Riding on a Pendulum

What happens when you make a change to a pendulum?

LEVEL
Grade Four

OBJECTIVES
Students will

- recognize that when a change is made to a system by adding weight or changing length, the patterns observed may also change.
- identify variables and systematic change in the experimental process.
- apply appropriate observation and note-taking skills.
- use data collected to explain results.
- use results to make and support a plausible recommendation for playground swings.

MATERIALS AND RESOURCES
- Washers to use as weights
- String
- Timer, handheld stopwatch or online equivalent
- Meter or yard sticks at each station to measure starting position of pendulum
- Data collection sheets or science journal for each station
- Graph paper or grid

ABOUT THIS LESSON
Students will explore how the changes in the length of string or the weight of the pendulum bob impact the swing of the pendulum. Students will apply findings to a pendulum they are most familiar with – the swings on their playground or at their local park. The goal of this lesson is not for students to explain how the pendulum works but to observe the pendulums and use evidence (observation and measurement) to report their results. Students will begin to develop an understanding of the big idea: sometimes changes to a system impact how the entire system works, but not all changes impact how a system works. This activity models for students how to systematically manage changing variables for experiments. Stations will be set up to allow students to change a variable and observe and record what happens.

A writing component in this lesson is optional. You may wish to have students make notes and record observations in their science journals. A pencil and paper icon has been added to select slides indicating a writing opportunity for students.

PRIOR LEARNING
Students can use a stop watch to record time. Students can identify which number is in the middle when the results of three trials are listed from least to greatest.
STANDARDS FOR SCIENCE CONTENT
NMSI Science lessons will be aligned with the next generation of multi-state science standards that are currently in development. These standards are being developed around the anchor documents, *A Framework for K-12 Science Education*, which was produced by the National Research Council. Where applicable, the NMSI science lessons are also aligned to the Common Core Standards for Mathematical Content as well as the Common Core Literacy Standards for Science and Technical Subjects.

TARGETED STANDARDS
NEXT GENERATION SCIENCE STANDARDS

4-PS3-a. Construct an argument using evidence about the relationship between the change in motion and the change in energy of an object. [Assessment Boundary: No attempt is made to give a precise or quantitative definition of energy. Students should not be assessed on quantitative measures of change.]

REINFORCED/APPLIED STANDARDS
COMMON CORE STATE STANDARDS

W.4.2 Write informative/explanatory texts to examine a topic and convey ideas and information clearly.

W.4.2a Introduce a topic clearly and group related information in paragraphs and sections; include formatting (e.g., headings), illustrations, and multimedia when useful to aiding comprehension.

W.4.2b Develop the topic with facts, definitions, concrete details, quotations, or other information and examples related to the topic.

W.4.2c Link ideas within categories of information using words and phrases (e.g., another, for example, also, because).

W.4.2d Use precise language and domain-specific vocabulary to inform about or explain the topic.

W.4.2e Provide a concluding statement or section related to the information or explanation presented.

4.MD.2 Use the four operations to solve word problems involving distances, intervals of time, liquid volumes, masses of objects, and money, including problems involving simple fractions or decimals, and problems that require expressing measurements given in a larger unit in terms of a smaller unit. Represent measurement quantities using diagrams such as number line diagrams that feature a measurement scale.

SCIENTIFIC PRACTICES
The Next Generation Science Standards (NGSS) are designed to engage students in Scientific and Engineering Practices by using Crosscutting Concepts to deepen the students’ understanding of Disciplinary Core Ideas. NMSI has developed icons to provide a visual reference for teachers to denote which dimensions students will explore during a given lesson.
**NMSI CONTENT PROGRESSION CHART**

In the spirit of NMSI’s goal to connect mathematics across grade levels, the Content Progression Chart demonstrates how specific skills build and develop from third grade through fifth grade. Each column under a grade level lists the concepts and skills that students in that grade should master. Each row illustrates how a specific skill is developed as students advance through their mathematics standards.

