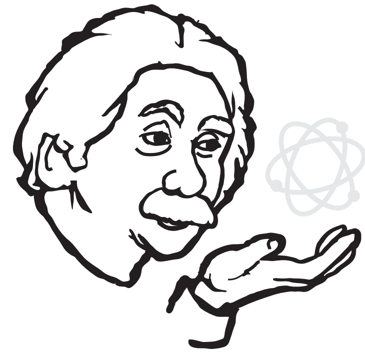
Teacher's Guide

energy weather planets light stars magnetism explore motion classification elements genes cells

Thrilling Experiments

Potential and Kinetic Energy

Grades 5-9



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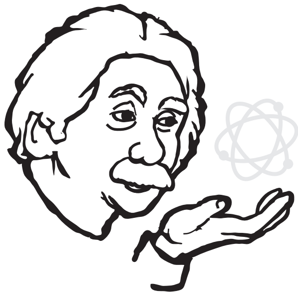

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About This Guide

Providing students with visual media is an excellent way to take them out of the classroom and into the real world. Our programs offer real-world footage, dynamic graphics, engaging dramatizations, and first-person testimonials that keep students interested and help them visualize difficult concepts. More importantly, they reinforce critical learning objectives shaped by state and national educational standards. However, the learning doesn't begin and end when the program does. You can make the learning experience even more effective by using the materials provided in this Teacher's Guide.

This guide is divided into the following sections:

- **Fast Facts** are designed to give your students a quick overview of the information presented within the video.
- **Before Viewing Activities** help identify what students already know about the subject, what they are curious about, and what they hope to learn.
- **During Viewing Activities** may be used during viewing to enhance students' understanding of the video.
- **After Viewing Activities** help students summarize and draw conclusions from the information that was presented.
- **After Viewing Quizzes** test students' retention of the information presented in the program and activity sheets.
- **Additional Resources** are designed to help you extend the information presented in the program into other areas of your curriculum.
- **Answer Keys** are provided for relevant activities or reproducible pages.
- **Script** content is provided in an unabridged version for future reference.

Program Overview

Thrilling Experiments: Potential and Kinetic Energy focuses on energy and its uses. The information presented by the narrator includes types of energy and forms of mechanical energy. Hands-on experiments are presented that demonstrate practical application of energy in mechanical and other applications.

Appropriate photos, graphics and illustrations enhance each experiment as well as live action demonstrations.

Viewing Objectives

After viewing the DVD/video and utilizing the activities provided in the Teacher's Guide, students will be able to:

- Understand and define key vocabulary words related to energy.
- Solve problems involving angular motion.
- Define, describe, and investigate forces in static and dynamic situations.
- State and explain Newton's Law of Gravitation.
- Describe the relationship between work and energy using narrative and mathematical descriptions.
- Apply the Law of Conservation of Energy to describe conceptually the conversions between potential and kinetic energy.
- Describe the relationship between momentum and impulse using narrative and mathematical descriptions.

Energy Fast Facts

- Energy is the ability to do work.
- Work involves movement.
- Any object with energy that moves is working.

- There are five types of energy: mechanical, heat, chemical, electromagnetic, and nuclear.

- Einstein was one of the first scientists to work with energy.
- $E=mc^2$ energy is equal to mass times the speed of light squared.

- The law of conservation of energy states that energy can be changed from one form to another, but cannot be created or destroyed.

- Joules are units of energy.
- Newton-Meters are units of work.
- 1 Joule is equal to the work done when the force of 1 Newton produces 1 meter of displacement.

- Two forms of mechanical energy are potential and kinetic.
- Potential energy is stored energy.
- Kinetic energy is energy in motion.
- Potential energy is converted into kinetic energy when the object begins to move, or work.

- Everything has potential energy stored in it.

