Science Content Lesson Plan

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Topic and Grade Level

This lesson will cover the concepts of Potential and Kinetic energy for a six grade level class.

State Standards of Learning

Strand: Force, Motion, and Energy

Science Standard 6.2 (a): The student will investigate and understand basic sources of energy, their origins, transformations, and uses. Key concepts include potential and kinetic energy.

Strand: Scientific Investigation, Reasoning, and Logic

Science Standard 6.1 (c,e,f,i,k): The student will plan and conduct investigations in which:

(c) precise and approximate measurements are recorded (if extension is used);
(e) hypotheses are stated in ways that identify the independent (manipulated) and dependent (responding) variables;
(f) a method is devised to test the validity of predictions and inferences;
(i) data are organized and communicated through graphical representation (graphs, charts, and, diagrams);
(k) an understanding of the nature of science is developed and reinforced.

Learning Objectives

Students should be able to

- comprehend and apply basic terminology related to energy sources and transformations.
- compare and contrast potential and kinetic energy through common examples found in the natural environment.
- create and interpret a model or diagram of an energy transformation.
- make precise and consistent measurements and estimations.
- differentiate between independent (manipulated) and dependent (responding) variables in a hypothesis.
- compare and contrast predictions and inferences. Analyze and judge the evidence, observations, scientific principles, and data used in making predictions and inferences.
- organize and communicate data, using graphs (bar, line, and circle), charts, and diagrams.

Orienting Questions

Does this marble have energy?

When I pick up the marble and hold it here (at the top of the maze), what type of energy does it have?

When I let it go, what type of energy does it have?

Think about the last time that you rode a roller coaster. What do you remember about the beginning of the ride?

Materials

- 6-6 foot sections of 1/2 inch vinyl tubing (Lowe's)
- 24 BBs (Wal-Mart or Dick's)
- 6 rolls of masking tape (Wal-Mart)
- 6 plastic cups (Wal-Mart)
- 6 dry erase panels (Lowe's)
- 6 dry erase markers (Wal-Mart)
- scratch paper and pencils
- Student Experiment Instructions
- Lab Observation Sheet
- Roller Coaster Video

Background Information

All energy exists in two basic forms, kinetic and potential. Potential energy is energy that is not "in use" (stored) and is available to do work. Kinetic energy is energy that is "in use," the energy a moving object has due to its motion. Energy can neither be created nor destroyed; it can only be transformed from one form to another. Potential energy can be transformed to kinetic energy and vice versa.

In this lesson, students will construct a model of a roller coaster. The energy that a roller coaster car (in this case, a BB) has at the top of a hill is potential energy. As the car starts down the hill, that potential energy is transformed to kinetic energy. This transformation of energy is what allows the car to go up and down hills, through loops, and come out at the end of the ride. The height of the first hill determines the amount of potential energy, in turn, affecting the amount of kinetic energy, which will be used to get the BB through the ride.

This particular activity would be used as the second lesson in a unit about energy, its forms, and its sources.

List of Terms

Energy	The ability to do work.
Work	The process of transferring energy.
Potential Energy	Energy of position; energy that is not "in use" and is available to do work.
Kinetic Energy	Energy of motion; energy that is "in use." Formula: K.E. = $\frac{\text{Mass} \times \text{Velocity}^2}{2}$
Law of Conservation of Energy	Energy can neither be created nor destroyed by ordinary means; it can only be converted from one form to another.
Energy Transformation	The change from one type of energy to another.
Gravitational Potential Energy (G.P.E.)	Potential energy that is dependent upon height. Formula: G.P.E. = Weight x Height

Plan of Action

Advance Preparation

To facilitate this lesson, the following items should be prepared ahead of time:

The materials listed above should be divided into kits. Each kit should consist of:

- One white board panel*
- One 6' section of 1/2" vinyl tubing
- 4 BBs
- One roll of masking tape
- One dry erase marker
- One Plastic cup
- Student Experiment Instructions
- Lab Observation Sheet

All items, other than the white board panel, will be placed in a large, reusable Ziploc bag.

Before the lesson begins, the roller coaster video should be prepared for viewing through the projector. The marble maze should be set up at the front table to spark interest and for use in demonstrating areas of kinetic and potential energy.

