Profile Sheet
PBL Lesson Plan for Diverse Learners

Original Title: Radioactive Asteroid Strikes Hilltop Town!
Primary Subject Area: Science
Outside Subject Area: Language Arts
Teacher: Laura Taff
Grade level: 4th Grade

Description of Student Roles and Problem Situations:
Students will assume one or more of the following roles: lead engineer, construction worker, graphic artist, documenting scientist, and liaison/presenter. The townspeople of Hilltopolis have discovered a round radioactive asteroid on the edge of their hilltop city. The Mayor has called for teams to design, evaluate, and present ramps to the Hilltopolis City Council that will move the asteroid as far from the city as possible. The teams will present their solutions and explain the science behind them to the Council.

Adaptations for Student from Non-Western culture:
• Include resources from the student’s culture
• Include audience member from the student’s culture
• Research values system of culture and align instructional techniques and classroom activities with these value systems

Adaptations for ESOL Student:
• Include resources in student’s first language
• Allow native language dictionaries
• Include audience member that speaks the student’s language
Title, Learner Characteristics, and Sunshine State Standards

Problem Based Learning Lesson Plan

Teacher: Laura Taff
Title: Hilltop Town Must Move Radioactive Asteroid!
Primary Subject Area: Science
Outside Subject Area: Language Arts
Class and Level: Regular class, no alternative level for this grade
Grade Level: 4th grade

Primary Sunshine State Standards:
SC.4.P.10.1: Observe and describe some basic forms of energy, including light, heat, sound, electrical, and the energy of motion.
SC.4.P.10.2: Investigate and describe that energy has the ability to cause motion or create change.
SC.4.P.12.1: Recognize that an object in motion always changes its position and may change its direction.
SC.4.N.1.6: Keep records that describe observations made carefully, distinguishing actual observations from ideas and inferences about observations.

Outside Subject Area Sunshine State Standards from Language Arts:
LA.4.5.2.2: The student will plan, organize, and give an oral presentation and use appropriate voice, eye, and body movements for the topic, audience, and occasion.

Learner Characteristics of Elementary Grades Students:

Physical: Obesity can begin to present in this age group. According to Snowman and Bieler (p. 78), poor food choices and physical inactivity are contributing to the rise in obesity. Justification: This problem based learning (PBL) lesson will engage the children in a moderate physical activity that will provide more exercise than learning from a chair.

Social: The peer group becomes a dominate force of behavior and achievement. Snowman and Bieler state that “by grades 4 and 5, children are more interested in getting along with one another without adult supervision.” (p. 79) Justification: This lesson will utilize the elementary need for autonomy to build teams players working toward a common goal.

Social: Children of this age tend to form close same-sex friendships, and according to Snowman and Bieler, will “avoid the opposite sex when left to their own devices.” (p. 79) Justification: This PBL will allow for homogenous groups of both sexes to interact in an emotionally safe environment, as teammates in an activity that requires thinking skills and fine motor skills where the playing field is even.

Emotional: During this period, children are developing a more complex self-image than their primary grade selves. Snowman and Bieler claim that “comparison with others is
the fundamental basis of a self-image during the elementary grades” (p. 81) Citing Marsh and Craven (2002), the authors point out that this “social comparison process can have detrimental effects on a student’s academic self-image when most of his classmates are more able learners.” (p. 81) Justification: Knowing that some students are less able learners, the teacher has the opportunity to steer those students toward appropriate “roles” in the activity that will allow them to fully participate and succeed as part of the team.

Cognitive: The cognitive characteristics of elementary grades children includes logical thinking, and they can solve tasks, but “only if they are based on concrete objects and ideas.” (Snowman and Bieler, p. 82) This makes the problem based lesson ideal for this age group. Justification: This PBL lesson will involve hands-on manipulation of concrete variables and observable outcomes.
Learning Outcomes, Student Role and Problem Situation, Meet the Problem Method
Problem Based Learning Lesson Plan

Original Title: Hilltop Town Must Move Radioactive Asteroid!
Teacher: Laura Taff

Primary Sunshine State Standards with Learning Outcomes:
SC.4.P.10.1: Observe and describe some basic forms of energy, including light, heat, sound, electrical, and the energy of motion.
LO #1: After observing and discussing marbles traveling down a ramp, and reading the handout “Kinetic and Potential Energy” the student will write a short essay comparing and contrasting the two forms of energy. The essay will be graded against a rubric with a proficiency of at least 80%. (Analysis)