- $KE=.5 \times \text{mass} \times \text{velocity}^2$
- Mass = object's volume times density
- Velocity = distance object travels/time
- Velocity = distance (d) divided by time (t)
- $PE = m \times g \times h$
- PE = mass times gravity times height

- A pendulum can illustrate the law of conservation.

Word Splash

Each of these words is related to potential and kinetic. Write a paragraph using as many of these words as you can to explain what you know about potential and kinetic energy.

mass

distance

potential

mechanical

chemical

electromagnetic

velocity

work

Heat

relativity

KINETIC

energy

nuclear

Name ______________________________

Where Is It?

Energy is explored throughout the video. Think for a moment about what you have done so far today. Besides physical energy, where have you experienced energy being used today? Give at least 5 examples, with explanatory details.

Example ONE
____
____

Example TWO
____
____

Example THREE
____
____

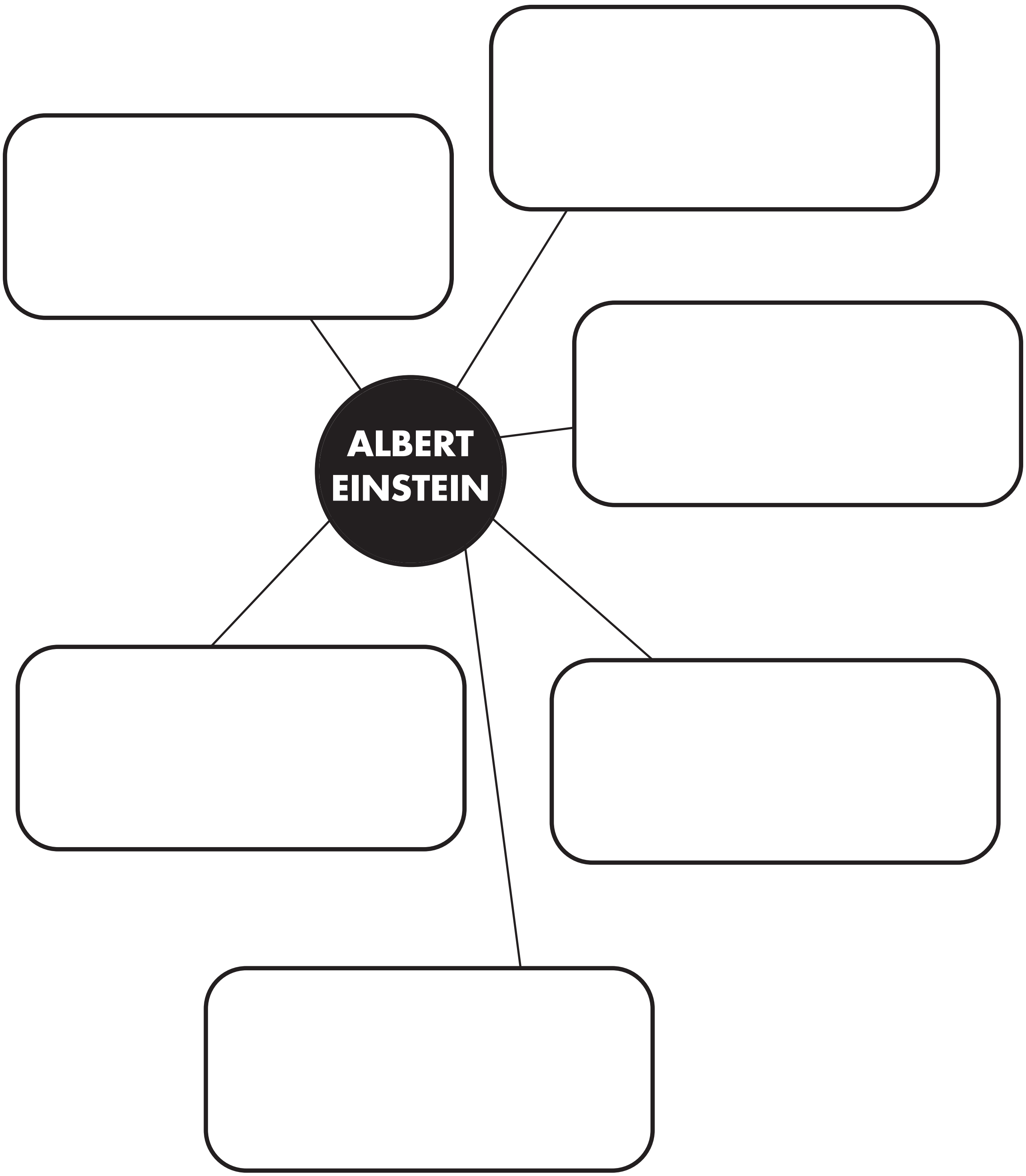
Example FOUR
____
____

Example FIVE
____
____

Name ______________________________

Albert Who?

The video you will see contains information about Albert Einstein. Use the web below to brainstorm all that you and your classmates already know about this great scientist.



Name ____________________

True or Untrue?

Each pair of statements below contains one true statement and one untrue statement. Put a check mark next to the true statement in each pair.

___ 1. Any object with energy that moves is working.
___ 1. Work does not involve energy.

___ 2. Energy is equal to the speed of light divided by mass.
___ 2. Energy is equal to mass times the speed of light squared.

___ 3. Einstein developed the theory of plate tectonics.
___ 3. Einstein developed the theory of relativity.

___ 4. Newtons are units of energy.
___ 4. Joules are units of energy.

___ 5. Two forms of mechanical energy are potential and kinetic.
___ 5. Two forms of mechanical energy are heat and electromagnetic.

___ 6. Potential energy is energy in motion.
___ 6. Kinetic energy is energy in motion.

___ 7. Everything does not have potential energy.
___ 7. Everything has potential energy.

___ 8. Velocity equals distance times time.
___ 8. Velocity equals time divided by distance.

Name ______________________________

