5E Integrated STEM Lesson Plan

Lesson Title: *The Pendulum and Variables*

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Topic: The pendulum and variables.
Focus Questions: What variables affect a pendulum? How can we design an experiment to test how different variables affect the period of a pendulum? How do we use the pendulum to calculate the rotation of the Earth?

Targeted Grade Level: 9th / 10th grade physics
ELLs (English Language Learners) and SLIFE (Students with Limited or Interrupted Formal Education)

Time Needed:
About four class periods of 55 minutes. (My students meet every day for almost an hour. They usually take longer to complete work due to the language barrier as ELLs.) The first class would be the *engage* and the beginning of the *explore* parts of the lesson. The second and third would be the *explore, explain,* and *elaborate* parts of the lesson. And the last day would be the *evaluate*.

Subject Integration: Science (Physics and Earth Science), Math, Literacy, Art (optional addition)

Justification:
This lesson is part of a unit about the pendulum and the how to do scientific investigations or experiments. My students are new to the country and often did not learn about independent, dependent, and control variables in an experiment. This is something they would have started in middle school. This unit bridges many of these content areas. The content is technically physics and we learn about the pendulum and a little of the history of the pendulum. Since it is a two-year course, my second year students can analyze the energy transformation and talk about kinetic and gravitational potential energy that they learned the year prior. All students will be able to talk about the motion of the pendulum. The course builds each year, but I also have to take into account that some of the students are new and might not know about energy or other concepts from the year before.

With the experiment there are connections to math. Each student has to gather data and find the average for their trials. They will then create a graph of the data using the independent and dependent variable. Making graphs is new for many of my students. The graph of their data allows them to analyze it, instead of just looking to see if the data increased or decreased. For the most basic analysis of data, I only ask them to say if it increased or decreased and what this means to them. The next step is to look at whether it is direct or indirect and then to create a graph to see if the data is linear or exponential. More advanced students will look at the equation of the graph as well. I check with the math department to see what content they are doing in order to align linear and exponential equations with them. This helps the students to decide how each aspect of the pendulum might affect the period.

Literacy is also integrated. The students have a short reading about the history of the pendulum and how Foucault showed the rotation of the Earth by using a pendulum. Having all three of these contents integrated allows for more access points for students. Some of them will understand more thru reading, some through experimenting, and others through analyzing and looking at the math.

Art is a possible extension integration. In the past I had an art teacher push into my room and we created pendulum paintings as a final project. I am unsure if I can do this on my own and especially with the probability of remote learning. The students really enjoyed created paintings in class and it was a very different experience for them. I was then able to use the paintings to decorate my classroom. If we do not do the paintings, then the final project is for each student to create their own pendulum out of objects found at home and to use it as a measure of time. They will then time themselves doing a task. (This is the final project of the unit which is not included in this lesson, but the lesson is building towards it.)

Standards:

NGSS Performance Expectations:

HS-PS3-1	**Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.** [Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.] [*Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.*]
HS-PS3-3.	**Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.*** [Clarification Statement: Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency.] [*Assessment Boundary:*

Assessment for quantitative evaluations is limited to total output for a given input. Assessment is limited to devices constructed with materials provided to students.]

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts:
Using Mathematics and Computational Thinking Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Create a computational model or simulation of a phenomenon, designed device, process, or system. **Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**PS3.A: Definitions of Energy** • At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. • Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. **PS3.B: Conservation of Energy and Energy Transfer** • Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. • Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. • Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. • The availability of energy limits what can occur in any system. **PS3.D: Energy in Chemical Processes** • Although energy cannot be destroyed, it can be converted to less useful forms—for	**Systems and System Models** • Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. **Energy and Matter** • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. - ***Connections to Nature of Science*** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science assumes the universe is a vast single system in which basic laws are consistent. ***Connections to Engineering, Technology, and Applications of Science*** **Influence of Science, Engineering and Technology on Society and the Natural World** • Modern civilization depends on major technological systems. Engineers continuously modify these technological systems by applying scientific knowledge

	example, to thermal energy in the surrounding environment. **ETS1.A: Defining and Delimiting an Engineering Problem** • *Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (secondary)*	and engineering design practices to increase benefits while decreasing costs and risks.

