Project-Based Inquiry Science: Energy
Storyline

Targeted Performance Expectations:
· MS–PS1–2 · MS-PS1-4 · MS–PS1–6 · MS–PS2–3 · MS–PS2–5 · MS–PS3–1 · MS–PS3–2 · MS–PS3–4 · MS–PS3–5 · MS–PS4–2 · MS–ESS3–1 · MS–ETS1–1 · MS–ETS1–2 · MS–ETS1–3 · MS–ETS1–4

Energy: What's the Big Challenge?
Design a Rube Goldberg Machine to Turn Off a Light

Storyline (with Disciplinary Core Ideas and Science Content)	Science and Engineering Practices	Crosscutting Concepts
In the *Introduction* to *Energy*, students begin by thinking about energy in order to address the *Big Challenge: Design a Rube Goldberg machine to turn off a light.* In the first step, they learn language for talking with each other about energy and work. They then consider multiple ways that people transform energy to serve their needs. They read about Rube Goldberg and learn about Rube Goldberg-like devices. They document and evaluate their current knowledge of energy and several everyday ways they see energy causing changes. They share their ideas with each other. After watching several examples of Rube Goldberg videos, students select their favorite parts and identify additional energy transfers with in the machines. Students work individually and in small groups to explore, observe, and record changes that are within Rube Goldberg drawings they will return to multiple times within the unit as they become experts at identifying energy transfers within the machines. After reading the specific requirements of their Rube Goldberg-like device for the final challenge, they create a criteria and constraints table as a class and work in small groups to begin to think about how they might start building their own Rube Goldberg devices, keeping in mind the criteria and constraints of the challenge. They then create the *Energy Project Board*, including questions they would like to investigate to help answer the *Big Challenge*. **Disciplinary Core Ideas:** **ETS1.A: Defining and Delimiting Engineering Problems** · The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. (MS-ETS1-1)	**Asking Questions and Defining Problems** (questions regarding energy and energy uses are gathered for work throughout the unit)	Unit Level: **Energy** Section Level: **Cause and Effect** **Stability and Change**

Energy: Learning Set 1
What is Energy?

Storyline (with Disciplinary Core Ideas and Science Content)	Science and Engineering Practices	Crosscutting Concepts
Introduction to *Learning Set 1*: In *Learning Set 1*, students explore the idea that "indicators" that they can observe and measure can identify changes in energy.	**Asking Questions and Defining Problems** (questions regarding energy and energy uses are gathered for work throughout the unit) **Analyzing and Interpreting Data** (trends in observational data begin to point to indicators of energy)	Unit Level: **Energy**
Section 1.1: Students work in small groups and as a class to identify indicators of energy change using a radiometer as an anchoring event, students look for indicators that energy is causing a change. They then read about energy changes in the radiometer. They look for patterns in others' ideas and update the *Project Board* with new ideas, thoughts and questions.		Unit Level: **Energy**

Section 1.2: Students begin with a common experience with an everyday object - a toaster - that includes many different types of energy changes that are identified by indicators such as heat and color change. Using this experience, students update their current understanding/definition of energy. They then read about several different types of energy and the indicators for these energy types. They then use additional everyday objects that represent different types of energy to identify the indicators of each type of energy. **Disciplinary Core Ideas:** **PS3.B: Conservation of Energy and Energy Transfer** · Energy is spontaneously transferred out of hotter regions or objects and into colder ones. (MS-PS3-3)	**Planning and Carrying Out Investigations** (investigation of a toaster and changes it creates are linked to indicators of energy)	Unit Level: **Energy**
Back to the Big Challenge: As they complete the first *Learning Set*, student groups return to their Rube Goldberg drawings and identify indicators that energy is being transformed. They add these transformations to their recorded data and discuss the indicators of the transformation. They then share these ideas with the class so that others can see examples from their drawing. Student groups then begin the planning for their Rube Goldberg-device that is the final project design challenge of the unit. They start by identifying the criteria for success of the device as described in the project description. Then they identify and design ideas for the final step of their device and consider how work and energy are going to be critical to the design. They read a short section on energy conservation and fossil fuels. These themes will then be part of the text throughout the *Energy* unit. **Disciplinary Core Ideas:** **ETS1.A: Defining and Delimiting Engineering Problems** · The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. (MS-ETS1-1) **ETS1.B: Developing Possible Solutions** · A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4) · There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3) · Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3) **ESS3.C: Human Impacts on Earth Systems** · Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. (MS-ESS3-3),(MS-ESS3-4)	**Asking Questions and Defining Problems** (questions regarding energy and energy uses are gathered for work throughout the unit)	Unit Level: **Energy**

Energy: Learning Set 2
What Affects How Much Energy an Object Has?