Vocabulary Cloze

Vocabulary words that you will see and hear in the video are listed in the box below. Using the word bank, match each word with its corresponding sentence and fill in the blanks.

1. Energy is the ability to do __________________ .

2. Work involves __________________ .

3. Five types of energy are

__________________ __________________

__________________ __________________

____

4. Albert Einstein developed the __________________ .

5. Energy is equal to __________________ times the speed of light squared.

6. The fact that energy can be changed from one form to another is part of the __________________ .

7. __________________ are units of energy.

8. __________________ are units of work.

9. Two forms of mechanical energy are

__________________ __________________

10. Potential energy is __________________ energy.

11. Kinetic energy is __________________ energy.

12. __________________ is equal to distance divided by __________________ .

13. Potential energy is equal to mass times __________________ times __________________ .

time
potential
movement
motion
velocity
Newton-Meters
chemical
electromagnetic
work
heat
kinetic
Theory of Relativity
mechanical
stored
Law of Conservation of Energy
gravity
height
mass
nuclear
Joules

Name ______________________________

Friction Facts

As you view the video, pay close attention to the information about the five types of energy. Write a short description about each type of energy in the charts below.

Chemical

____

____

Heat

____

____

Mechanical

____

____

Electromagnetic

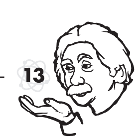
____

____

Nuclear

____

____



Name ______________________________

Energy Basics

In the video, demonstrations are presented which outline the basics of energy. Use the information presented in the video to complete the following organizers about energy.