<table>
<thead>
<tr>
<th>3rd Grade Skills/ Objectives</th>
<th>4th Grade Skills/Objectives</th>
<th>5th Grade Skills/ Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>3.MD.2</strong></td>
<td><strong>4.MD.2</strong></td>
<td><strong>5.MD.1</strong></td>
</tr>
<tr>
<td>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.</td>
<td>Use the four operations to solve word problems involving distances, intervals of time, liquid volumes, masses of objects, and money, including problems involving simple fractions or decimals, and problems that require expressing measurements given in a larger unit in terms of a smaller unit. Represent measurement quantities using diagrams such as number line diagrams that feature a measurement scale.</td>
<td>Convert among different-sized standard measurement units within a given measurement system (e.g., convert 5 cm to 0.05 m), and use these conversions in solving multi-step, real world problems.</td>
</tr>
</tbody>
</table>
ACCOMMODATIONS/ SCAFFOLDING SUGGESTIONS

Gifted and Talented (GT)

- Challenge gifted students to design their own experiments. Introduce students to the interactive Pendulum Lab on the University of Colorado at Boulder web site. This simulation can be run on the website or downloaded to a computer. The simulation provides students with an opportunity to change the length of the string and mass of the bob as well as compare two pendulums. The interactive lab also includes a stopwatch for student use.

English Language Learners (ELL)

- Students’ understanding increases when the teacher uses the PowerPoint that accompanies this lesson. Color coded vocabulary and visual representations help students build understanding of content specific vocabulary.
- Providing students with opportunities to work informally with materials prior to doing the labs will build background knowledge and understanding.

Special Education (Sp. Ed.)

- The activity is hands-on which allows for students of any ability to engage and to gain understanding. Teachers may elect to pair special education students with students who are good note-takers. Notes for the lab can be copied and used by both students.
- Providing students with opportunities to work informally with materials prior to doing the labs will build background knowledge and understanding.

THE FOLLOWING ARE FORMATIVE ASSESSMENTS

- Students explain why multiple trials are needed and why each trial has to be done in the same way.
- Students complete testing, measuring and data collection. The way students complete their data collections sheets can provide valuable information about student progress.

THE FOLLOWING ARE SUMMATIVE ASSESSMENTS

- Students clearly state how changing one part of a system impacts the performance of the whole system.
- Students are able to use the data collected to explain and support their results.
- Students are able to use the data collected to make a plausible recommendation.

TECHNOLOGY SUGGESTIONS

Create your own graph paper – http://incompetech.com/graphpaper/plain/

Online Stopwatch can be used to count the periods for 30 seconds – http://www.online-stopwatch.com/large-stopwatch/

Interactive Pendulum Lab – http://phet.colorado.edu/en/simulation/pendulum-lab

United Streaming – This site has a vast amount of student centered videos by grade level, subject, topic or standard. www.unitedstreaming.com

Britannica for Kids – This site has a wealth of information and interactive activities by grade level, standard and topic. http://kids.britannica.com/

PBS Kids Pendulum Games and Factoids – http://pbskids.org/zoom/games/pendulum/
REFERENCES

A Framework for K-12 Science Education – a free copy is available at http://www.nap.edu/catalog.php?record_id=13165


COMMON MISCONCEPTIONS

Students may think that

- the period of a pendulum (the time it takes for a complete cycle swinging both left and right) is determined by the weight (mass) of the pendulum bob.
- a heavier or lighter bob will swing faster.
- materials used to make the pendulum will determine the period.
- the shape of the pendulum bob will determine the period of the pendulum.
- the definition of “period” is how long a pendulum swings before stopping, instead of it being a cycle including only one swing left and one swing right.

TEACHER BACKGROUND

A pendulum is any object that hangs from a fixed point and is allowed to swing freely. The swing down of the object is caused by the pull of gravity. The swing up of the object is inertia, the tendency of an object to stay in motion. Students experience pendulums in the form of swings on the playground. They may be less familiar with pendulums on clocks. Because the swing of a pendulum is predictable, pendulums have been used to keep time. Students may enjoy learning about the old-fashioned clocks that use pendulums.