SC.4.N.1.6: Keep records that describe observations made carefully, distinguishing actual observations from ideas and inferences about observations.
LO #2: Given the materials to build at least two ramps, the students will predict the kinetic output of a marble traveling down each ramp. Then the students will record the kinetic output of a marble descending each ramp. The slope of each ramp will be accurately depicted on graph paper, and the predictions and observations will be recorded on their respective graphs. The components of this assignment will be graded against a rubric with a proficiency of at least 90%. (Analysis, Synthesis)

Outside Subject Area Sunshine State Standards from Language Arts:
LA.4.5.2.2: The student will plan, organize, and give an oral presentation and use appropriate voice, eye, and body movements for the topic, audience, and occasion.
LO #3: Given the results of their ramp investigation, the students will present evaluations of their ramps and offer conclusions on the best ramp design for the greatest possible kinetic energy. The presentation will be graded against a rubric with a proficiency of at least 80%. (Evaluation)

Description of Student Roles and Problem Situations:
Students will assume one of the following roles: lead engineer, construction worker, graphic artist, documenting scientist, and liaison/presenter. The townspeople of Hilltopolis have discovered a round radioactive asteroid on the edge of their hilltop city. The mayor has called for teams to design, evaluate, and present ramps to the Hilltopolis council that will move the asteroid as far from the city as possible.

Meet the Problem Documents:
Memorandum from the Hilltopolis mayor, “Kinetic and Potential Energy” handout
MEMORANDUM – TOP SECRET

To: Lead Engineers
   Hilltopolis Ramp Teams

From: Honorable Al T. Tood
      Mayor, Hilltopolis, Colorado

Date: January 25, 2012

Re: Radioactive Asteroid Problem!

Greetings Women and Men,
You and your teams have been assembled to help the town of Hilltopolis with a terrible crisis. A round, radioactive asteroid has been discovered at the edge of our fair city. This plague must be removed quickly and as far as possible from the heart of our beloved township.

Our city council has determined that the cheapest method for removal will be by ramp, using the potential energy of the asteroid itself. Toward this end, the council has provided building materials for teams to construct ramps. The teams will have three days to build and test three ramps in order to determine the most effective construction to carry the sphere the farthest. The teams will carefully observe and record the kinetic energy output from all three ramps, and will document the ramps themselves.

The teams will present their findings before the city council on January 29, 2012 at 1:30pm at city hall. The teams will explain the scientific basis for their research and make recommendations on the best course of action for the city.

Mayor, Al T. Tood
KINETIC AND POTENTIAL ENERGY

What is energy?
Energy makes change; it does things for us. It moves cars along the road and boats over the water. It bakes a cake in the oven and keeps ice frozen in the freezer. It plays our favorite songs on the radio and lights our homes. Energy makes our bodies grow and allows our minds to think. Scientists define energy as the ability to do work. People have learned how to change energy from one form to another so that we can do work more easily and live more comfortably.

Forms of Energy
Energy is found in different forms, such as light, heat, sound and motion. There are many forms of energy, but they can all be put into two categories: kinetic and potential.

<table>
<thead>
<tr>
<th>KINETIC ENERGY</th>
<th>POTENTIAL ENERGY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Kinetic energy</strong> is motion—of waves, electrons, atoms, molecules, substances, and objects.</td>
<td><strong>Potential energy</strong> is stored energy and the energy of position—gravitational energy. There are several forms of potential energy.</td>
</tr>
<tr>
<td><strong>Electrical Energy</strong> is the movement of electrical charges. Everything is made of tiny particles called atoms. Atoms are made of even smaller particles called electrons, protons, and neutrons. Applying a force can make some of the electrons move. Electrical charges moving through a wire is called electricity. Lightning is another example of electrical energy.</td>
<td><strong>Chemical Energy</strong> is energy stored in the bonds of atoms and molecules. It is the energy that holds these particles together. Biomass, petroleum, natural gas, and propane are examples of stored chemical energy.</td>
</tr>
<tr>
<td><strong>Radiant Energy</strong> is electromagnetic energy that travels in transverse waves. Radiant energy includes visible light, x-rays, gamma rays and radio waves. Light is one type of radiant energy. Solar energy is an example of radiant energy.</td>
<td><strong>Stored Mechanical Energy</strong> is energy stored in objects by the application of a force. Compressed springs and stretched rubber bands are examples of stored mechanical energy.</td>
</tr>
<tr>
<td><strong>Thermal Energy</strong>, or heat, is the internal energy in substances—the vibration and movement of the atoms and molecules within substances.</td>
<td><strong>Nuclear Energy</strong> is energy stored in the nucleus of an atom—the energy that holds the nucleus together. The energy can be released when the nuclei are combined or split apart. Nuclear power plants split the nuclei of uranium atoms in a process called <strong>fission</strong>. The sun combines the nuclei</td>
</tr>
</tbody>
</table>
Geothermal energy is an example of thermal energy.