TEMPERATURE AND KINETIC ENERGY

materials used: ______________________________
____

demonstration diagram:

what happened? ______________________________
____

RELEASING POTENTIAL ENERGY

materials used: ______________________________
____

demonstration diagram:

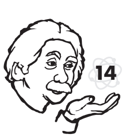
what happened? ______________________________
____

CALCULATING KINETIC ENERGY

materials used: ______________________________
____

demonstration diagram:

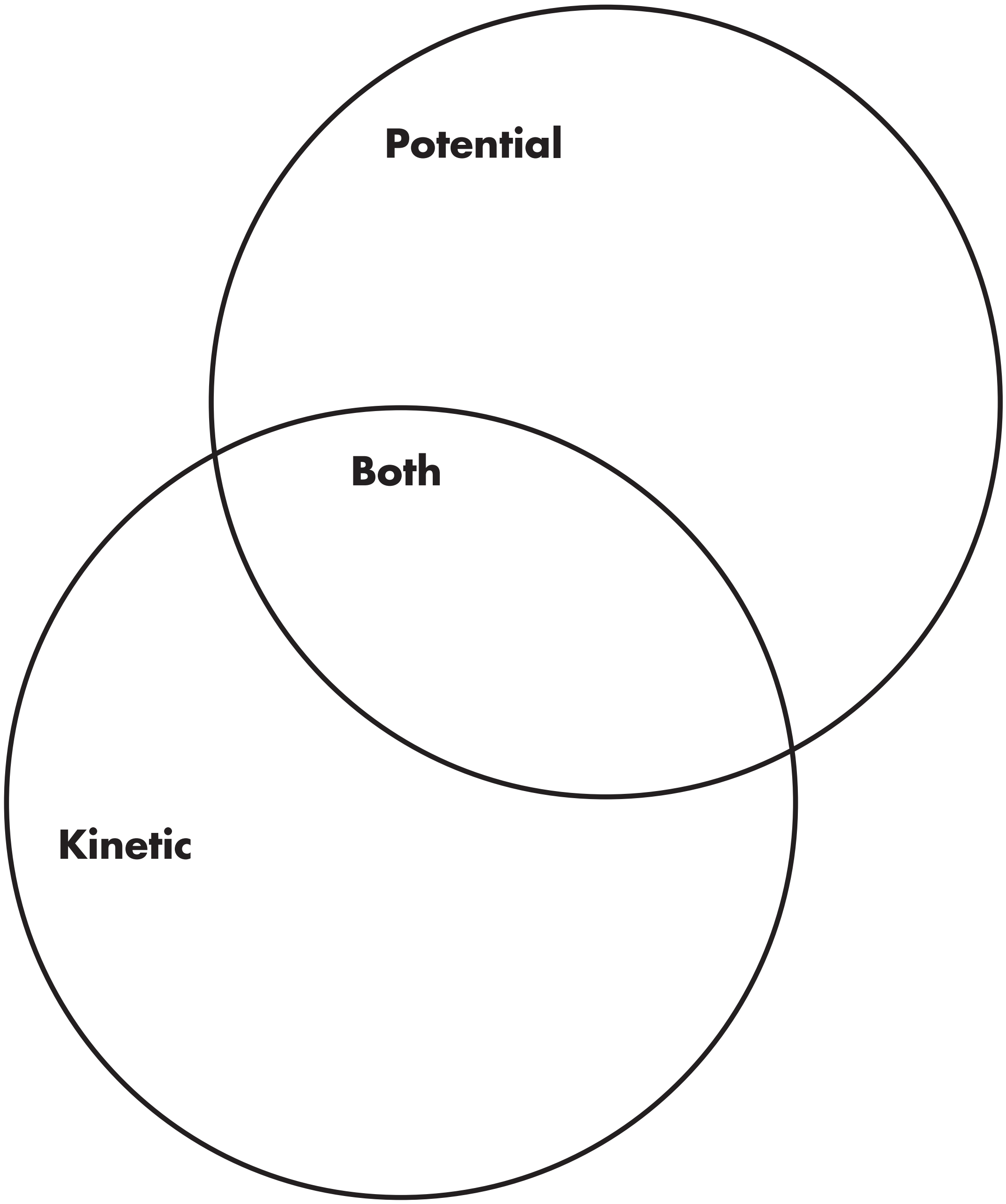
what happened? ______________________________
____

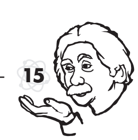


Name ______________________________

Potential or Kinetic?