The parts of the pendulum: string and bob may be referred to as a system where the parts work together interacting as one complete whole. The bob is the weight (mass) found at the end of the string.

Students at this age find it difficult to distinguish between mass and weight. Weight will be used throughout the lesson. From the Next Generation Science Standards for grade 5 (“Boundary: At this grade level, mass and weight are not distinguished…”), teachers are given the option of using a meter stick or yard stick. While science measurements are often done using the metric system, students at this age would benefit from using the yard stick to become comfortable with tools that measure in fractional units.

Period is a common term used to describe a full swing of the pendulum. This is the movement of the pendulum from the start position to the other side and back again.

The frequency of a pendulum is the number of full swings or periods in a specific length of time. Students will be counting the periods, full swings, in 30 seconds and recording those results.

Students will vary string length to see if changing the length of the string will affect the number of periods in 30 seconds. Longer pendulums have a lower frequency than shorter pendulums. On the playground you may have observed students shortening the chains on the swing by winding them over the top bar of the swing set. Now students will be able to use scientific evidence in the form of measured data to explain why shorter swings are more fun.

If time permits, allow students to change other variables. These could include changing the weight of the bob. Changing the weight of the bob should make no change to the frequency of the pendulum. Challenge students to apply the data from their experiments to the swings on the playground.
LESSON WITH TEACHING SUGGESTIONS

PHASE I: BUILDING BACKGROUND KNOWLEDGE

1. Activate prior knowledge. Ask students what they know about pendulums. Students may not have the word “pendulum” as part of their vocabulary but may have seen pictures of clocks with pendulums. Grandfather clocks with pendulums are sometimes found in the illustration of children’s classics such as “Hickory, Dickory Dock!” A quick search for “Hickory, Dickory Dock” on the web will bring up images to share with students.

2. If using the PowerPoint, note that a tablet and pencil appears at the top right hand corner of some of the pages. This is a good opportunity to remind students to make “research” notes about pendulums.

3. Explain the parts of the pendulum: string, pendulum bob. Together these parts form a system.

4. Explain that pendulums are not just found in clocks.

5. Create a simple pendulum by tying a string to a washer and demonstrating how the weight allows the system to swing freely.

6. Ask students, “What force causes the pendulum to fall when you pull it to the side?” Students should observe that gravity causes the pendulum to fall. Students may not have the vocabulary to explain why the pendulum swings back up as well. Explain that inertia is an object’s tendency to continue what it is doing.

7. Ask students if something on their playground or at their local park allows them to be a weight that uses gravity to swing freely.

8. Students may think of swings.

9. Ask students what changes can be made to a swing that would change the way it works.

10. Students may suggest that the size of the person using the swing affects how it works.

11. Students may also suggest that the length of the chains or rope holding up the swing affects how the swing works.

12. Share the PowerPoint slide where students are wondering if changing the length of the chains on the swings would improve the way the swings work.

13. Ask students what would happen to how the swing works if the swing chain lengths were changed.

14. Students may suggest reasons why changes would make the swings better. Ask students to explain their answers to determine if they are just guessing or are basing ideas on some prior knowledge.

15. Explain that they will be working as scientists making changes to the swing or pendulum as a system to observe how the changes may affect the performance of the system.

16. Tell students that the first test will be to change the lengths of the string. Since we cannot change the actual swings, we will use a washer on a string as a substitute.

17. Explain that scientists often create models they can use for testing when they cannot change the real thing.

18. Ask students what the pendulum and the swing have in common that would make the pendulum a good model for testing. Students may note that they both swing freely on a string as both use gravity. The weight on the end is like a tire on a tire swing.
**PHASE II: SETTING UP THE TRIALS**

1. Prior to the discussion, set up multiple work stations varying the length of the string but keeping the weight of the pendulum bob constant. Washers purchased together are standard in weight. Check to confirm the weight.

2. Demonstrate how students will work with a partner to report to each station and gather test data.

3. Explain that the students can work in any order as long as they record the data in the correct section of their data collection sheet.