**Motion Energy** is the movement of objects and substances from one place to another. Objects and substances move when a force is applied according to Newton’s Laws of Motion. Wind is an example of motion energy.

**Sound** is the movement of energy through substances in longitudinal (compression/rarefaction) waves. Sound is produced when a force causes an object or substance to vibrate—the energy is transferred through the substance in a wave.

of hydrogen atoms in a process called **fusion**. Scientists are working on creating fusion energy on earth, so that someday there might be fusion power plants.

**Gravitational Energy** is the energy of position or place. A rock resting at the top of a hill contains gravitational potential energy. Hydropower, such as water in a reservoir behind a dam, is an example of gravitational potential energy.

**Law of Conservation of Energy**

conservation of energy is not saving energy. The law of conservation of energy says that energy is neither created nor destroyed. When we use energy, it doesn’t disappear. We change it from one form of energy into another.

A car engine burns gasoline, converting the chemical energy in gasoline into mechanical energy. Solar cells change radiant energy into electrical energy. Energy changes form, but the total amount of energy in the universe stays the same.
Scientists at the Department of Energy think they have discovered a mysterious new form of energy called "dark energy" that is actually causing the universe to grow!

Energy Efficiency

Energy efficiency is the amount of useful energy you get from a system. A perfect, energy-efficient machine would change all the energy put in it into useful work—an impossible dream. Converting one form of energy into another form always involves a loss of usable energy.

In fact, most energy transformations are not very efficient. The human body is a good example.

Your body is like a machine, and the fuel for your machine is food. Food gives you the energy to move, breathe, and think. But your body isn’t very efficient at converting food into useful work. Your body is less than five percent efficient most of the time. The rest of the energy is lost as heat. You can really feel that heat when you exercise!

Sources of Energy

We use many different energy sources to do work for us. Energy sources are classified into two groups—renewable and nonrenewable. Renewable and nonrenewable energy can be converted into secondary energy sources like electricity and hydrogen.
In the United States, most of our energy comes from nonrenewable energy sources. Coal, petroleum, natural gas, propane, and uranium are nonrenewable energy sources. They are used to make electricity, to heat our homes, to move our cars, and to manufacture all kinds of products.

These energy sources are called nonrenewable because their supplies are limited. Petroleum, for example, was formed millions of years ago from the remains of ancient sea plants and animals. We can’t make more petroleum in a short time.

Renewable energy sources include biomass, geothermal energy, hydropower, solar energy, and wind energy. They are called renewable energy sources because they are replenished in a short time. Day after day, the sun shines, the wind blows, and the rivers flow. We use renewable energy sources mainly to make electricity.

Electricity and hydrogen are different from the other energy sources because they are secondary sources of energy. Secondary sources of energy—energy carriers—are used to store, move, and deliver energy in easily usable form. We have to use another energy source to make electricity or hydrogen. In the United States, coal is the number one energy source for generating electricity. Today the cheapest way to get hydrogen is by separating it from natural gas, a nonrenewable energy source. Hydrogen can also be separated from water and from renewables but hydrogen made from these sources is currently too expensive to compete with other fuels.

**U.S. ENERGY CONSUMPTION BY SOURCE, 2007**

<table>
<thead>
<tr>
<th>Source</th>
<th>Percentage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Biomass</strong></td>
<td>3.6%</td>
<td>Nonrenewable, heating, electricity, transportation</td>
</tr>
<tr>
<td><strong>Petroleum</strong></td>
<td>37.5%</td>
<td>Nonrenewable, transportation, manufacturing</td>
</tr>
<tr>
<td><strong>Hydropower</strong></td>
<td>2.4%</td>
<td>Nonrenewable, electricity</td>
</tr>
<tr>
<td><strong>Natural Gas</strong></td>
<td>23.3%</td>
<td>Nonrenewable, heating, manufacturing, electricity</td>
</tr>
<tr>
<td><strong>Coal</strong></td>
<td>22.5%</td>
<td>Nonrenewable, electricity</td>
</tr>
<tr>
<td><strong>Geothermal</strong></td>
<td>0.3%</td>
<td>Nonrenewable, heating, electricity</td>
</tr>
<tr>
<td><strong>Wind</strong></td>
<td>0.3%</td>
<td>Nonrenewable, electricity</td>
</tr>
<tr>
<td><strong>Uranium</strong></td>
<td>8.3%</td>
<td>Nonrenewable, electricity</td>
</tr>
<tr>
<td><strong>Solar &amp; Other</strong></td>
<td>0.1%</td>
<td>Nonrenewable, light, heating, electricity</td>
</tr>
<tr>
<td><strong>Propane</strong></td>
<td>1.7%</td>
<td>Nonrenewable, manufacturing, heating</td>
</tr>
</tbody>
</table>
Scientists are working on ways to make hydrogen from water and renewables more affordable.