Common Core State Standards:

NYS Standards
Key Idea 4: Energy exists in many forms, and when these forms change energy is conserved.
4.1 Observe and describe transmission of various forms of energy.
i. describe and explain the exchange among potential energy, kinetic energy, and internal energy for simple mechanical systems, such as a pendulum, a roller coaster, a spring, a freely falling object
iv. determine the factors that affect the period of a pendulum

STANDARD 1—Analysis, Inquiry, and Design
MATHEMATICAL ANALYSIS: Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions.
Key Idea 1: Abstraction and symbolic representation are used to communicate mathematically.
M1.1 Use algebraic and geometric representations to describe and compare data.
• represent physical quantities in graphical form
• construct graphs of real-world data (scatter plots, line or curve of best fit)
Key Idea 2: Deductive and inductive reasoning are used to reach mathematical conclusions.
M2.1 Use deductive reasoning to construct and evaluate conjectures and arguments, recognizing that patterns and relationships in mathematics assist them in arriving at these conjectures and arguments.
• interpret graphs to determine the mathematical relationship between the variables
Key Idea 3: Critical thinking skills are used in the solution of mathematical problems.
M3.1 Apply algebraic and geometric concepts and skills to the solution of problems.
• explain the physical relevance of properties of a graphical representation of real-world data, e.g., slope, intercepts, area under the

curve

STANDARD 1 Analysis, Inquiry, and Design
SCIENTIFIC INQUIRY:
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.
S2.1 Devise ways of making observations to test proposed explanations.
• design an experiment to investigate the relationship between physical phenomena
S2.2 Refine research ideas through library investigations, including electronic information retrieval and reviews of the literature, and through peer feedback obtained from review and discussion.
S2.3 Develop and present proposals including formal hypotheses to test explanations; i.e., predict what should be observed under specific conditions if the explanation is true.
Key Idea 3: The observations made while testing proposed explanations, when analyzed using conventional and invented methods, provide new insights into phenomena.
S3.1 Use various means of representing and organizing observations (e.g., diagrams, tables, charts, graphs, and equations) and insightfully interpret the organized data.
• use appropriate methods to present scientific information (e.g., lab reports, posters, research papers, or multimedia presentations)

Common Core State Standards Connections:
ELA/Literacy –

SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. *(HS-PS3-1)*

Mathematics -

MP.2 Reason abstractly and quantitatively. (HS-PS3-1)

MP.4 Model with mathematics. (HS-PS3-1)

HSN.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS3-1)

HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-PS3-1)

HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS3-1)

Common Core State Standards Connections:
ELA/Literacy -

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. *(HS-PS3-3)*

Measurable Student Learning Objectives:

My school is transitioning into outcomes. This is our second year working with them and I feel like I still have a great deal to learn about them. Especially as we teach remotely, how will the outcomes change since we eliminated a lot of content in the spring. When we started the year last year my outcomes were more content driven and now they are more skills driven with the content as the means for learning the skill. The idea is to have the outcomes this year focus on the scientific method and how we create experiments. Next year the students will focus on outcomes that incorporate using the engineering design process. The outcomes below are most of the outcomes we will see for the year, but I removed *critique original design* and *paraphrase* because those outcomes are not addressed within this lesson plan. We do our outcomes on a 4-point scale and they have been modeled after the science rubrics that my students will use for their graduation projects. The students do not take regents exams, but instead have to do a graduation worthy project for each subject. These projects are usually done in 11th and 12th grade when they have a better grasp on the English language. For outcomes we do not normally fill in the rubric for *not yet* because we use that space to give individualized targeted feedback to the students to show them where exactly they need to improve to achieve a *competent* understanding of the outcome. I have found that it is easier to have the outcomes be consolidated to a single word. This way I can post a one-word outcome that is the focus for a lesson or a week.

Content Outcomes for the year

1) Contextualize
   a) Hypothesis and Question

a. Experimental Design - Variables
b. Collect Organize and Present Data
c. Analyze and interpret - math comparisons, draw conclusions, is hypothesis supported (using evidence)

Language Outcome for the year

1) Communicate information

Outcome (content)	Outstanding (O)	Good (G)	Competent (C)	Not Yet (NY)
Contextualize	I can pose and explain my own	I can write a testable research	I can write a testable research	