Storyline (with Disciplinary Core Ideas and Science Content)	Science and Engineering Practices	Crosscutting Concepts
Introduction to *Learning Set 2*: To begin, students are introduced to the idea that varying certain "factors" might change the amount of energy an object has and that these factors affect how much energy an object has. This builds on the idea of indicators introduced in *Learning Set 1*. *Section 2.1:* As they begin to investigate this idea, they investigate with three toys and explore and record the kinetic energy indicators of motion and factors that affect the motion. They share their ideas with each other and then read about kinetic energy. In the reading students learn more about potential energy, elastic potential energy and gravitational potential energy as they begin to differentiate between kinetic energy and potential energy. Evaluating their current thinking from the exploration with the ideas obtained in the reading. After synthesizing their reading by making connections to the toys they explored, students update the *Project Board* adding their initial understanding of potential and kinetic energy indicators and factors. **Disciplinary Core Ideas:** **PS3.A: Definitions of Energy** · Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed. (MS-PS3-1)	**Planning and Carrying Out Investigations** (investigations of toys provides additional evidence for indicators of energy and builds the idea of factors) **Asking Questions and Defining Problems** (questions regarding energy and energy uses are gathered for work throughout the unit) **Analyzing and Interpreting Data** (observational data collected and interpreted to help identify factors related to energy)	Unit Level: **Energy**
Section 2.2: Now that students can use the idea of factors to identify quantities of energy, they begin by discussing in small groups and then sharing with the class, what factors they think affect the amount of kinetic energy an object has. They then explore three different demonstrations related to collisions with various masses and the amount of energy in the collisions. Using their currently held ideas about factors, students observe the changes in clay when impacted by various masses. Students analyze the data from the investigations to help them identify the factors that affect the amount of kinetic energy. They then share their evidence in small groups and in the whole class and begin to identify the relationship between mass and energy, and define mass as a "factor" determining the amount of energy. As they move into the next sections of the unit, students are asked to begin recording their learning of indicators and factors of energy. They read about play pumps - water pumps connected to playground equipment - and identify the factors that affect the amount of pumping. **Disciplinary Core Ideas:** **PS3.A: Definitions of Energy** · Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed. (MS-PS3-1)	**Planning and Carrying Out Investigations** (investigations identify mass as a factor of kinetic energy) **Analyzing and Interpreting Data** (analyzed data connects mass to kinetic energy) **Obtaining, Evaluating, and Communicating Information** (reading about PlayPumps connects kinetic energy to everyday phenomenon)	Unit Level: **Energy**

Section 2.3: Students have seen energy transfers in the previous demonstrations and have identified that mass is a factor. Now they begin to scientifically define work through multiple scaffolded investigations. In the first, students observe, quantify, and record the motion created by various spheres of the same size and then through reflection begin to make connections between the outcome of the investigation and the scientific understanding of "work." Through reading they begin to develop the connection between work and kinetic energy. **Disciplinary Core Ideas:** **PS3.C: Relationship Between Energy and Forces** · When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object. (MS-PS3-2)	**Asking Questions and Defining Problems** (regarding the relationship between factors and indicators of kinetic energy) **Developing and Using Models** (using a physical model, students develop an understanding of kinetic energy) **Planning and Carrying Out Investigations** (use the physical model and a series of investigations to understand motion) **Analyzing and Interpreting Data** (interpret data to connect mass with motion) **Obtaining, Evaluating, and Communicating Information** (read about the connections between kinetic energy and work)	Unit Level: **Energy** Section Level: **Systems and System Models**
Section 2.4: Returning to the toys they explored earlier in the unit, students use them as examples to obtain information about gravitational and elastic potential energy. They are then introduced to the academic language they can use to discuss these ideas and answer questions about these two forms of potential energy. They add their developing understanding to the *Project Board*. **Disciplinary Core Ideas:** **PS3.A: Definitions of Energy** · A system of objects may also contain stored (potential) energy, depending on their relative positions. (MS-PS3-2)	**Asking Questions and Defining Problems** (updating the *Project Board*) **Obtaining, Evaluating, and Communicating Information** (obtain information about how elastic and gravitational potential energy is stored and about conservation of mechanical energy)	Unit Level: **Energy** Section Level: **Cause and Effect** **Systems and System Models**

Section 2.5: Focusing now on gravitational potential energy, students observe several demonstrations. In the first they define the problem of identifying the factors of gravitational potential energy and the relationship between gravitational potential energy and kinetic energy. Students then select factors to investigate and plan and carry out an investigation to identify how the factors are related. They share their designs with other groups and revise their plans based on feedback. In their small groups, students analyze their collected data and look for trends in the data that help them explain the relationship between gravitational potential energy and kinetic energy. Results are shared with the whole class through presentations and students reflect on the data from all the groups. Students return to the Rube Goldberg drawings and identify potential energy and how it can be changed. They also update the energy types chart they have been keeping throughout the unit. Students read about hydropower and see the application of the transfer from gravitational potential energy to kinetic energy. They then add their new understanding, supported by evidence, to the *Project Board*. **Disciplinary Core Ideas:** **PS3.A: Definitions of Energy** · A system of objects may also contain stored (potential) energy, depending on their relative positions. (MS-PS3-2) **PS3.C: Relationship Between Energy and Forces** · When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object. (MS-PS3-2)	**Asking Questions and Defining Problems** (updating the *Project Board*) **Planning and Carrying Out Investigations** (design an experiment to determine the factors that could affect the potential energy of a marble) **Analyzing and Interpreting Data** (analyze data by creating a graph to look for trends) **Using Mathematics, Information and Computer Technology, and Computational Thinking** (create a graph that represents the data collected in the investigation) **Engaging in Argument from Evidence** (communicating results to the class providing the question being answered, the independent variable, procedures, data, description of the trend, and a claim about what was learned) **Obtaining, Evaluating, and Communicating Information** (sharing their plan with their classmates during a *Plan Briefing*. Groups revise their investigations based on class input)	Unit Level: **Energy** Section Level: **Cause and Effect** **Scale, Proportion, and Quantity**
Section 2.6: Students now look for factors and indicators of elastic potential energy and kinetic energy. They share ideas and scaffold a plan for a project through communicating with each other. They return to their group Rube Goldberg drawing and find examples of elastic potential energy. Now that they have explored elastic potential energy in a couple ways, they read about elasticity and then explore and elaborate on these ideas through questions and discussion, thinking about the application of elastic potential energy with everyday objects. To complete the section, they add their understanding and evidence to the *Project Board*. **Disciplinary Core Ideas:** **PS3.A: Definitions of Energy** · Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed. (MS-PS3-1) · A system of objects may also contain stored (potential) energy, depending on their relative positions. (MS-PS3-2)	**Asking Questions and Defining Problems** (updating the *Project Board*) **Engaging in Argument from Evidence** (results are communicated with the class, including a claim about what was learned) **Obtaining, Evaluating, and Communicating Information** (students share their plans with the class)	Unit Level: **Energy** Section Level: **Cause and Effect**