Last Revised: October 2008
Problem Statement, Know/Need to Know Boards, and Possible Resources

Original Title: Hilltop Town Must Move Radioactive Asteroid!
Teacher: Laura Taff

Primary Sunshine State Standards with Learning Outcomes:

SC.4.P.10.1: Observe and describe some basic forms of energy, including light, heat, sound, electrical, and the energy of motion.

LO #1: After observing and discussing marbles traveling down a ramp, and reading the handout “Kinetic and Potential Energy” the student will write a short essay comparing and contrasting the two forms of energy. The essay will be graded against a rubric with a proficiency of at least 80%. (Analysis)

SC.4.N.1.6: Keep records that describe observations made carefully, distinguishing actual observations from ideas and inferences about observations.

LO #2: Given the materials to build at least two ramps, the students will predict the kinetic output of a marble traveling down each ramp. Then the students will record the kinetic output of a marble descending each ramp. The slope of each ramp will be accurately depicted on graph paper, and the predictions and observations will be recorded on their respective graphs. The components of this assignment will be graded against a rubric with a proficiency of at least 90%. (Analysis, Synthesis)

Outside Subject Area Sunshine State Standards from Language Arts:

LA.4.5.2.2: The student will plan, organize, and give an oral presentation and use appropriate voice, eye, and body movements for the topic, audience, and occasion.

LO #3: Given the results of their ramp investigation, the students will present evaluations of their ramps and offer conclusions on the best ramp design for the greatest possible kinetic energy. The presentation will be graded against a rubric with a proficiency of at least 80%. (Evaluation)

Sample Problem Statement:

How can we, a team assembled to include lead engineer, construction workers, graphic artist, documenting scientist, and liaison/presenter, determine the best ramp construction for moving an “asteroid” as far as possible from the fair city of Hilltopolis, in such a way that:

1.) We meet the deadline for the presentation to the Hilltopolis City Council.
2.) We build at least three different types of ramps.

3.) We accurately observe and record the physical properties of the constructed ramps, and accurately observe and record the output of kinetic energy on each ramp.

4.) We present our findings to the Hilltopolis City Council, explaining the concepts of potential and kinetic energy, and the results of our ramp study. We will recommend the best solution for the city, and explain the scientific concepts behind our findings.

Know Board:

1.) A round asteroid has been found near the town of Hiltopolis.
2.) The Hiltopolis City Council has determined that the asteroid will be moved by ramp.
3.) The mayor has asked us to make a presentation to the Hiltopolis City Council.
4.) Energy makes change.
5.) Energy can be found in many different forms.
6.) The two categories of energy are kinetic and potential.
7.) Kinetic energy is motion.
8.) Motion energy is a type of kinetic energy that involves the movement of objects and substances from one place to another.
9.) Potential energy is stored energy.
10.) Gravitational energy is a type of potential energy. It is the energy of position or place, for example a rock resting at the top of a hill contains gravitational energy.
11.) Converting one form of energy to another involves a loss of usable energy.

Need to Know:

1.) What materials will we have to make our ramps?
2.) What is the starting height of the ramp?
3.) How do we keep the marble, or “asteroid” on the ramp?
4.) What are some different types of ramps that we might build?
5.) What are the considerations that may influence the kinetic output of our “asteroid” as it travels down the ramp?
6.) What can we do to limit the loss of usable energy as our “asteroid” moves?
7.) How do we determine the slope of our ramp?
8.) How do we transfer the ramp’s slope to graph paper?
9.) How will we measure the output of the “asteroid’s” kinetic energy?
10.) How will we explain the differences in ramp output?
Resources

Websites:

Think Quest: Kinetic and Potential Energy
http://library.thinkquest.org/2745/data/ke.htm

Physics4Kids: Motion

Zona Land: Education in Physics and Mathematics

eHow: How to Calculate the Slope of a Ramp

Books:


Human Resources:

John Bradshaw, retired bridge engineer, Florida Department of Transportation (850) 224-1637
Capstone Performance

Original Title:       Hilltop Town Must Move Radioactive Asteroid!
Teacher:            Laura Taff

Primary Sunshine State Standards with Learning Outcomes:

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Sample Problem Statement:

How can we, a team assembled to include lead engineer, construction workers, graphic artist, documenting scientist, and liaison/presenter, determine the best ramp construction for moving an “asteroid” as far as possible from the fair city of Hilltopolis, in such a way that:

1.) We will meet the deadline for the presentation to the Hilltopolis City Council.
2.) We will use only the resources provided by the Hilltopolis City Council.