	individual testable research question. I can write and explain my own unique hypothesis	question. I can write a hypothesis with some scaffolds.	question with scaffolds. I can write a hypothesis with scaffolds.	
Experimental Design	I can justify the independent, dependent, and control variables.	I can define the independent, dependent, and control variables.	I can state the independent and dependent variables.	
Collect, Organize, and Present Data	I can **collect and organize** data in a self created table with no errors. Captions describe relevant information from the table. I can create a graph properly on my own with captions and descriptions of relevant and accurate information from the figures in captions.	I can **collect** data in an appropriate table with no errors. Tables are captioned. I can create a graph properly with captions, axes titles, and graph titles.	I can collect data in an appropriate table with minor errors. I can create graphs or figures of the data with minor errors	
Analyze and Interpret	I can describe relevant qualitative and quantitative patterns in the data in precise detail, calculating statistical significance of results. I can draw conclusions supported by the data and synthesis and interpret trends. I can explain whether the hypothesis was supported using the data. Ties conclusion to background research.	I can appropriately represent some relevant quantitative or qualitative patterns in the data and show calculations (mean, median and mode). I can draw conclusions that are mostly support by the data and discuss trends. I can discuss whether the hypothesis was supported by referencing the data.	I can describe some relevant patterns in the data with basic numerical information (e.g. smallest, largest, etc). I can draw conclusions that reference the data, but not explained. I can state whether the hypothesis was supported or not.	
Outcome (language)	**Outstanding (O)**	**Good (G)**	**Competent (C)**	**Not Yet (NY)**
Obtain,	COMMUNICATEs information in an	COMMUNICATEs information in	COMMUNICATEs	Does not

connect, and communicate information	accurate, accessible, and engaging manner. The entire presentation is in English. Responds to questions accurately and adds more depth to the experiment	a mostly accurate, accessible, and engaging manner. The majority of the presentation is in English. Responds to questions and adds some depth to the experiment	information in a manner that is accurate but not accessible or engaging OR communication is engaging but has many inaccuracies. Attempts to present parts of the presentation in English. Responds to questions accurately	COMMUNICATE in an accurate or accessible way. Does not try to use any English. Attempts to respond to questions, but might not respond accurately.

Nature of STEM:

This addresses the nature of science in a few of the tenants. First the investigation aspect as the students are doing hands on experiments to investigate the pendulum in a few different ways. They are also being exposed to a variety of different uses of a pendulum. Pendulums are used to show a transfer of energy, to tell time, to show the rotation of the Earth, they can be used for painting, creating designs, etc. The lesson addresses the history of the pendulum and how much we have learned from it and how it has changed our understanding of the Earth. The lesson shows that science is based on empirical evidence by how each group is gathering different evidence for the explanation. Each group is doing a version of the same experiment and by the end will do all three experiments. Each experiment is gathering a different set of data to analyze. The students are exposed to science as a human endeavor by seeing the creativity of it. This comes out more with looking at how the artists use the pendulum to create and by changing the medium (sand or paint) of art or the angle or speed of the pendulum varies the image that is produced.

Pendulums also address the nature of technology, engineering, and math. Students are exposed to the engineering design process in the pendulum experiment. We see the criteria and constraints of the design process in the space available to test a pendulum. Many of the students want to create a large pendulum with a bowling ball after watching some of the videos I share and I don’t have the space to do this. The nature of math is addressed to improve the students understanding of pendulums and how they work. They are looking at numbers and statistics of the period. The students are calculating average time and are analyzing a graph of their results. There are different levels of access depending on the students understanding, and the most basic level of understanding still allows the students to analyze the data. It shows that data can be analyzed no matter the level of math.

Engaging Context/Phenomena:

The students will watch a video (or I will create a set up depending on if we are in person or not) of a Coupled pendulum. They will be asked to make observations and predictions about the motion. Why does the second pendulum move? Why does the first pendulum stop? Make a connection to energy and conservation of energy (2nd years only). The students are used to seeing a video and making observations as I often start units or lessons this way. They are asked to write, "*I see… I think…"* on a post it.

Data Integration:

The students will be gathering their own data to analyze. They will choose what variable to test about their pendulum and then they will conduct an experiment changing only one of the variables (length of string, angle of pendulum, mass of pendulum) to see what affects the period of the pendulum. Once they have gathered the data they will create their own graph and analyze the set up. They will then share the information with the class to come to a conclusion about what variables affect the period of the pendulum. Some students will be given a piece of graph paper and asked to create their own graph and scale while newer students will be given a labeled graph and assisted in plotting the points. The students have varying levels of understanding in math and graphing.