*The white board panels included in the experiment kits were purchased in a large sheet and cut into smaller panels at home using a table saw. Lowe's provides cutting as a service if you do not have the equipment at home.

A Day at the Amusement Park
Activity Procedure

Purpose: The purpose of this activity is to reinforce the concepts of potential and kinetic energy and to allow students to identify the points of maximum and minimum energy of each type. This will increase understanding of the effect of height on potential and kinetic energy. Students will also be able to use this hands-on activity to cement their understanding of the transformation of kinetic to potential energy and vice versa.

Lesson Sequence:

1.) Refresh concepts of Potential and Kinetic Energy as learned in Lesson One by showing roller coaster video about Kinetic Energy.

2.) Use the marble maze to demonstrate the potential energy at the top of a hill being transformed to kinetic energy going downhill. Have a plastic cup attached to the bottom of the maze. This will also provide an example through which students will understand the purpose of the cup in their own roller coaster experiment.

3.) Divide class into roller coaster design teams, each consisting of three students. (In the interest of time, teams will be assigned based on current seating arrangement.)

4.) Each team will receive an activity kit.

5.) Explain to the class that they will be assuming the role of roller coaster designers working on an engineering design team. The task of the design team is to create a model of their roller coaster using the vinyl tubing as the track and the BB as the car. Design teams must use their knowledge of potential and kinetic energy to get their car to the end of the track. **They must follow the rules listed in Step 7.**

6.) Explain the "rules" of the experiment.

- ✓ The roller coaster must start at the top of the first hill.
- ✓ There must be at least two loops on the track.
- ✓ There must be at least two hills after the last loop.
- ✓ Every hill must be lower than the one that comes before it.
- ✓ Every loop must be lower than the hill that comes before it.

7.) Design teams can use scratch paper for their initial and subsequent design plans.

8.) Once the team has agreed on an initial design, they can draw the design on the white board panel with a dry erase marker.

9.) Using masking tape, the designers can tape the vinyl tubing to the dry erase board over the design, which has been drawn on the board. The plastic cup should be taped to the end opening of the track to catch the BB.

10.) Holding the board flat against the wall, the designers will release **(Not Push!)** the BB into the vinyl tubing track.

11.) A successful roller coaster is one in which the BB travels from beginning to end without getting stuck in the tube.

12.) Each student will complete a Lab Observation Sheet (See Assessment & Evaluation). If he/she is unable to complete this in class, it may be done as homework. This will be graded for quality and completion (see rubric) and placed in the Science Learning Journal.

13.) ***If time allows***: Once a design team has come up with an effective design, they can change their design to include different numbers of hills and loops, etc. to further investigate the transformation between potential and kinetic energy.

14.) Students will remove tape from white board panel and tubing, clean white board panel, and return all materials to the large plastic bag.

15.) **Class Discussion:** If time allows, each team will be able to share their roller coaster with the class.

Students will be asked the following questions:

What types of things affected whether or not your roller coaster worked?
Did you notice what happened when you made a steep hill?
At what point during the ride did the BB have the most potential energy?
At what point during the ride did the BB have the most kinetic energy?
What do you think happened to the kinetic energy as the BB went from the top of the hill to the bottom of the hill?
Using the roller coaster as an example, try to explain the concept of the Law of Conservation of Energy.

For the teacher:
Using the principles of potential and kinetic energy, the students should be able to construct the roller coaster.

Possible Hypothesis: The energy at the top of the roller coaster will be enough to move the BB through all the loops and hills to reach the end.

The height of the first hill determines the initial amount of energy in the roller coaster.

Possible Conclusion: Potential energy at the top of the first hill was sufficient to lift the car to the top of the first loop. The potential energy there was enough to continue moving the car through all the loops and hills. As the car moved down, the potential energy changed to kinetic energy. As the car moved up, kinetic energy changed to potential energy.

Extended Thinking:
Friction was also a factor because it used up some of the potential energy so there was not as much kinetic energy.

Extension and Enrichment

Discuss further the effect of height on potential energy. Talk about the concept of Gravitational Potential Energy, which is potential energy that is dependent upon height. The formula for calculating G.P.E. is G.P.E. = Weight x Height. This concept helps to demonstrate the relationship between mass, height, and acceleration.