3.) We will build at least three ramps and observe and record the outcome of an object rolling down each.

4.) We will our findings to the Hiltopolis City Council, explaining the principles of potential and kinetic energy, and make a recommendation to the Council based on our findings.

**Capstone Performance Description:**

The capstone performance for the problem consists of an individual report and a group presentation. Individual students will be assessed on both of these parts via two different rubrics, a report rubric and a presentation rubric. Student will be given four days to prepare, and a fifth day to make their group presentation. The presentation will not exceed twenty minutes.

In giving her/his report, the student will enact the role of lead engineer and present his/her findings to the team. Each student will provide at least two solutions to the problem, and then will give four justifications for choosing one solution over the other. Each report will define potential and kinetic energy, and will relate these concepts to their solution.

The team will read and discuss each other’s reports and create an overall “best” solution, and overall “best” explanation of the energy concepts to be presented in their oral presentation.

In the oral presentation, each member of the engineering team will present her own “best” solution from the two in her report. One student will then present the team’s overall “Best Solution”, and each team member must provide one justification for this solution.

A group of parents will play the part of Hilltopolis Mayor and the parts of Hilltopolis City Council members. Mr. John Bradshaw (ret. bridge engineer, Florida Department of Transportation) will represent an expert in the field brought in to advise the Council. Following their presentation, the Hilltopolis Council will be prepared to ask each team member a question related to the energy of motion and a question about their methods of observation and record keeping. The engineer team will stand in front of the classroom, and may use a podium, whiteboard, PowerPoint projector, or paper graphs and charts. The mayor, council members and expert in field will be seated at a table facing the front of the classroom. Behind them, the remaining classmates will be seated as “townspeople” and will be given the opportunity to ask questions as well. (See room arrangement below.)
The capstone performance encourages autonomy as the individual can decide which of her “best” solutions to showcase in the presentation, and can choose a justification to support the team’s overall “Best Solution.” Meta-cognition is encouraged as each student will complete a “debriefing” form of coaching questions following their presentation.

Room Arrangement:
Rubric for Assessing the Capstone Performance

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Report Rubric

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Superior</th>
<th>Adequate</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content Accuracy</td>
<td>All science information and calculations are 100% to 90% accurate.</td>
<td>All science information and calculations are 89% to 80% accurate.</td>
<td>Scientific information and calculations are less than 80% accurate.</td>
</tr>
<tr>
<td>Alignment to Problem Statement</td>
<td>Each solution must align with conditions stated in the problem statement.</td>
<td>One solution aligns with all conditions; the other aligns with all but one condition.</td>
<td>Neither solution aligns with all conditions.</td>
</tr>
<tr>
<td>Required Components</td>
<td>The report must contain:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) The group’s problem statement</td>
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<tr>
<td></td>
<td>b) A written explanation of the forces working on the marbles of at least three of the ramps constructed, including accurate diagrams of the ramps.</td>
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<tr>
<td></td>
<td>c) Written observations of the kinetic output of the marbles from at least three of the ramps (the distance that the marble is able to move a milk carton).</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>d) Two different best solutions.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>e) Four reasons for choosing one solution over another.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Scoring Guide:

<table>
<thead>
<tr>
<th>Grade</th>
<th>Score Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>100-110</td>
</tr>
<tr>
<td>B</td>
<td>89-99</td>
</tr>
<tr>
<td>C</td>
<td>78-88</td>
</tr>
<tr>
<td>D</td>
<td>66-77</td>
</tr>
<tr>
<td>F</td>
<td>Less than 66</td>
</tr>
</tbody>
</table>
## Oral Presentation Rubric