Differentiation of Instruction:

My students are all ELLs (English Language Learners) and new arrivals to the country. Many of them are SLIFE (Students with Limited or Interrupted Formal Education) and have gaps in their education. In differentiating instruction for my students I use at least three levels which are Explorers, Builders, and Engineers. I sometimes use pre Explorers as well and translate the worksheet into a student's native language. Explorers are new to English and are exploring the language. They are learning English and know some words. Builders are building on their knowledge of English. They can help their classmates with English. Engineers (this level is added just in science class) are using more complex sentences and are learning different ways to express themselves in English. These students can be leaders in the class. The naming was taken from the English department a couple years ago in order to have the same differentiation levels in multiple subjects to enable students to self identify their level. The students are in classes with 9th and 10th graders in the same class for all subjects. They are not always separated by 9th and 10th grade with their level of English and understanding. The idea is that the 10th graders will be able to help the 9th graders in understanding English and adjusting to a new school setting and structure. I often will use 10th graders as translators for other students since I do not speak all the languages that the students do. Students work in groups for almost all activities (especially experiments). They are grouped heterogeneously by language to assist them in learning and using more English.

Real-life Connection:

One of the harder things for the unit on the pendulum is the real world connection. In past years we have had an art teacher that works with us throughout the year and we have created pendulum paintings, this was a really great activity for the students. Another connection is the Foucault pendulum and how it proved the rotation of the Earth. This unit is a great way to incorporate ideas about energy from the year before and is used to teach about the scientific method and variables.

Possible Misconceptions:

Students think that the mass and the angle of the pendulum will affect the period. One way to teach this is to have each student do all three of the experiments to show that only the length of string will affect the period. It is hard for the students to understand that without air resistance a pendulum would keep moving. They struggle to comprehend something that they cannot see. Gravity and air resistance are both hard concepts for them to understand. I have found videos of a bowling ball and a feather dropped in a vacuum to help dispel this idea, but students tend to think that it isn't real.

Lesson Procedure:

5E Model	5E Objectives
Engage	**Procedure:** Introduce the coupled pendulum either by video or by creating one in the classroom. (This depends on what the school year will look like and if it is remote.) Show the set up and ask the students to write on a post it "*I see… I think…"* , they are familiar with this as a **Do Now**. Show the demo and have them fill out their thoughts and place their post its on the board (if in class) or in the chat in a zoom class. **Modifications:** See *differentiation of instruction* section above. **Standards Addressed:** STANDARD 1—Analysis, Inquiry, and Design MATHEMATICAL ANALYSIS: Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions.

	Formative/Summative Assessments: For this section of the lesson it is just a small check for understanding done on a post it. All the students write their answers and I can assess what each student knows. **Resources:** Coupled pendulum
Explore	**Procedure:** Ask the students, "What do you think will affect a pendulum's motion?" and elicit their thoughts and ideas. Do not correct them, but ask them to explain why they think this. Write the ideas up on the board. Have each group choose one of the variables that the class came up with to test in an experiment. If they choose a variable besides the length of string, angle of string, or mass of pendulum then they will use this worksheet. It does not have as many scaffolds in place as the other experiments do. **Modifications:** See *differentiation of instruction* section above. **Standards Addressed:** **HS-PS3-3.** **Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.*** [Clarification Statement: Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency.] [*Assessment Boundary: Assessment for quantitative evaluations is limited to total output for a given input. Assessment is limited to devices constructed with materials provided to students.*] **Formative/Summative Assessments:** In this part of the lesson the students will be doing an experiment and gathering data. Teacher circulates the room and checks in with groups as they work to help clarify. **Resources:** These are the worksheets by level for the experiments. Each link has the three different experiment

	worksheets within them so that the student can choose which one they will need. If the experiment needs to be done in remote learning then they students can use this phet simulation to do the experiments. It is also hyper linked on the worksheet in the experiment section. As the students are working they will also have at their table a copy of the science writing tools to help them with sentence structures and writing. Explorers worksheets Builders worksheets Engineers worksheets
Explain	**Procedure:** The students will be analyzing their data and writing about their findings. Each group will have a mini lesson with the teacher as they go over what they have found. **Modifications:** See *differentiation of instruction* section above. **Standards Addressed:** **HS-PS3-1** **Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.** [Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.] [*Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.*] STANDARD 1—Analysis, Inquiry, and Design MATHEMATICAL ANALYSIS: Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions. *Key Idea 1*: Abstraction and symbolic representation are used to communicate mathematically. M1.1 Use algebraic and geometric representations to describe and compare data. • represent physical quantities in graphical form • construct graphs of real-world data (scatter plots, line or curve of best fit) *Key Idea 2*: Deductive and inductive reasoning are used to reach mathematical conclusions. M2.1 Use deductive reasoning to construct and evaluate conjectures and arguments, recognizing that patterns and relationships in mathematics assist them in arriving at these conjectures and arguments.