While watching the video, pay attention to the two types of energy. Complete the Venn diagram below, comparing the two.





Name ____________________

Energy Math

Potential and Kinetic energy can be equated to numerical equations. As you watch the video, record the equations you see. You will be using these at a later time. Write each equation numerically and in words.

Theory of Relativity

numeric equation ____________________

written equation ____________________

____

____

Kinetic Energy

numeric equation ____________________

written equation ____________________

____

____

Velocity

numeric equation ____________________

written equation ____________________

____

____

Potential Energy

numeric equation ____________________

written equation ____________________

____

____

Name ____

Stepping Through Energy

While watching the video, look for the experiment that shows a release of potential energy. The steps to this experiment are listed below. Number the steps to show the correct order in recreating this experiment.

______ Slide the BBQ skewer through the holes on the small can.

______ Gather materials - small bag of unsalted and shelled peanuts, a cork, a needle, a large coffee can with both ends removed, a soup can, a can opener, a hammer, a nail, a metal BBQ skewer, and water.

______ Take the temperature of the water in the can after the peanut has gone out.

______ Carefully push the eye of the needle into the end of the cork.

______ Take the temperature of the water with the thermometer.

______ Record the second temperature and compare.

______ Use the hammer and nail to punch 2 holes near the top of the soup can, opposite each other.

______ Light the peanut with matches.

______ Fill the soup can about half full with water.

______ Place the cork and peanut on a nonflammable surface like tin foil.

______ Push the pointed end of the needle into the peanut.

______ Once the peanut is lit, immediately place the large can over it.

______ Remove the top end of the soup can.

______ Take the small can with the skewer through it and balance it on the large can that has been placed on top of the burning peanut.

______ Let the water sit so that it is at room temperature.

______ Use the hammer and nail to punch holes around the bottom of the large can.

Name ______________________________

Energy Law

In the space below, draw and label a diagram to show the egg experiment as seen on the video. Be sure to include all labeled parts in your diagram. At the bottom of the page, write the conclusion that was drawn from completing this experiment.

Conclusion

____

____

____

____

____

____

____

____

Heads Up!

Follow the steps to experiment with potential and kinetic energy.

1. Gather materials -A metal weight or rock with a mass of roughly 5 kilograms. (10 pounds), a soda bottle filled with water, a wooden plank about 2 meters long. (2″ x 4″ – or smaller), 2 tennis balls – one cut in half, wood screw and washer to fix half tennis ball onto plank at one end.

2. Rest the plank on the soda bottle. The water inside the bottle prevents it from collapsing.

3. Place the tennis ball on the half tennis ball at one end of the plank.

4. Drop the weight onto the other end of the plank to launch the tennis ball upwards.

5. Vary the distance between the fulcrum of the lever (the soda bottle) and one end of the plank to increase or decrease the amount of leverage applied to the tennis ball when launched.

6. Vary the height from which the weight is dropped onto the other end of the plank.

7. Determine the best position for the fulcrum to provide maximum altitude for the tennis ball.

8. Describe how the gravitational potential energy of the weight is converted to kinetic energy as it falls and how the kinetic energy of the tennis ball is converted to gravitational potential energy as it travels upwards – and back to kinetic energy as it falls.

____

____

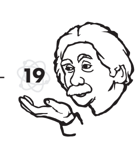
____

9. Theoretically, the tennis ball should gain the most kinetic energy when it is launched as far as possible from the fulcrum when the weight is dropped onto the other end of the plank. How does the mass of the plank affect the best position for the fulcrum?

____

____

____



Vocabulary Match-Up

Draw a line to match each word with its correct definition.