4. Students should count only complete swings in thirty seconds. Demonstrate for them how to count a full swing, called the “period” of a pendulum.

5. Students should start the pendulum from the same spot each time. You may want to place a marker at each testing station for students to use as a starting point. Remind students that this marker (starting from the same point each time) will keep the variable the same for every test, making this a fair test.

6. Share the data collection sheet, assign groups and if necessary, roles for group members. Roles for groups of two could be (a) timer and (b) counter, with both students as recorders. Roles for groups of three could be (a) timer, (b) counter and (c) recorder. The timer and counter could copy the recorder’s notes at the end of the trials.

**PHASE III: COMPLETING THE DATA COLLECTION**

1. Explain that students will be reporting the data from their tests to let other scientists in the building know what we discovered.

2. Ask students what they could do to show other scientists a comparison of the data for each length of string.

3. Share that a graph is a good visual tool to show results.

4. Explain that they will record one number for each of the string lengths. To do that they will find the middle number or (median) for each string length.

5. Review finding the median number with students.

**PHASE IV: CREATING THE GRAPHS**

1. Have students work together to create a label for their graph. The results of the class should be the same or nearly the same for each station. Model creating the increments and labels for string length and number of swings.

2. Have students use data from their table to graph their results.

**PHASE V: MAKING OBSERVATIONS**

1. Discuss with students the data they collected. Ask students to describe what they see when they look at the graph. What does the data tell them?

2. Based on the data, would they like to see changes made to the swings in their playground or local park? Why or why not?

**ADDITIONAL TEST SUGGESTIONS**

1. Invite students to compare how swings would work with weight changes to the pendulum bob.

2. Repeat the process used in the initial investigation.

3. Invite students to compare the number of swings when they swing higher. In this exploration students will start the pendulum from different heights finding out if swinging higher means swinging faster.

4. Repeat the process used in the initial investigation.
Students will be investigating the real world by discovering how changing the length on a swing impacts the motion of the swing.

ANSWERS

Answers for this lesson will vary. To obtain the maximum benefit of the lesson, ask students to go beyond the expected responses, using background knowledge, making other conceptual connections, or generating a new prediction to test. Students should be able to explain what the data tells them and apply the data collected to a plausible recommendation.
Riding on a Pendulum

NAME __________________________

PENDULUM DATA COLLECTION

*Use this sheet to collect data as you complete your trials.*

<table>
<thead>
<tr>
<th>Number of Swings in 30 seconds</th>
<th>Length of string</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
<th>Middle Number</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
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<tr>
<td>Station 1</td>
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<tr>
<td>Station 2</td>
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<td>Station 3</td>
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<td>Station 4</td>
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<tr>
<td>Station 5</td>
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<tr>
<td>Station 6</td>
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</tr>
</tbody>
</table>

FIND THE MIDDLE NUMBER.

List the numbers from each trial from least to greatest. Record the middle number in the Middle Number column for each situation.

ANSWER THE FOLLOWING QUESTIONS IN COMPLETE SENTENCES.

1. What change was made to the pendulum at each station?
2. Why did you complete multiple trials at each station?

3. What did you observe about the pendulum period when the string was longer?

MAKE A RECOMMENDATION

“How will the swings be different if the chains of the swings are longer?”

Answer this question using your test data
Should the length of the chains of the swing be changed?

Use the box below to create a labeled diagram of your recommendation for the swings. Below the box explain your test results and make a recommendation.
NAME __________________________________________

PENDULUM DATA COLLECTION

Use this sheet to collect data as you complete your trials.

<table>
<thead>
<tr>
<th>Station</th>
<th>Weight of Pendulum Bob</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
<th>Middle Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Station 1</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Station 2</td>
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<td>Station 3</td>
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<tr>
<td>Station 4</td>
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<tr>
<td>Station 5</td>
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<tr>
<td>Station 6</td>
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<td></td>
</tr>
</tbody>
</table>

FIND THE MIDDLE NUMBER

ANSWER THE FOLLOWING QUESTIONS IN COMPLETE SENTENCES.