The roller coaster experiment can be adapted or extended to include the use of a heavier roller coaster car. The student can then predict what will happen when the heavier car is used in the track. Leaving the track design unchanged, students could use differently weighted cars as the independent variable in the experiment. Differently weighted BBs will be available to test this.

The student can then take height measurements of the track (overall length of tubing, height of hills, etc.) and weigh the individual roller coaster cars. Using these measurements, students should be able to calculate G.P.E.

Students may also extend this activity by measuring (with a stopwatch) the amount of time it takes the different cars to go through the track from start to finish. They can use this time measurement to determine the amount of Kinetic Energy by using the following formula. The answer will be expressed in joules.

$$\text{K.E.} = \frac{\text{mass} \times \text{velocity}^2}{2}$$

Other Differentiation:

Student groups can be predetermined so that weaker students are placed with stronger students who can support them. LD students can also participate by doing the wordsearch and matching activities that are included in the experiment kits.

Multiple Intelligences:

This lesson will appeal to a broad range of learning styles, including linguistic, logical-mathematical, spatial, kinesthetic, and naturalistic intelligences. The group nature of the project also incorporates interpersonal intelligence.

Integration

Math

Math integration is a natural part of this lesson. Measuring and time reading and recording can also be used in the extension activities. Math will also be used in further extension activities in calculating the answers by applying the formulas for Kinetic Energy and Gravitational Potential Energy.

Language Arts

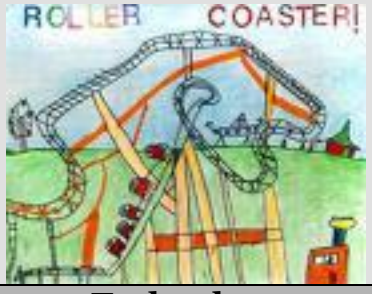
Language Arts can be integrated into this lesson by allowing students to write a poem or short story about the last time they went to an amusement park and rode a roller coaster. They can be encouraged to use descriptive language to tell about how the ride made them feel and what the effect of height is not only on potential energy, but on their emotions! Students could also be given the job of marketing their roller coaster by writing a persuasive ad.

Social Studies

Students can be challenged to find out about what engineers and physicists do and the different ways in which they affect and contribute to our society. Students could also research the history of roller coasters.

Art

Students can make artistic renderings of the roller coasters that they designed for the experiment. They could use this rendering as part of a poster promoting their roller coaster.



Technology

Students can play the Roller Coaster Tycoon, which will allow them to design roller coasters, market the ride, and make a living as an amusement park entrepreneur. There are also many websites that allow students to make and test roller coaster designs.

Assessment and Evaluation

Student learning will be assessed in several different ways during this lesson. Throughout the experiment, the teachers will circulate among the student groups to ask:

Attention Focusing Questions, such as:

What have you noticed about how much energy the car has when it goes through the loop?

Or

Action Orienting Questions, such as:

What would happen if the two loops were placed together, instead of separated by a hill?

Or

Problem Posing Questions, such as:

Can you find a way to five the car more energy by adjusting the height of the hills?

During and after the experiment, the students will complete a lab observation sheet. This will be collected, graded with a rubric, and used as a graded assessment of student learning.

Copies of the lab observation sheet and the coordinating rubric are attached.

Support Materials

Support materials to be used in this lesson include:

Student Experiment Instructions
Student Vocabulary Terms (included on Lab Observation Sheet)
Lab Observation Sheet
Grading Rubric
PowerPoint images/videos of roller coasters
Video of Potential and Kinetic Energy
Word Search
Matching Cards
Marble Maze

Resources

Lesson Plan Resources:

American Society for Engineering Education:
asee.org/acPapers/2005-2065_Final.pdf

Judy Schneider (Round and Round):
www.lessonplanspage.com/ScienceExCanIMakeARollerCoasterMO68.htm

Curricular Resources:

Chesterfield County (CPRs)
VA Department Of Education (SOLs)

Knowledge Resources:

Guy, Robert G. (Ed.) (1989) Discover Science. Illinois: Scott Foresman & Co.