Back to the Big Question: Students update and share they description of energy they began creating in *Learning Set 1*. As they make these changes public, they track how their ideas are changing over time. They share their ideas with the class and then use all the class ideas to add steps to their Rube Goldberg design to include kinetic energy. As they share their design with the class, students identify how much kinetic energy they will have in their steps, how the moving part gains kinetic energy, and how the amount of kinetic energy can be controlled. Students then discuss their ideas and add them to the *Project Board.* **Disciplinary Core Ideas:** **ETS1.A: Defining and Delimiting Engineering Problems** · The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. (MS-ETS1-1) **ETS1.B: Developing Possible Solutions** · A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4) · There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3) · Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3)	**Asking Questions and Defining Problems** (updating the *Project Board*) **Engaging in Argument from Evidence** (Rube Goldberg machines are revised based on investigations, data analysis) **Obtaining, Evaluating, and Communicating Information** (student identify different types of energy, how they know it is present, and the factors that determine how much energy is there. They share their ideas with the class)	Unit Level: **Energy**

Energy: Learning Set 3
What are Thermal Energy and Chemical Energy?

Storyline (with Disciplinary Core Ideas and Science Content)	Science and Engineering Practices	Crosscutting Concepts
Section 3.1: Students begin by considering the indicators and factors of thermal and chemical energy. In the introduction to the unit, students investigated the types of energy in a toaster. They now return to this anchoring event and search for factors and indicators of thermal and chemical energy. The class then explores a hand warmer as a phenomenon that combines both chemical and thermal energy. They collect some data and then, through scaffolded questions, analyze the data and share the results. After reading more about the reaction that activates the hand warmer and how chemical and thermal energy work, students reflect on their Rube Goldberg cartoon and then update the *Project Board.* **Disciplinary Core Ideas:** **PS1.B: Chemical Reactions** · Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS-PS1-2),(MS-PS1-3),(MS-PS1-5) **PS3.A: Definitions of Energy** · Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. (MS-PS3-3),(MS-PS3-4)	**Asking Questions and Defining Problems** (updating the *Project Board*) **Developing and Using Models** (exploring chemical and thermal energy using a hand warmer) **Constructing Explanations and Designing Solutions** (reviewing previous investigations to construct a theory about the indicators of thermal and chemical energy) **Obtaining, Evaluating, and Communicating Information** (obtaining information about how hand warmers work and sharing their ideas with the group)	Unit Level: **Energy** Section Level: **Patterns** **Cause and Effect**

Section 3.2: Having investigated indicators of thermal energy, students now find more factors. In small groups they complete one of two experiments that vary temperature and volume. Using provided procedures they explore to find the effect of mass and temperature on thermal energy. After creating a graph of the data, comparing the graphs from the two experiments, and sharing their ideas, students read about the factors that affect how much thermal energy an object has. They then use this information, in combination with their experiment, and revise their energy types page. **Disciplinary Core Ideas:** **PS3.A: Definitions of Energy** · Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. (MS-PS3-3),(MS-PS3-4) · Energy is spontaneously transferred out of hotter regions or objects and into colder ones. (MS-PS3-3)	**Analyzing and Interpreting Data** (after conducting experiments that vary temperature and volume, collected data is graphed and analyzed) **Using Mathematics, Information and Computer Technology, and Computationa Thinking** (measuring time and temperature in investigations. These variables are graphed) **Obtaining, Evaluating, and Communicating Information** (prepare and present the results of the investigationsto the class)	Unit Level: **Energy** Section Level: **Cause and Effect** **Scale, Proportion, and Quantity** **Stability and Change**
Section 3.3: As they learn more about the factors and indicators of thermal energy, the connection to temperature because apparent. Students begin by exploring temperature through a mental model - drawing on their knowledge of kinetic energy and applying it to motion at the microscopic level. They analyze the data from the model and discuss how the model represents temperature. They then connect the model to the investigations they completed in *Section 3.2*. Students then obtain information about temperature through a reading, building on their understanding of thermal energy from the marbles example. They reflect on the reading and apply their understanding to everyday examples and share their ideas. **Disciplinary Core Ideas:** **PS1.A: Structure and Properties of Matter** · Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. (MS-PS1-4) · In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations. (MS-PS1-4) · Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals). (MS-PS1-1) · The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter. (MS-PS1-4) **PS3.A: Definitions of Energy** · Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. (MS-PS3-3),(MS-PS3-4) · Energy is spontaneously transferred out of hotter regions or objects and into colder ones. (MS-PS3-3)	**Developing and Using Models** (use of a thought experiment to model the relationship between temperature and energy) **Analyzing and Interpreting Data** (use of provided data to draw conclusions about average speed and total speed) **Using Mathematics, Information and Computer Technology, and Computational Thinking** (obtain additonal information about temperature and thermal energy)	Unit Level: **Energy** Section Level: **Patterns** **Cause and Effect** **Structure and Function**