- Heat Energy
- Joule
- Kinetic Energy
- Elastic Energy
- Energy
- Kinetic Energy
- Mechanical Energy
- Nuclear Energy
- Gravity
- Potential Energy
- Chemical Energy

- capacity to do work
- unit of energy and of work
- energy resulting from motion
- energy resulting from position in a force field
- force that results from a force field that exists around objects
- energy of an object due to speed
- energy of an object due to position or motion
- stored in the food we eat, gives us energy, cars run on it
- stored in a stretched spring, can do work when released
- stored in the nucleus of an atom, runs the Sun, hydrogen bomb
- depends on the energy of the molecules

Name ______________________________

Fact Quiz

Fill in the missing words

1. The two main forms of mechanical energy are:

   ____

   ____

2. Kinetic energy is the energy of ______________ .

3. What equation is used to represent kinetic energy? ____________________

4. Explain what the formula means.

   ____

5. The standard metric unit of measurement for kinetic energy is the ______________ .

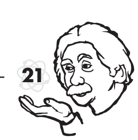
6. Potential energy is ______________ .

7. What equation is used to represent potential energy? ____________________

8. Explain what the formula means.

   ____

9. What is the energy of an object as a result of its motion called? ______________



Name ______________________________

Fact Quiz (cont.)

Answer the following questions.

10. If a person tries to push a car that has its hand brake on and the car doesn't move, is work being done on the car?

____

____

____

11. If the person manages to move the car a distance of 2 meters in 2 seconds by applying a force of 300 N in the direction of movement: How much work is done?

____

____

____

12. Gravitational potential energy is always measured in terms of an object's position relative to another position. Relative to the floor, what is gravitational potential energy associated with a 10 Kilogram mass that is 2.5 meters above the floor?

____

____

____

13. If the potential energy stored in a spring is equivalent to 300 Joules, how much work could it do?

____

14. If 200 Joules are used to wind up the spring of a clockwork motor, neglecting friction, how much work is done?

____

Extensions

• Clipped Car Investigation

Distribute the following materials to each group of students: a 30-inch length of string, a small, freely rolling toy car, a paper clip opened to serve as a hook, a variety of weights that can be attached to the paper-clip hook, and a stopwatch. Divide the class into small groups, distributing the necessary materials to each group. Instruct students to set up their experiment by tying one end of the string onto the toy car and the other end to the paper-clip hook. Have students place their cars on a flat table or desktop and hang the paper-clip hook over the edge of the table. Calling attention to the variety of weights each group has been given, ask students to predict how the cars will move if different weights are hung from the paper-clip hook and allowed to fall to the floor. Possible predictions might include: (1) as the weight increases, the car will move with increasingly higher constant speeds toward the edge of the table; (2) different weights will have no effect on how the car moves; (3) as the weight increases, the car will move toward the edge of the table with greater and greater acceleration. (Correct prediction: the car will move with greater acceleration as the weight increases.) After students have made their predictions, ask them to support them by creating illustrated diagrams using arrows and labels to indicate the forces and counter forces acting on the car. Once the charts are complete, have students conduct experiments using the cars, weights, and stopwatch to confirm or refute their predictions. Students should record the results of their experiments. Extension/Challenge: Challenge them to determine a mathematical relationship between the mass of the car and the weight of the object attached to the paper-clip hook.

• Gravity Writing

Initiate a class discussion about gravity and how it affects us each day. Now ask students to write a short story about what a typical day would be like if there was no gravitational force. Students must include descriptions of normal activities, such as eating meals, sleeping, going to school, participating in a sport, etc.

• Science at the Dam

Students can study the development of hydroelectric dams in the Tennessee Valley and the Northwest used to turn the potential energy and kinetic energy of falling water to produce electrical energy to do work. Students can then listen to and read the lyrics of Woodie Guthrie's songs about the Columbia River and the Grand Coulee Dam. Students may also read and discuss Ken Kesey's vivid and physically accurate description of a downhill escape on a railroad handcar, in the novel A Sailor Song.