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Superior</th>
<th>Adequate</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delivery</td>
<td>30 Points</td>
<td>20 Points</td>
<td>10 Points</td>
</tr>
<tr>
<td>The student maintains eye contact with the audience at least 80% of the time; voice is loud enough to be heard in the back of the room 90% or more of the time; and changes in voice enhance the presentation. All body movements are restricted to those that aid the presentation.</td>
<td>The student maintains eye contact 80% to 70% of the time; voice is loud enough to be heard in the back of the room 89%- 80% of the time. No more than one reminder to speak up. 1-3 movements that detract from the presentation.</td>
<td>Eye contact is less than 70%; voice is audible in the back of the room less than 80% of the time with more than one reminder to speak up; more than 3 distracting body movements.</td>
<td></td>
</tr>
<tr>
<td>Comprehension and Accuracy</td>
<td>20 Points</td>
<td>15 Points</td>
<td>5 Points</td>
</tr>
<tr>
<td>Student answers city commissioner’s question correctly, providing at least one accurate scientific fact.</td>
<td>Student answers city commissioner’s question correctly, providing at least one accurate scientific fact with coaching.</td>
<td>Student fails to answer the question, or could not provide at least one accurate scientific fact with coaching.</td>
<td></td>
</tr>
<tr>
<td>Quality of Individual Solution Explanation</td>
<td>20 Points</td>
<td>15 Points</td>
<td>5 Points</td>
</tr>
<tr>
<td>The student gives two individual “best solutions” and gives an accurate explanation of at least two of the factors affecting the outcomes.</td>
<td>The student gives two individual “best solutions” and gives an accurate explanation of at least one of the factors affecting the outcomes.</td>
<td>The student gives two individual “best solutions” but fails to explain the factors affecting the outcomes.</td>
<td></td>
</tr>
<tr>
<td>Quality of Individual Justification Explanation</td>
<td>20 Points</td>
<td>10 Points</td>
<td>5 Points</td>
</tr>
<tr>
<td>Reason given for supporting the group “best solution” is scientifically accurate.</td>
<td>Reason given for supporting the group “best solution” is not 100% scientifically accurate.</td>
<td>No reason is given for supporting the group “best solution.”</td>
<td></td>
</tr>
<tr>
<td>Reflection</td>
<td>10 Points</td>
<td>7 Points</td>
<td>3 Points</td>
</tr>
<tr>
<td>Student answers all 5 “debriefing” questions.</td>
<td>Student answers at least 4 of the “debriefing” questions.</td>
<td>Student answers less than 4 of the “debriefing” questions.</td>
<td></td>
</tr>
</tbody>
</table>

### Scoring Guide:

- A 90-100
- B 79-89
- C 68-78
- D 57-67
- F Less than 57
Two Alternative Solutions and “Best” Solution Analysis

Original Title: Hilltop Town Must Move Radioactive Asteroid!
Teacher: Laura Taff

Primary Sunshine State Standards with Learning Outcomes:

SC.4.P.10.1: Observe and describe some basic forms of energy, including light, heat, sound, electrical, and the energy of motion.

LO #1: After observing and discussing marbles traveling down a ramp, and reading the handout “Kinetic and Potential Energy” the student will write a short essay comparing and contrasting the two forms of energy. The essay will be graded against a rubric with a proficiency of at least 80%. (Analysis)

SC.4.N.1.6: Keep records that describe observations made carefully, distinguishing actual observations from ideas and inferences about observations.

LO #2: Given the materials to build at least three ramps, the students will predict the kinetic output of a marble traveling down each ramp. Then the students will record the kinetic output of a marble descending each ramp. The slope of each ramp will be accurately depicted on graph paper, and the predictions and observations will be recorded on their respective graphs. The components of this assignment will be graded against a rubric with a proficiency of at least 90%. (Analysis, Synthesis)

Outside Subject Area Sunshine State Standards from Language Arts:

LA.4.5.2.2: The student will plan, organize, and give an oral presentation and use appropriate voice, eye, and body movements for the topic, audience, and occasion.

LO #3: Given the results of their ramp investigation, the students will present evaluations of their ramps and offer conclusions on the best ramp design for the greatest possible kinetic energy. The presentation will be graded against a rubric with a proficiency of at least 80%. (Evaluation)
Sample Problem Statement:

How can we, a team assembled to include lead engineer, construction workers, graphic artist, documenting scientist, and liaison/presenter, determine the best ramp construction for moving an “asteroid” as far as possible from the fair city of Hilltopolis, in such a way that:

1.) We meet the deadline for the presentation to the Hilltopolis City Council.

2.) We build at least three different types of ramps using and reusing the materials provided.

3.) We accurately observe and record the physical properties of the constructed ramps and accurately observe and record the output of kinetic energy of the marble on each ramp.

4.) We present our findings to the Hilltopolis City Council, explaining the concepts of potential and kinetic energy, and the results of our ramp study. We will recommend the best ramp for the city, and be prepared to theorize about why an object on that ramp has the greatest potential energy.