Section 3.4: Building on their current understanding of thermal energy, students obtain additional information from a science reading. They begin to understand specific heat and ways to compare the thermal energy of different materials. They then make a connection between specific heat and the climate of regions where water and land interact. They then explore the previous investigations from *Section 3.2* as they apply conduction, convection, and radiation as ways thermal energy moves between materials. Students read and then reflect on the reading. To complete the connections with thermal energy, students read about thermal energy from the earth and from the Sun. They then add their developing understanding to the *Project Board*. **Disciplinary Core Ideas:** **PS3.A: Definitions of Energy** · Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. (MS-PS3-3),(MS-PS3-4) **PS3.B: Conservation of Energy and Energy Transfer** · The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment. (MS-PS3-4) · Energy is spontaneously transferred out of hotter regions or objects and into colder ones. (MS-PS3-3) **ESS2.D: Weather and Climate** · The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents. (MS-ESS2-6) **ESS3.A: Natural Resources** · Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes. (MS-ESS3-1)	**Asking Questions and Defining Problems** (updating the *Project Board*) **Obtaining, Evaluating, and Communicating Information** (obtain information about thermal energy as it relates to different materials, specific heat, and the three types of energy transfer)	Unit Level: **Energy** Section Level: **Patterns**
Section 3.5: Chemical energy is introduced as students begin to consider the indicators of chemical energy. Students complete several investigations with simple home materials (vinegar and baking soda, vinegar copper and salt, vinegar salt and other metals, and antacid) to determine some of the indicators of chemical energy and reactions that occur over various timescales. Students analyze the data for changing in heat, light or sound as indicators of chemical energy and then compare those indicators to kinetic or potential energy indicators. They share their small group results with the class and look for trends. They then read about chemical energy indicators in different applications and apply their current understanding to these instances. Students complete the section by adding their understanding to the *Project Board*. **Disciplinary Core Ideas:** **PS1.B: Chemical Reactions** · Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS-PS1-2),(MS-PS1-3),(MS-PS1-5) · Some chemical reactions release energy, others store energy. (MS-PS1-6)	**Asking Questions and Defining Problems** (updating the *Project Board*) **Analyzing and Interpreting Data** (observational data about reactions and temperature changes are analyzed) **Using Mathematics, Informational and Computer Technology, and Computational Thinking** (the amounts of vinegar, baking soda, salt, and antacids used in the investigations are measured) **Obtaining, Evaluating, and Communicating Information** (results are presented to the class, additional information about the indicators of chemical reactions is obtained)	Unit Level: **Energy** Section Level: **Patterns**

Section 3.6: Following the same format as before, students now investigate factors that affect how much chemical energy a substance has. Building on what they have learned about the chemical reaction of antacids in *Section 3.5*, students follow an experimental procedure, vary the quantity of antacid in a reaction and measure the differences in energy that is released. As they analyze their results through graphs, they share their results with others and then read additional information about chemical energy and reactions at the molecular and atomic level. They also link this to combustion as one type of a chemical reaction and strengthen their developing understanding of the link between thermal and chemical energy through questions and a discussion. They then add this link to the *Project Board*. **Disciplinary Core Ideas:** **PS1.B: Chemical Reactions** · Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS-PS1-2),(MS-PS1-3),(MS-PS1-5) · Some chemical reactions release energy, others store energy. (MS-PS1-6) **PS3.D: Energy in Chemical Processes and Everyday Life** · The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen. (secondary to MS-LS1-6) · Cellular respiration in plants and animals involve chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials. (secondary to MS-LS1-7)	**Asking Questions and Defining Problems** (updating the *Project Board*) **Planning and Carrying Out Investigations** (carrying out an investigation using different amounts of antacids with water to measure how high and far a film canister travels) **Using Mathematics, Informational and Computer Technology, and Computational Thinking** (students calculate the average distance their canister travels and then calculate a class average) **Obtaining, Evaluating, and Communicating Information** (students obtain additional information about chemical energy, and about how chemical processes are involved in processes like respiration and photosynthesis)	Unit Level: **Energy** Section Level: **Cause and Effect**
Back to the Big Question: Students reflect on the indicators and factors of chemical and thermal energy by returning to their Rube Goldberg drawings and finding examples of chemical and thermal energy transformations in the drawing. They record their findings about their group's drawing and explain individually and in small groups that there is a connection between thermal energy and chemical energy and potential and kinetic energy. They then work in small groups to add a chemical and thermal energy step to their own Rube Goldberg designs and share their planned addition with the rest of the class, obtaining feedback, answering questions, and then adding any additional information to the *Project Board*. **Disciplinary Core Ideas:** **ETS1.B: Developing Possible Solutions** · A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4) · There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3) · Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3)	**Asking Questions and Defining Problems** (updating the *Project Board*) **Engaging in Argument from Evidence** (students communicate their new Rube Goldberg design and explain their reasoning for their changes based on evidence)	Unit Level: **Energy**

Energy: Learning Set 4
How Can Sound and Light Be Forms of Energy?