List the numbers from each trial from least to greatest. Record the number in the middle in the Middle Number column above.

1. What change was made to the pendulum at each station?

2. Why did you complete multiple trials at each station?
3. What did you observe about the pendulum period when the weight (mass) was changed?

**MAKE A RECOMMENDATION**

“How will the swings be different if the weight (mass) of the student changes?”

Answer this question using your test data

Do students of different weight (mass) have the same experience on the swings?

Use the box below to draw your recommendation for the swings.
Below the box explain your test results and make a recommendation.
THE FOLLOWING ARE STATION CARDS TO REMIND STUDENTS WHAT ACTIVITY THEY ARE COMPLETING WHILE WORKING AS SCIENTISTS.

STRING LENGTH CHANGES
Elementary—Riding on a Pendulum

Station 1

**Identify Variables**
- The length of the string is your variable.
- Measure the length of the string and record the number on your data collection sheet.

**Investigate**
- The *timer* starts the stopwatch and the *counter* counts the swings.
- Count the number of full swings for 30 seconds.
- Record the number of swings on your data collection sheet.

Station 2

**Identify Variables**
- The length of the string is your variable.
- Measure the length of the string and record the number on your data collection sheet.

**Investigate**
- The *timer* starts the stopwatch and the *counter* counts the swings.
- Count the number of full swings for 30 seconds.
- Record the number of swings on your data collection sheet.
Elementary—Riding on a Pendulum

Station 3

Identify Variables

The length of the string is your variable.
Measure the length of the string and record the number on your data collection sheet.

Investigate

The timer starts the stopwatch and the counter counts the swings.
Count the number of full swings for 30 seconds.
Record the number of swings on your data collection sheet.

Station 4

Identify Variables

The length of the string is your variable.
Measure the length of the string and record the number on your data collection sheet.

Investigate

The timer starts the stopwatch and the counter counts the swings.
Count the number of full swings for 30 seconds.
Record the number of swings on your data collection sheet.
Elementary—Riding on a Pendulum

Station 5

Identify Variables

The length of the string is your variable.

Measure the length of the string and record the number on your data collection sheet.

The timer starts the stopwatch and the counter counts the swings.

Count the number of full swings for 30 seconds.

Record the number of swings on your data collection sheet.

Investigate

Station 6

Identify Variables

The length of the string is your variable.

Measure the length of the string and record the number on your data collection sheet.

The timer starts the stopwatch and the counter counts the swings.

Count the number of full swings for 30 seconds.

Record the number of swings on your data collection sheet.

Investigate
Elementary—Riding on a Pendulum

Station 7

**Identify Variables**
- The length of the string is your variable.
- Measure the length of the string and record the number on your data collection sheet.

**Investigate**
- The *timer* starts the stopwatch and the *counter* counts the swings.
- Count the number of full swings for 30 seconds.
- Record the number of swings on your data collection sheet.

Station 8

**Identify Variables**
- The length of the string is your variable.
- Measure the length of the string and record the number on your data collection sheet.

**Investigate**
- The *timer* starts the stopwatch and the *counter* counts the swings.
- Count the number of full swings for 30 seconds.
- Record the number of swings on your data collection sheet.
THE FOLLOWING ARE STATION CARDS TO REMIND STUDENTS WHAT ACTIVITY THEY ARE COMPLETING WHILE WORKING AS SCIENTISTS.

PENDULUM BOB MASS CHANGES
Station 1

Identify Variables

The weight of the pendulum bob is your variable.
Record the weight (mass) of the pendulum bob on your data collection sheet.

Investigate

The timer starts the stopwatch and the counter counts the swings.
Count the number of full swings for 30 seconds.
Record the number of swings on your data collection sheet.

Station 2

Identify Variables

The weight of the pendulum bob is your variable.
Record the weight of the pendulum bob on your data collection sheet.

