5.2f Machines can change the direction or amount of force, or the distance or speed of force required to do work
  - ☆ 5.2g Simple machines include a lever, a pulley, a wheel and axle, and an inclined plane. A complex machine uses a combination of interacting simple machines, e.g., a bicycle

Standard 6 Interconnectedness: Common Themes

Students will understand the relationships and common themes that connect mathematics, science, and technology and apply the themes to these and other areas of learning.

MODELS, ELEMENTARY: *Key Idea 2*

Models are simplified representations of objects, structures, or systems, used in analysis, explanation, or design.

- Analyze, construct, and operate models in order to discover attributes of the real thing
- Discover that a model of something is different from the real thing but can be used to study the real thing
- Use different types of models, such as graphs, sketches, diagrams, and maps, to represent various aspects of the real world

OPTIMIZATION, ELEMENTARY: *Key Idea 6*

In order to arrive at the best solution that meets criteria within constraints, it is often necessary to make trade-offs

- Choose the best alternative of a set of solutions under given constraints
- Explain the criteria used in selecting a solution orally and in writing

Session 3 Standards Addressed

Standard 7 Interdisciplinary Problem Solving

Students will apply the knowledge and thinking skills of mathematics, science, and technology to address real-life problems and make informed decisions.

STRATEGIES, ELEMENTARY: *Key Idea 2*

Solving interdisciplinary problems involves a variety of skills and strategies, including effective work habits; gathering and processing information; generating and analyzing ideas; realizing ideas; making connections among the common themes of mathematics, science, and technology; and presenting results.

- Working Effectively: Contributing to the work of a brainstorming group, laboratory partnership, cooperative learning group, or project team; planning procedures; identifying and managing responsibilities of team members; and staying on task, whether working alone or as part of a group
- Gather and process information
- Generate and analyze ideas
- Observe common themes
- Realize Ideas: Constructing components or models, arriving at a solution, and evaluating the result
- Present Results: Using a variety of media to present the solution and to communicate results

Common Core Standards for Mathematics

2.MD.1. Measure the length of an object by selecting and using appropriate tools such as rulers, yardsticks, meter sticks, and measuring tapes

2.MD.3. Estimate lengths using units of inches, feet, centimeters, and meters

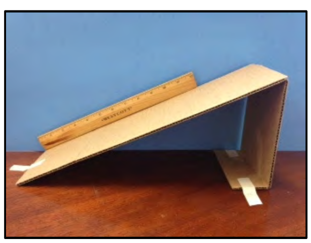
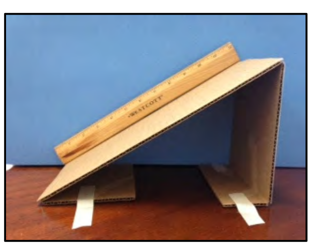
3.MD.4. Generate measurement data by measuring lengths using rulers marked with halves and fourths of an inch

Measuring Force on an Inclined Plane

Hypothesis: Which will require the least amount of force to lift the weight?

- ☐ no ramp (lifting the weight a straight vertical distance)
- ☐ a long ramp
- ☐ a short ramp

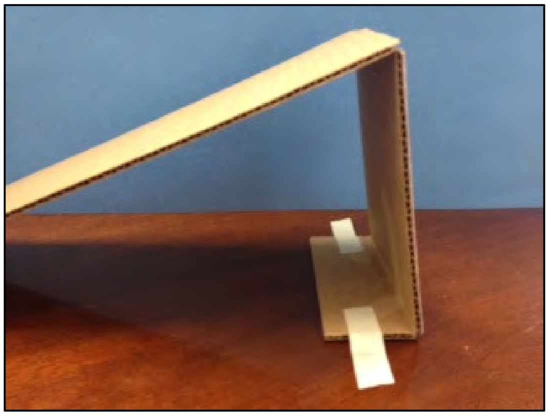
Experiment:

Method of lifting	Distance	Force (Newtons)
No ramp 	6 inches	
Long ramp 		
Short ramp 		

Conclusion: ______________________________ requires less force to lift the weight.

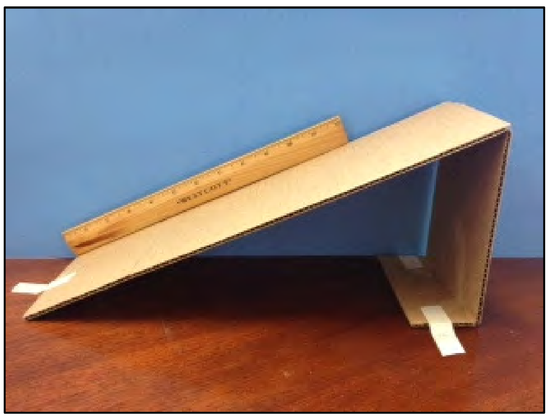
Steps: Measuring Force on an Inclined Plane

Step 1 Fold the small flap under and tape it to the table.



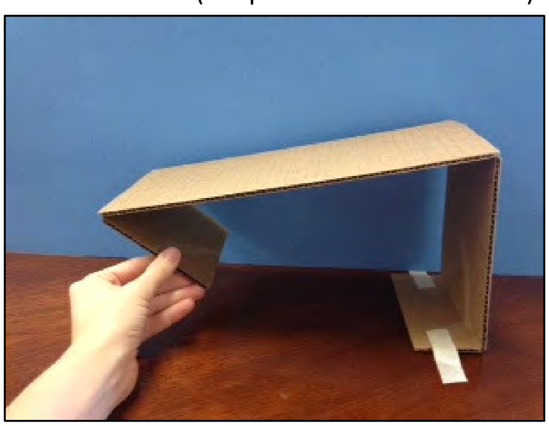
Step 2 Tape the other end to the table. (Keep the back end vertical.)

Step 3 Measure and record the length of the ramp.

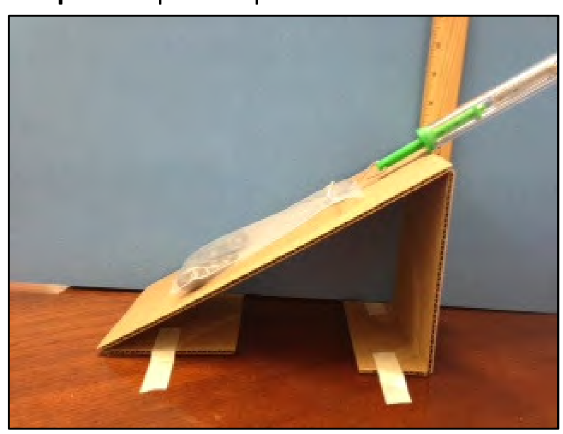


Step 4 Pull the bag of weights up the ramp at a steady rate; measure the force.

Step 5 Bend the cardboard at the dotted line; fold it under and tape it to the table. (Keep the back end vertical.)



Step 6 Repeat steps 3 and 4.



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