Storyline (with Disciplinary Core Ideas and Science Content)	Science and Engineering Practices	Crosscutting Concepts
Section 4.1: As individuals and then in small groups, students list examples of sound and light as energy. They identify potential indicators and factors and share with the class. Students then use tuning forks or light sources to identify indicators of sound or light in small group. The small groups share their investigation results with the class and reflect on the indicators of sound or light by returning to the small group's Rube Goldberg drawing looking for indicators of sound or light energy. They reflect on what they have found through a series of questions and then add their ideas to the *Project Board.* **Disciplinary Core Ideas:** **PS4.A: Wave Properties** · A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude. (MS-PS4-1) · A sound wave needs a medium through which it is transmitted. (MS-PS4-2)	**Analyzing and Interpreting Data** (collecting and analyzing observational data of a set of sound or light sources to determine if there are any indicators of the presence of energy) **Obtaining, Evaluating, and Communicating Information** (sharing examples, indicators, observations, and analysis with the class)	Section Level: **Cause and Effect**
Section 4.2: Students identify that sound is the most obvious indicator of sound energy but realize that sometimes human ears are not a good tool for identifying sound. They then explore three different ways they might observe sound energy that does not include hearing it. Through these investigations they also identify factors for sound energy. Students share what they learned in their small group exploration and notice trends across the explorations by adding the information to a *Sound Energy Chart*. Students then write an explanation of how the factors they identify affect sound energy. Students share their explanations with the class and record each group's explanation. They then discuss the explanations and add new ideas to the *Project Board*, supporting all new ideas with evidence. **Disciplinary Core Ideas:** **PS4.A: Wave Properties** · A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude. (MS-PS4-1) · A sound wave needs a medium through which it is transmitted. (MS-PS4-2)	**Asking Questions and Defining Problems** (updating the *Project Board*) **Developing and Using Models** (models of instruments are created) **Planning and Carrying Out Investigations** (carry out an investigation into three different ways sound energy can be observed) **Constructing Explanations and Designing Solutions** (construct theories and an explanation about how kinetic energy can be produced by sound energy)	Section Level: **Cause and Effect** **Patterns**
Section 4.3: Students now explore the differences and similarities between how sound and light are transmitted. They are first introduced to the idea of waves using common models to represent wave motion. They then complete a scaffolded investigation using the model to explore wave transmission. As they gather data and answer questions they focus on the types of waves and are introduced to the academic vocabulary related to waves through a reading about the characteristics of waves that helps focus students on the factors and indicators of wave energy. **Disciplinary Core Ideas:** **PS4.A: Wave Properties** · A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude. (MS-PS4-1) · A sound wave needs a medium through which it is transmitted. (MS-PS4-2)	**Developing and Using Models** (models of waves are created) **Analyzing and Interpreting Data** (the movement of waves is analyzed) **Obtaining, Evaluating, and Communicating Information** (students share their findings about the factors that affect mechanical waves)	Section Level: **Patterns**

Section 4.4: Focusing only on sound now, students read about the speed of sound and how sound travels. They apply their current understanding of the factors and indicators of sound to the examples in the reading and extend to speed and pitch of sound. Though questions, students connect environmental factors to the pitch and frequency of sound and then revise their explanations about sound. After sharing their explanations, students update the *Project Board.* **Disciplinary Core Ideas:** **PS4.A: Wave Properties** · A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude. (MS-PS4-1) · A sound wave needs a medium through which it is transmitted. (MS-PS4-2)	**Asking Questions and Defining Problems** (updating the *Project Board*) **Constructing Explanations and Designing Solutions** (students revise their explanations about the factors that affect sound) **Obtaining, Evaluating, and Communicating Information** (obtaining information about sound)	Unit Level: **Energy and Matter**
Section 4.5: Students now turn to factors that affect the intensity of light energy by watching a demonstration using a flashlight and various distances from a surface. As they analyze the data, they begin to observe that the light intensity varies depending on distance. They then test this claim using additional light sources, analyze the data from this exploration and rank the various lights based on their intensity and distances. By sharing the data, larger trends are identified. Students then build on this understanding by reading about light intensity and distance and introduced to photons and additional information about how light travels. Using evidence from their investigations and from the science reading, students write an explanation that connects the indicators and factors of light intensity. They share these explanations with the class, develop a consensus explanation and then update the *Project Board.* **Disciplinary Core Ideas:** **PS4.B: Electromagnetic Radiation** · When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light. (MS-PS4-2) · The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends. (MS-PS4-2) · A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media. (MS-PS4-2) · However, because light can travel through space, it cannot be a matter wave, like sound or water waves. (MS-PS4-2) **ESS2.D: Weather and Climate** · Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns. (MS-ESS2-6)	**Asking Questions and Defining Problems** (updating the *Project Board*) **Analyzing and Interpreting Data** (collect data from three light sources at three different distances and analyze that data) **Using Mathematics, Information and Computer Technology, and Computational Thinking** (student groups share data by creating a graph and presenting their explanation with the class)	Section Level: **Cause and Effect Patterns**