	• interpret graphs to determine the mathematical relationship between the variables *Key Idea 3*: Critical thinking skills are used in the solution of mathematical problems. M3.1 Apply algebraic and geometric concepts and skills to the solution of problems. • explain the physical relevance of properties of a graphical representation of real-world data, e.g., slope, intercepts, area under the curve STANDARD 1 Analysis, Inquiry, and Design SCIENTIFIC INQUIRY: *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. S2.1 Devise ways of making observations to test proposed explanations. • design an experiment to investigate the relationship between physical phenomena S2.2 Refine research ideas through library investigations, including electronic information retrieval and reviews of the literature, and through peer feedback obtained from review and discussion. S2.3 Develop and present proposals including formal hypotheses to test explanations; i.e., predict what should be observed under specific conditions if the explanation is true. *Key Idea 3*: The observations made while testing proposed explanations, when analyzed using conventional and invented methods, provide new insights into phenomena. S3.1 Use various means of representing and organizing observations (e.g., diagrams, tables, charts, graphs, and equations) and insightfully interpret the organized data. • use appropriate methods to present scientific information (e.g., lab reports, posters, research papers, or multimedia presentations) **MP.4** Model with mathematics. (HS-PS3-1) **Formative/Summative Assessments:** Each student will analyze their data and be prepared to present it the following day in class. **Resources:** The students will continue to use the science writing tools to write about their findings.
Elaborate **My idea of this section**	**Procedure:** The students watch the Jimmy Neutron Pendulum video and make observations about it. They then will do a reading about the history of the pendulum and the Foucault pendulum. There are a few follow up questions to the text.

is going beyond what we did in class and not all students will get to it. These are additional ideas for them to explore.	**Modifications:** See *differentiation of instruction* section above. **Standards Addressed:** **SL.11-12.5** Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. *(HS-PS3-1)* *ELA/Literacy -* **WHST.9-12.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. *(HS-PS3-3)* **Formative/Summative Assessments:** The students are evaluated on *paraphrasing* **Resources:** These are three interesting videos about pendulums and art that the students can watch on their own time. They can be given as homework after the third day. I included them because I find them engaging and a different way to look at the pendulum. (Pendulums swinging and walk through, Pendulum drawing machine, Sand art pendulum) worksheet
Evaluate	**Procedure:** Students will share their findings from their experiments to the class. Teacher (or a student) will facilitate a discussion. Each group will get a mini whiteboard to write up their results and findings to share with the class. They will explain their experiment, the data that they found, and their analysis. The students will l be able to ask questions of each other for clarification. By the end of the share out each student should understand that the length of the string is the only variable that will affect the period of a pendulum. **Modifications:** See *differentiation of instruction* section above. **Standards Addressed:**

	Key Idea 4: Energy exists in many forms, and when these forms change energy is conserved. 4.1 Observe and describe transmission of various forms of energy. i. describe and explain the exchange among potential energy, kinetic energy, and internal energy for simple mechanical systems, such as a pendulum, a roller coaster, a spring, a freely falling object iv. determine the factors that affect the period of a pendulum STANDARD 1—Analysis, Inquiry, and Design MATHEMATICAL ANALYSIS: Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions. *Key Idea 1*: Abstraction and symbolic representation are used to communicate mathematically. M1.1 Use algebraic and geometric representations to describe and compare data. **Formative/Summative Assessments:** I will use the rubric listed above to evaluate the students on different outcomes (my school is shifting to outcomes which started last year). I would evaluate them on *contextualize (hypothesis and question), experimental design, collect organize and present data, analyze and interpret,* and *communicate information* outcomes from the rubric. The first four outcomes come from the experiment and the last one comes from the discussion day. **Resources:** This will be a discussion and the students will not have their own worksheet for it. Each table has a copy of the science discussion stems. They will be taking notes and will use discussion stems to talk about what they learned.

<u>Teacher Background:</u>

The students will need to know how to write a hypothesis. They will need to understand the difference between an independent, dependent, and control variable in order to do the experiments. This is something I would weave in as they prepare each experiment. The students will need to know how to calculate average if they do not already. Calculating the average, I usually teach each group as a mini lesson, or I go over it with a few advanced students in the class and have them teach it to their groups. They will need to know how to create and label a graph. Depending on the students, some of them I will give the scale of the graph (I went over this in the *justification* section at the beginning). The worksheets and simulations are all linked within the lesson plan. This could be done in a shorter amount of time and the students can be pushed more in different areas; it really depends on the students. This is created for my specific population of students where I teach.