Investigate

The timer starts the stopwatch and the counter counts the swings.
Count the number of full swings for 30 seconds.
Record the number of swings on your data collection sheet.
Elementary—Riding on a Pendulum

Station 3

Identify Variables

The weight of the pendulum bob is your variable.

Record the weight of the pendulum bob on your data collection sheet.

Investigate

The timer starts the stopwatch and the counter counts the swings.

Count the number of full swings for 30 seconds.

Record the number of swings on your data collection sheet.

Station 4

Identify Variables

The weight of the pendulum bob is your variable.

Record the weight of the pendulum bob on your data collection sheet.

Investigate

The timer starts the stopwatch and the counter counts the swings.

Count the number of full swings for 30 seconds.

Record the number of swings on your data collection sheet.
Elementary—Riding on a Pendulum

Station 5

Identify Variables

The weight of the pendulum bob is your variable.

Record the weight of the pendulum bob on your data collection sheet.

Investigate

The timer starts the stopwatch and the counter counts the swings.

Count the number of full swings for 30 seconds.

Record the number of swings on your data collection sheet.

Station 6

Identify Variables

The weight of the pendulum bob is your variable.

Record the weight of the pendulum bob on your data collection sheet.

Investigate

The timer starts the stopwatch and the counter counts the swings.

Count the number of full swings for 30 seconds.

Record the number of swings on your data collection sheet.
Station 7

Identify Variables

The weight of the pendulum bob is your variable.

Record the weight of the pendulum bob on your data collection sheet.

The timer starts the stopwatch and the counter counts the swings.

Count the number of full swings for 30 seconds.

Record the number of swings on your data collection sheet.

Investigate

Station 8

Identify Variables

The weight of the pendulum bob is your variable.

Record the weight of the pendulum bob on your data collection sheet.

The timer starts the stopwatch and the counter counts the swings.

Count the number of full swings for 30 seconds.

Record the number of swings on your data collection sheet.
<table>
<thead>
<tr>
<th>NAMES</th>
<th>PENDULUM EVALUATION RUBRIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student will be able to</td>
<td>Expert</td>
</tr>
<tr>
<td>Identify Variables</td>
<td>Student is able to state how the variable changed at each station affected the data collected without assistance.</td>
</tr>
<tr>
<td>Describe / Name Variable</td>
<td>Investigating</td>
</tr>
<tr>
<td>Student is able to collect data and use available research tools without assistance.</td>
<td>Student is able to collect data and use available research tools with minimal guidance and support.</td>
</tr>
<tr>
<td>Investigating</td>
<td>Evaluating</td>
</tr>
<tr>
<td>Student evaluates data and successfully identifies patterns without assistance.</td>
<td>Student evaluates data and successfully identifies patterns with minimal guidance and support.</td>
</tr>
<tr>
<td>Evaluating</td>
<td>Explaining</td>
</tr>
<tr>
<td>Student is able to defend conclusions using data collected without assistance.</td>
<td>Student is able to defend conclusions using data collected with minimal guidance and support.</td>
</tr>
<tr>
<td>Explaining</td>
<td>Share Your Findings</td>
</tr>
<tr>
<td>Students can develop a written report without assistance.</td>
<td>Students can develop a written report with minimal guidance and support.</td>
</tr>
<tr>
<td>Share Your Findings</td>
<td>Math Sills</td>
</tr>
<tr>
<td>Students can find the median and develop a graph of data without assistance.</td>
<td>Students can find the median and develop a graph of data with minimal guidance and support.</td>
</tr>
</tbody>
</table>

Comments:
Elementary—Riding on a Pendulum
Riding on a Pendulum

Working as Scientists
Experiment 1
What is a pendulum?
A pendulum is a **weight** hung from a **support** that uses **gravity** to allow the **system** to swing freely.
Where do we find pendulums?

Grandfather Clock

The pendulum in a grandfather clock swings once a second!

The pendulum is attached to weights.
The weights move when the pendulum swings.
Hands on the clock are moved by the weights.
Grandfather clocks keep accurate time.
Any other pendulums?
Students on the playground were wondering how they could improve the swings.
One student asks,

“How will the swings be different if the chains of the swings are longer?”
If the chains of the swings are longer then the swings will
_______________________________________
_______________________________________
_______________.