Section 4.6: Students are introduced to the phenomenon of light bending as it passes from air to water. They then develop a model that might explain why a straw in a glass looks bent. They create a class list of the factors that might affect the movement of light. They then read about light waves and how light waves act, comparing light waves to sound waves. Students then update their explanation of waves to include factors related to light energy and read about electromagnetic radiation. Based on the reading they update their explanation to apply the academic vocabulary and then add their ideas to the *Project Board*. **Disciplinary Core Ideas:** **PS4.A: Wave Properties** · A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude. (MS-PS4-1) · A sound wave needs a medium through which it is transmitted. (MS-PS4-2) **PS4.B: Electromagnetic Radiation** · When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light. (MS-PS4-2) · The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends. (MS-PS4-2) · A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media. (MS-PS4-2) · However, because light can travel through space, it cannot be a matter wave, like sound or water waves. (MS-PS4-2)	**Asking Questions and Defining Problems** (updating the *Project Board*) **Analyzing and Interpreting Data** (observational data is collected and interpreted to determine other factors of light waves) **Constructing Explanations and Designing Solutions** (explanations about the factors that affect light are revised) **Obtaining, Evaluating, and Communicating Information** (ideas about light waves are shared, obtain information about how light waves and sound waves are similiar)	Unit Level: **Energy**
Back to the Big Question: Students conclude their exploration of light and sound by returning to the Rube Goldberg drawings and check their indicators of light and sound energy and identify the transformations that occur. Through scaffolded questions, students identify the connection between kinetic and potential energy and light and sound energy. They then write an explanation related to this connection and share their explanation with the class. As students complete this *Learning Set* they plan for adding sound and light energy resources to their Rube Goldberg plan, share their ideas with each other, reflect on other's ideas, and then update the *Project Board*. **Disciplinary Core Ideas:** **ETS1.B: Developing Possible Solutions** · A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4) · There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3) · Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3)	**Asking Questions and Defining Problems** (updating the *Project Board*) **Engaging in Argument from Evidence** (Rube Goldberg machines are revised based on investigations, data analysis) **Obtaining, Evaluating, and Communicating Information** (ideas and explanations for using light energy in Rube Goldberg machines are shared with the class)	Unit Level: **Energy**

Energy: Learning Set 5 How Do Electricity and Magnetism Provide Energy?		
Storyline (with Disciplinary Core Ideas and Science Content)	**Science and Engineering Practices**	**Crosscutting Concepts**
Section 5.1: Students begin this learning set by investigating simple electric circuits using a battery, bulb and wire. They record their investigations and results for each investigation and debrief based on what they are learning. For the electric circuits they draw a model to show where all the parts of the circuit are and how electricity flows in the circuit. In a second investigation, students build another model and use it to investigate magnets and electromagnetism by building and then messing about with an electromagnet. Students update their models of the flow of electricity and draw on them to explain the functioning of the electromagnets. Students share their understanding developed from the investigations and reflect on what these experiences help them to understand about what electricity is. Students then read about the indicators of electrical and magnetic energy and return to the Rube Goldberg drawing to look for indicators of both electrical and magnetic energy and to identify if magnetic energy is a form of potential or kinetic energy and to identify indicators and factors of these energy types. Students add their current understanding about factors and indicators to the *Project Board.* **Disciplinary Core Ideas:** **PS2.B: Types of Interactions** · Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects. (MS-PS2-3)	**Asking Questions and Defining Problems** (updating the *Project Board*) **Analyzing and Interpreting Data** (observational data from creating permanent magnets and electromagnets are compared and interpreted) **Constructing Explanations and Designing Solutions** (explanations of what happened during investigations are constructed) **Obtaining, Evaluating, and Communicating Information** (student groups share their observations with the class)	Unit Level: **Energy** Section Level: **Cause and Effect**
Section 5.2: Focusing on the factors that allow the control of electrical energy, students investigate using light intensity as a measure of electrical energy, create a switch to stop and start the flow of electricity and then reflect on these investigations using the model they created in the previous section. Building on what they have learned through their investigations, students read about electricity and are introduced to the appropriate academic vocabulary. As they review the reading, students identify indicators and factors of electric energy and add these ideas to the *Project Board.* **Disciplinary Core Ideas:** **PS2.B: Types of Interactions** · Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects. (MS-PS2-3)	**Asking Questions and Defining Problems** (updating the *Project Board*) **Planning and Carrying Out Investigations** (investigate ways to make the light from a light bulb more intense, investigate how to control the light and energy going to a light bulb)	Section Level: **Cause and Effect** **Systems and System Models**

Section 5.3: Measurement tools are a critical part of science data collection. In this section students build a galvanometer, applying the ideas about circuits they have previously learned, students build a galvanometer and explore how changes to the way the tool is built affect the measurement accuracy. They read more about how galvanometers work and begin to explain how galvanometer works, identifying factors that affect the galvanometer and are related to magnetism. **Disciplinary Core Ideas:** **PS2.B: Types of Interactions** · Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects. (MS-PS2-3) · Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object, or a ball, respectively). (MS-PS2-5)	**Developing and Using Models** (develop and build a galvonometer to simulate measuring electricity)	Section Level: **Systems and System Models**
Section 5.4: Students now explore the power of batteries and factors that affect the electric energy of batteries. Following a scaffolded procedure and using their galvanometer, students test multiple batters for differences in power and then analyze the data, search for those factors that affect the circuit. Students then read about how batteries work, applying potential and kinetic energy knowledge to batteries. **Disciplinary Core Ideas:** **PS2.B: Types of Interactions** · Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects. (MS-PS2-3) · Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object, or a ball, respectively). (MS-PS2-5)	**Analyzing and Interpreting Data** (analyze data from batteries to determine which provides the most electricity) **Obtaining, Evaluating, and Communicating Information** (students share the results of their investigations with the class in an *Investigation Expo*)	Section Level: **Scale, Proportion, and Quantity**
Section 5.5: In small groups, students predict and then sketch a model of how more than one bulb might be lit in a single circuit. They then build the circuit and use the sketch to show the flow of electricity in the circuit. Through discussion, students share the problems and solutions they found within the task and with their sketches representing electricity flowing. After reading about series and parallel circuits, students build a parallel circuit and use this to identify the differences between a parallel and series circuit. They then update their energy types pages to include factors and indicators of electrical energy. They complete this section by updating the *Project Board* with their complete understanding of factors and indicators related to electrical energy. **Disciplinary Core Ideas:** **PS2.B: Types of Interactions** · Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects. (MS-PS2-3) · Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object, or a ball, respectively). (MS-PS2-5)	**Asking Questions and Defining Problems** (updating the *Project Board*) **Planning and Carrying Out Investigations** (an investigation is carried out to create a circuit with more than one light bulb) **Obtaining, Evaluating, and Communicating Information** (findings are communicated with the class)	Unit Level: **Energy** Section Level: **Cause and Effect**