Extensions

- **Tennis Ball Roller Coaster**
  Tell students they will be designing and constructing cardboard "tennis ball" roller coasters with three hills. The tennis ball in each design must start from the top of the first hill, roll up and down the other two hills, and exit the end of the track. Each roller coaster will be judged in a class competition. The track with the greatest total of vertical heights for all three hills—if the tennis ball completes the course—will be named the winning design. Have students consider the following when designing their roller coasters: Can all the hills be the same height? If not, why? Can they get bigger or must they get smaller? How will you determine how big or how small the hills can be and still win this contest? Does how steep the hill is count? Is it better to make the hills steep or not so steep? Why? How curvy should the tops of the hills and the valleys be? Should you design sharp turns or smooth turns? Why? What provides resistance on the roller coaster causing the tennis ball to slow down? How can this resistance be reduced? Divide students into small groups and give each group the materials listed. The left and right roller coaster tracks will be made from the two pieces of corrugated cardboard that must be cut out as identical shapes. Each valley in the roller coaster *must* dip to a height of 20 centimeters from the bottom of the cardboard. Have students use heavy-duty scissors or a box knife to cut out both tracks. They will probably have their own ideas on how the roller coaster should be shaped, but here is an idea on how to lay out the roller coaster on the cardboard. Students should cut out twenty-five 4 cm ? 12 cm rectangles. These rectangles will serve as spacers between the two cutout tracks. Put glue along both of the 12-centimeter edges and fasten them to various places between the two tracks so that the tracks are rigid and separated by a distance of 4 centimeters. Measure the heights of each of the three required hills and add them up. The roller coaster with the greatest total height of the three hills, whose tennis ball successfully completed its journey, is the winner.

- **Riding on the Gravity Express**
  Amusement park rides, water park rides, and rides in the local playground provide thrills while gravitational potential energy (GPE) and kinetic energy (KE) transform from one to the other. Make a list of such rides and explain where in the ride the GPE and the KE are the greatest. Where do the forces act in each ride providing the resistance that converts the total GPE and KE into heat?

- **Sports Connection**
  Have students choose a sporting event to research and ask them to write descriptions of how acceleration, mass and force interact in the event chosen. Direct struggling students toward car racing.

Extensions

- **The Thrill Factor**
  On rides such as roller coasters (and even swings), where the rider experiences fast changes in velocity due to increases or decreases in speed or simply changes in direction, the rider is subjected to unbalanced forces that give the rider an illusion of feeling heavier or lighter than normal. Through our sensing of these unbalanced forces, we judge the "thrill factor" of a ride to be high when they occur frequently in a ride. Some of the best rides give us the illusion of weightlessness for short periods of time. Where on the roller coaster would you expect to feel heavier, and where would you feel lighter? Use Newton's law of inertia to explain these illusions of heaviness and lightness, also known as positive and negative "g forces." Students can design and conduct experiments and demonstrations to back up their explanations.

- **Bob Who?**
  To demonstrate the conversion of elastic potential energy to kinetic energy and gravitational potential energy, give each group of students one coiled spring (can be made from winding 8 meters of wire onto a plastic pipe), a metal object with a mass of 150 grams (called a bob), a board with a bracket for mounting the upper end of the spring, and white paper attached to the board for marking the upper and lower positions of the metal object as it oscillates on the end of the spring. Weigh the metal object. (bob), attach one end of the spring to the mounting bracket at the top of the board and attach the bob to the other end of the spring. Mark the normal position at rest of the bob by placing a mark on the paper directly behind it on the board. Pull the bob about 20 cm below its normal position at rest and mark the paper behind the bob. Let the bob go and mark the highest point reached as it cycles up and down. Measure the distance between the highest and lowest points As the bob cycles, elastic potential energy is converted to kinetic energy to gravitational potential energy back to kinetic energy and back to elastic potential energy. The gravitational potential energy is calculated from the mass of the bob and the height reached above its normal position at rest. $PE = mgh$. As the bob cycles, elastic potential energy is converted to kinetic energy to gravitational potential energy back to kinetic energy and back to elastic potential energy. The gravitational potential energy is calculated from the mass of the bob and the height reached above its normal position at rest. $PE = mgh$. The maximum speed can be calculated from the kinetic energy equation: $KE = ?mv^2$