Record your prediction.
How will we know if there is a difference?

We can use a stopwatch and count how many swings the pendulum makes in 30 seconds.
How do we define swing?

• Is it a swing when the object moves both left and right?

Or

• Is it a swing when the object moves only one direction?

*Period of a pendulum is the completion of a swing left and a swing right.*
Station 1

Identify Variables

The length of the string is your variable.

Measure the length of the string and record the number on your data collection sheet.

Investigate

The timer starts the stopwatch and the counter counts the swings.

Count the number of swings for 30 seconds.

Record the number of swings on your data collection sheet.
We will use a table to record test data.

- The length of the string is written at each station.
- Copy the length of the string at the station into the table.
- One partner will count the number of swings.
- One partner will be the timer.

<table>
<thead>
<tr>
<th>Length of string</th>
<th>Number of Swings in 30 seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trial 1</td>
</tr>
<tr>
<td>Station 1</td>
<td></td>
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<tr>
<td>Station 6</td>
<td></td>
</tr>
</tbody>
</table>
Middle Number

Example:

<table>
<thead>
<tr>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>3</td>
<td>5</td>
</tr>
</tbody>
</table>

If the number of swings were 9, 5, 3

Then the Middle number would be 5

Because, it comes between the 9 and the 5 when we count in order

3, 5, 9

Middle number when counting

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We will use a table to record test data.

Why should we repeat the trials three times?

<table>
<thead>
<tr>
<th>Length of string</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
<th>Middle Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Station 1</td>
<td>10</td>
<td>9</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
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</table>
Calculate the Middle Number

- We may have different numbers of swings for each trial.
- We will help our reader better understand our trial results.
- We can find the number in the middle of the trials.

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<tr>
<th>Station</th>
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</table>
Working as a Scientist

- **Identify variables** – length of string
- **Investigate** – count number of swings in 30 seconds
- **Evaluate** – observe what happened
- **Explain** – what you observed
- **Share** – graph and write
### Middle *Periods* of Pendulums

(Middle *Number*)

<table>
<thead>
<tr>
<th>Length of string</th>
<th>Trial 1</th>
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</table>

### Making a graph

Graph the Middle Number of swings for each string length.
### Observations?

What pattern do you see when the length of the string increases?

<table>
<thead>
<tr>
<th>Number of Periods</th>
<th>Length of String</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td>1 2 3 4 5 6 7 8 9</td>
</tr>
</tbody>
</table>

**Middle Periods of Pendulums**

*(Middle Number)*
Make a Recommendation

Scientists will make a recommendation for the length of the swing chains.

• Draw your recommendation.

• Explain how you used the data to make your recommendation.
One student asks,

“How will the swings be different if the students are bigger or smaller?”
Record your prediction

If the students are bigger then the swings will
_______________________________________
_______________________________________
_______________________________________
____________.

You can make a prediction about bigger or smaller students!
Working as a team

Station 1

Identify Variables

- The weight of the pendulum bob is your variable.
- Record the weight of the pendulum bob on your data collection sheet.

Investigate

- The timer starts the stopwatch and the counter counts the swings.
- Count the number of swings for 30 seconds.
- Record the number of swings on your data collection sheet.
We will use a table to record test data.

- The weight of the pendulum bob is written at each station.
- Copy the weight of the pendulum bob at the station into the table.
- One partner will count the number of swings.
- One partner will be the timer.

<table>
<thead>
<tr>
<th>Station 1</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
<th>Middle Number</th>
</tr>
</thead>
<tbody>
<tr>
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Number of Swings in 30 seconds

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<th>Weight of bob</th>
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Calculate the Middle Number

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Making a graph

Graph the middle number of swings for each weight of the bob.
Middle *Periods* of Pendulums

**Middle Number**

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
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**Observations?**

What pattern do you see when the weight of the pendulum bob increases?
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