Section 5.6: Students know how to measure and identify indicators and factors of electrical energy but they don't know how energy can be transformed into electrical energy or exactly how a battery works. In small groups students now build a battery and identify the parts of a battery. Then students build a generator, again identify the parts of the generator and making connections to their previous experiences building circuits. Students then "dissect" the generator, making sense of the purpose of each piece of the generator and matching the part to previously used materials. They identify the factors that affect the amount of energy and make predictions about how they might be able to generate more voltage. After listing the factors in both batteries and generators explorations students compare batteries and generators. Finally, they read about how batteries are similar to and different from generators and update the *Project Board*. **Disciplinary Core Ideas:** **PS2.B: Types of Interactions** · Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects. (MS-PS2-3) · Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object, or a ball, respectively). (MS-PS2-5)	**Asking Questions and Defining Problems** (updating the *Project Board*) **Developing and Using Models** (develop and build a model of a battery)	Section Level: **Stability and Changes** **Systems and System Models**
Back to the Big Question: First students return to their Rube Goldberg group drawings and identify electricity and magnetic energy in each, as well as identifying the indicators and factors in each step. In small groups, students explain how electrical energy is a form of kinetic or potential energy and how electrical energy can be transformed to do work. They repeat this process for magnetic energy and add their plan for including these energy types to their Rube Goldberg design. Small groups share their planned ideas and gain feedback from others to incorporate into their design. They then update the *Project Board*. **Disciplinary Core Ideas:** **ETS1.B: Developing Possible Solutions** · A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4) · There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3) · Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3)	**Asking Questions and Defining Problems** (updating the *Project Board*) **Engaging in Argument from Evidence** (Rube Goldberg machines are revised based on investigations, data analysis) **Constructing Explanations and Designing Solutions** (explanations about how electrical energy is a form of kinetic or potential energy and how electrical energy can be transformed to do work) **Obtaining, Evaluating, and Communicating Information** (Rube Goldberg machine designs are shared in a *Plan Briefing*)	Unit Level: **Energy**

<table>
<tr><th colspan="3">Energy: Learning Set 6
How is Energy Transformed?</th></tr>
<tr><th>Storyline (with Disciplinary Core Ideas and Science Content)</th><th>Science and Engineering Practices</th><th>Crosscutting Concepts</th></tr>
<tr><td>Introduction to Learning Set 6:
The backdrop of this unit has been the transformation of energy. In the final Learning Set, students begin to consider how energy resources are identified and then transformed into usable forms. Drawing from the previous examples, batteries, sounds, toasters, etc., students review the energy transformations they have seen and discuss the energy transformations using the factors and indicators present in each device as energy powers the device and changes within the device.</td><td rowspan="2">Asking Questions and Defining Problems (updating the Project Board)

Analyzing and Interpreting Data (four different objects are analyzed to determine the energy transformations taking place)

Obtaining, Evaluating, and Communicating Information (groups share ideas with other groups, presenting a completed chart on the object they were assigned)</td><td rowspan="2">Section Level:
Cause and Effect
Patterns</td></tr>
<tr><td>Section 6.1:
Small groups share their ideas with the class and begin to explain what happens to all the energy within the system. Students then add their questions about energy transformations to the Project Board.</td></tr>
<tr><td>Section 6.2:
Mechanical energy transformations are explored at two different explorations, using bouncing balls and balls on tracks. Students create diagrams and use other representations to document the transformation from potential energy to kinetic energy as the ball bounces and the ball rolls on the U-shaped track. Students begin to observe that energy is lost in the system and that this energy is not easily measured. As groups share their what they have learned and compare the two explorations, students begin to identify many different places where energy transformations might be seen as “energy lost”.
Using science knowledge from a reading and building on their discussions, students identify where the potential and kinetic energy changes happen in the two investigations and then read about the energy transformation that happen in a dance floor they were introduced to in Section 6.1. As they reflect on this reading, students make connections between the dance floor example and the ball explorations from earlier in the section. Finally, students update the Project Board, adding more sophisticated understanding of how energy transforms from one type to another.

Disciplinary Core Ideas:
PS3.B: Conservation of Energy and Energy Transfer
· When the motion energy of an object changes, there is inevitably some other change in energy at the same time. (MS-PS3-5)</td><td>Asking Questions and Defining Problems (updating the Project Board)

Analyzing and Interpreting Data (energy cartoons are analyzed to determine efficient and inefficient energy transformations)

Constructing Explanations and Designing Solutions (construct explanations about what happens to mechcanical energy)

Obtaining, Evaluating, and Communicating Information (additional information about energy transformations and energy loses is obtained)</td><td>Unit Level:
Energy