Solution One:

The engineering team has built three different ramps using the materials provided, and has graphed those ramps and recorded the kinetic energy of a marble descending each. The team has determined that the potential energy of the marble is determined by the ramp’s height, the mass of the marble and gravity, which are the same in each case. The engineering team recommends building ramp “A” with a gentle slope of 20 degrees. In our model we gave the marble energy of position as we lifted it to the top of the ramp. The energy was stored as potential energy. This energy was released as the marble rolled down the ramp; it was changed into energy of movement (kinetic energy). When the rolling marble hit the milk carton it had a force as a result of mass and speed. Energy of movement was transferred to the carton, and the distance traveled by the carton was used to indicate the force of the marble.
**Consequences:**

1) This solution will be costly in terms of materials and construction time.
2) This solution will work safely and dependably because the “asteroid” will stay on the ramp and not bounce as it goes horizontal.

**Solution Two:**

The engineering team has built three different ramps using the materials provided, and has graphed those ramps and recorded the kinetic energy of a marble descending each. The team has determined that the potential energy of the marble is determined by the ramp’s height, the mass of the marble and gravity, which are the same in each case. The engineering team recommends building ramp “B” with a steep slope of 45 degrees. In our model we gave the marble energy of position as we lifted it to the top of the ramp. The energy was stored as potential energy. This energy was released as the marble rolled down the ramp; it was changed into energy of movement (kinetic energy). When the rolling marble hit the milk carton it had a force as a result of mass and speed. Energy of movement was transferred to the carton, and the distance traveled by the carton was used to indicate the force of the marble.

<table>
<thead>
<tr>
<th>PRO</th>
<th>CON</th>
</tr>
</thead>
<tbody>
<tr>
<td>The marble moved down this ramp more</td>
<td>The greater velocity made it more likely to</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PRO</th>
<th>CON</th>
</tr>
</thead>
<tbody>
<tr>
<td>The marble stayed on this ramp in each trial.</td>
<td>We noticed that the speed of the marble was not as great as the marble on ramps with steeper slope.</td>
</tr>
<tr>
<td>We were able to construct this ramp using the provided materials.</td>
<td>Due to the length of the run the ramp was wobbly; more construction materials would be needed to make it more stable in a real life situation.</td>
</tr>
<tr>
<td>The marble from this ramp caused the milk carton to move 5cm on average.</td>
<td>If we had been allowed to make the ramp higher, the kinetic output would have been greater.</td>
</tr>
<tr>
<td>This solution will successfully move the “asteroid” away from the hilltop.</td>
<td>This solution took the most time to construct.</td>
</tr>
<tr>
<td>Quickly than on other models.</td>
<td>Jump the track.</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>----------------</td>
</tr>
<tr>
<td>This solution required fewer building materials and was more stable.</td>
<td>Using fewer building materials didn’t improve the outcome.</td>
</tr>
<tr>
<td>Using this model, when the marble didn’t jump the ramp the milk carton moved 5cm on average.</td>
<td>This is exactly the same kinetic output as the other ramps, but with more marbles lost.</td>
</tr>
<tr>
<td>This model took less time to build.</td>
<td>It was less reliable.</td>
</tr>
</tbody>
</table>

**Consequences:**

1) Using this model would move the asteroid more quickly, but with greater risk that it would jump the ramp and land at the foot of Hilltopolis.

2) Using this model would save resources, both time and building materials.

**Justification:**

Best solution: Ramp “A” of solution one. Given the dangerous nature of the radioactive asteroid, the most important factor of the winning ramp solution is that it works consistently, and ramp “A” is the most reliable. The potential energy of the marble is its energy of position at the top of the ramp. The formula to determine potential energy is mass \( \times \) gravity \( \times \) height. Its kinetic energy is its motion energy or the force that it gathers as it moves down the ramp. These trials demonstrate the conversion of potential energy to kinetic energy. In each trial the marbles stayed on ramp “A”, and moved the milk carton 5 cm when they collided. This shows that the energy of motion of the marble was transferred to the milk carton, and supports the law of conservation of energy. In our experiment we kept the same ramp rise and marble mass. We changed the slope by increasing or decreasing the run. We found that slope was not a determining factor in the outcome of the kinetic energy output of the marble.

We thought that the greater velocity of the marbles with the steeper slopes would result in greater force on the milk carton. However, the results of our observations show that the energy outcome was the same. The big difference was the tendency of the ramp “B” marble to jump the ramp and land at the foot of the “hilltop.” Our findings seem to confirm that potential energy is only affected by mass, gravity and height.