Section Level:
Patterns</td></tr>
</table>

Section 6.3: Students have identified that some amount of energy has been lost in any transformation but they need to better understand what happened to the lost energy. Using a simplified model of collisions, students begin to explain, from collected data, where the lost energy might have gone. Students use the exploration to make some predictions and then apply those predictions as they read more about where the lost energy goes. Students then apply the information from the reading to the graphs they created in *Section 6.2* with the bouncing ball and rolling ball investigations. Students then return to their Rube Goldberg cartoon and collaborate to find the "lost" energy for each of the transformations they have previously identified. Since each of the four drawings includes different transformations, students share what they have found in their drawings. Then students update the *Project Board*, answering some of the questions they added to the *Project Board* at the end of *Section 6.2.* **Disciplinary Core Ideas:** **PS3.B: Conservation of Energy and Energy Transfer** · When the motion energy of an object changes, there is inevitably some other change in energy at the same time. (MS-PS3-5)	**Asking Questions and Defining Problems** (updating the *Project Board*) **Obtaining, Evaluating, and Communicating Information** (information about conversaton of energy is obtained)	Unit Level: **Energy**
Section 6.4: The Law of Conservation of Energy guides all energy explorations. Students have explored various energy transformations and have come close to understanding the ideas of this scientific law. Now they engage in obtaining information about the Law of Conservation of Energy. To support the development of their understanding of the nature of science, students read about Richard Feynman and his thought experiments around energy. This model provides a conceptual framework for thinking about that "lost" energy and how conservation of energy might work. Students also connect the ideas of Feynman's analogy to begin to construct and understand the boundaries of a system. They update the *Project Board*, restating ideas from *Section 6.3* in terms of the Law of Conservation of Energy. **Disciplinary Core Ideas:** **PS3.B: Conservation of Energy and Energy Transfer** · When the motion energy of an object changes, there is inevitably some other change in energy at the same time. (MS-PS3-5)	**Asking Questions and Defining Problems** (updating the *Project Board*) **Obtaining, Evaluating, and Communicating Information** (information about the conservation of energy is obtained)	Section Level: **Systems and System Models**
Section 6.5: Connecting to human impacts and natural resources, students read about and record the pros and cons of several types of energy resources: wind, hydroelectric, solar, fossil fuels, trash and biomass, wave, and geothermal. They then choose one of these resources and complete a research project on the resource. Students share their research in a presentation and then evaluate the various resources for their area and make a recommendation about which of the resources makes the most sense for their region. **Disciplinary Core Ideas:** **ESS3.A: Natural Resources** · Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes. (MS-ESS3-1)	**Engaging in Argument from Evidence** (student groups select an energy resource) **Obtaining, Evaluating, and Communicating Information** (information about different energy resources and nuclear energy is obtained)	Unit Level: **Energy** Section Level: **Patterns** **Cause and Effect**

Section 6.6: Students return to their project and evaluate the pathway of the use of the natural resource for electricity in homes. They identify the various energy transformations that have to occur to turn the particular energy resource into electricity that is useful and complete an energy generation pathway diagram. Throughout this investigation, students focus on efficiency as part of the criteria for using alternative fuels. Each group shares their diagrams with the class and then students provide feedback on efficiency. Students then work together to make a recommendation about the use of an alternative energy source for generating electricity near the seashore. Finally, they update the *Project Board* with information about alternative energy resources. **Disciplinary Core Ideas:** **ESS3.A: Natural Resources** · Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes. (MS-ESS3-1)	**Asking Questions and Defining Problems** (updating the *Project Board*) **Obtaining, Evaluating, and Communicating Information** (students create a presentation that demonstrates energy transformations)	Unit Level: **Energy** Section Level: **Cause and Effect**
Back to the Big Challenge: Now the students have been using the ideas of efficiency, they return to their Rube Goldberg drawings and identify efficiency issues within their drawings. They evaluate their machines using the data they have collected and recorded throughout the unit to help them define the efficiency at each step in the device. Students then brief their class on the efficiency issues within their machine and update the *Project Board*. **Disciplinary Core Ideas:** **PS3.B: Conservation of Energy and Energy Transfer** · When the motion energy of an object changes, there is inevitably some other change in energy at the same time. (MS-PS3-5) **Disciplinary Core Ideas:** **ETS1.B: Developing Possible Solutions** · A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4) · There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3) · Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3)	**Asking Questions and Defining Problems** (updating the *Project Board*) **Constructing Explanations and Designing Solutions** (final designs of Rube Goldberg machines are made based on what was learned about energy and energy transformations) **Obtaining, Evaluating, and Communicating Information** (students consider how efficient their Rube Goldberg machine is, communicate their planned sequence in a *Plan Briefing*)	Unit Level: **Energy**

Energy: Address the Big Challenge Design a Rube Goldberg Machine to Turn Off a Light		
Storyline (with Disciplinary Core Ideas and Science Content)	**Science and Engineering Practices**	**Crosscutting Concepts**
The *Big Challenge* of the unit is to design a Rube Goldberg device that turns out a light. Before students continue to work on their plans, they revise the criteria and constraints for the design challenge. As they complete their plans they identify steps that are efficient and those that are not efficient as well as the energy type changes that occur at each step and the factors and indicators they took into consideration at each step. Students share they draft plans, obtain feedback on them and then complete their plans. The final plans are presented to the class. **Disciplinary Core Ideas:** **ETS1.B: Developing Possible Solutions** · A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4) · There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3) · Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3) **ETS1.C: Optimizing the Design Solution** · Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. (MS-ETS1-3) · The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (MS-ETS1-4)	**Asking Questions and Defining Problems** (updating the *Project Board*) **Obtaining, Evaluating, and Communicating Information** (students present their Rube Goldberg machine designs to obtain ideas and suggestions. they communicate their final designs to the class in a *Solution Showcase*)	Unit Level: **Energy** Section Level: **Cause and Effect** **Stability and Change**