Some people may say that we could have broadened our examination of converting potential energy into kinetic energy. Perhaps we could have constructed a catapult or a sling shot, but we were instructed to use our ramp materials. We would have needed a counter weight or a stretchy band to add to our material options. We could have
increased the kinetic energy of the models by increasing the rise of the ramps, but again the height was set.
Debriefing Plan and Coaching Questions

**Original Title:** Hilltop Town Must Move Radioactive Asteroid!

**Teacher:** Laura Taff

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Sample Problem Statement:

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5.) We meet the deadline for the presentation to the Hilltopolis City Council.

6.) We build at least three different types of ramps using and reusing the materials provided.

7.) We accurately observe and record the physical properties of the constructed ramps and accurately observe and record the output of kinetic energy of the marble on each ramp.

8.) We present our findings to the Hilltopolis City Council, explaining the concepts of potential and kinetic energy, and the results of our ramp study. We will recommend the best ramp for the city, and be prepared to theorize about why an object on that ramp has the greatest potential energy.

Debriefing Plan:

Each of the engineering teams will make their presentations to the “Hilltopolis City Council,” and in the presence of all other teams. In this way, all students will hear all possible solutions. The teacher will act as scribe and record the characteristics of each proposed “best solution.” These characteristics will be provided on a handout to all students on the day of class following the presentations. The engineering teams will rate each “best solution” providing a list in priority order (#1 is the best of the “best”). Points are assigned for each “place” on the list designated below. The teacher will tally the points for each solution.

The two solutions receiving the most points will then be examined in a whole class session. The teacher will ask the class if there is a way to combine the two solutions to make one “even better” solution. Through a class discussion, students will reach consensus on portions of the solutions to use. The teacher will write a bulleted list of these portions on the board for all to see.

Points on the Ordered List

<table>
<thead>
<tr>
<th>Place</th>
<th>Points Awarded</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>7</td>
</tr>
</tbody>
</table>
Five Essential Concepts:

The “best” solutions must utilize accurate scientific concepts. This includes explaining how each of the following affects the motion of the marble on the ramp.

1. Potential Energy
2. Kinetic Energy
3. Gravitational Energy
4. The solution will reflect accurate observations and recording of data regarding both the ramp, and the kinetic output of the marble on that ramp.
5. The solution will include a statement on the team prediction for each outcome, and a scientific explanation of the actual outcome.

In the course of the problem based learning lesson, the teacher will be rotating between the engineering teams, making sure that they are focused on the essential concepts. The teacher will provide the “Hilltopolis City Council” with questions for the teams that will guarantee eliciting responses to the essential concepts. In the event that a concept doesn’t get addressed or the response is “off the mark,” the teacher will step in and ask a prompting question.

Coaching Questions:

C – Cognitive
M – Meta-cognitive
E – Epistemic

<table>
<thead>
<tr>
<th>Type of Question</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Meet the Problem</strong></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Can you summarize the information you’ve received?</td>
</tr>
<tr>
<td>M</td>
<td>What do you already know about motion energy?</td>
</tr>
<tr>
<td>E</td>
<td>How realistic is this problem?</td>
</tr>
<tr>
<td><strong>Know/Need to Know Board</strong></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>What can we do to limit the loss of usable energy on our ramps?</td>
</tr>
<tr>
<td>M</td>
<td>How do you “know” this?</td>
</tr>
<tr>
<td>---</td>
<td>--------------------------</td>
</tr>
<tr>
<td>E</td>
<td>Is it necessary to find the answers to all the “need to know” questions?</td>
</tr>
</tbody>
</table>

**Problem Statement**

<table>
<thead>
<tr>
<th>C</th>
<th>How long do you have to work on this problem?</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>Are you comfortable with the problem statement your group has written? Would you add anything?</td>
</tr>
<tr>
<td>E</td>
<td>What factors do you need to consider in order to reach a “good” solution?</td>
</tr>
</tbody>
</table>

**Research**

<table>
<thead>
<tr>
<th>C</th>
<th>How can you verify the factors that impact the marble’s downward motion?</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>What kinds of resources have been most helpful to you so far? Why?</td>
</tr>
<tr>
<td>E</td>
<td>What different types of resources can be helpful in solving problems?</td>
</tr>
</tbody>
</table>

**Generating Possible Solutions**

<table>
<thead>
<tr>
<th>C</th>
<th>What scientific evidence do you have to back up this solution?</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>Why do you think Solution 1 is better than Solution 2? Explain your reasoning.</td>
</tr>
<tr>
<td>E</td>
<td>Will this solution resolve all the issues? If not, what are the unresolved issues?</td>
</tr>
</tbody>
</table>