Extensions

- **Soda Towers**
  Have students create soda can towers by stacking empty soda cans in a variety of different ways. Use different variations and different numbers of cans to create several towers. Crash the towers by rolling a single empty can into them. Students should observe the cans as they fall and note how far they roll. Have them add up the number of inches they roll and graph their findings.

- **Physical Science**
  Students can calculate the work done and energy consumed over an entire work out. Track and field, skiing, gymnastics, and professional wrestling provide great examples of the use of work and energy transformations.

- **Marbles in Motion**
  Gather marbles or other small balls of various mass, ruler or other guide track, lined paper and tape, stopwatch. Make a V-shaped catcher from cardboard, a 5x8-index card, etc. Tape the lined paper and the ruler down to a flat surface. Mark the starting point for the catcher, making sure it is exactly in line with the ball the marbles take. Flick the marble along the track and time how long it takes from when it leaves the track until it hits the catcher. Precise timing is tricky. It will take practice. The longer the distance from the ruler to the catcher the longer the time is and the easier to time accurately, but the more the marble will slow down due to friction. If no stopwatch is available, rough qualitative comparisons can still be made. Measure the distance from the end of the track to the catcher $v=d/t$. Note how far the catcher is dragged by the marble. Note the effect of varying speeds and masses. Do the same experiment on a larger scale with larger balls rolled across the floor into a larger catcher made rom a cardboard box. Try different designs for the catcher. Use baseballs, tennis balls, softballs etc. The balls can be rolled without a track to guide them as care is taken to hit the catcher in the center. Again note the effects of mass and velocity. The faster a car is going, the longer the distance required to stop.

- **Tug-O-War Science**
  Head outside to the playground for a tug of war! Use different size groups of students on each side. Record the number of minutes it takes to win when the students on the winning side are short, tall, heavy, etc. Have additional contests with the students standing on various surfaces (grass vs. pavement for example) and discuss whether one team has an advantage or not. Have students record and graph the results from the contests for comparison.

Suggested Reading List

Arnold, Nick. *Fatal Forces* Scholastic, 1997. Let science be fun as this college professor explains physical forces so that even nonscientists can understand them. Lots of humor and lots of cartoons make this an entertaining, informative volume.

Feynman, Richard. *Six Easy Pieces: Essentials of Physics Explained by Its Most Brilliant Teacher* Addison-Wesley Publishing Company, 1995. This witty discussion of gravity, written without equations and technical jargon, is an ideal introduction to the concept written by one of the most admired and accessible scientists of our time.

Feynman, Richard. *The Character of Physical Law* MIT Press, 1994. Fascinating writing by a truly great scientist—gravitation is Richard Feynman's principal law in this outstanding book. His approach and enthusiasm for the subject makes this title classic reading in the field.

Gardner, Robert. *Experiments with Motion* Enslow, 1995. Easy-to-do experiments better illustrate the text and allow a student to understand Newton's Laws of Motion and their application to space flight as well as to the movement of animals and vehicles. Diagrams, explicit lists of materials needed, answers to puzzles, and a bibliography contribute to the usefulness of this work.

Cook, Nick. *Roller Coasters, or, I Had So Much Fun I Almost Puked* Carolrhoda Books, 1998. It's all here – the history of coasters, the physics that make them work, different types of roller coasters, and how they are designed and constructed. There are great pictures, easy-to-understand explanations, and even a section on tips for a scarier ride.

Morgan, Sally and Adrian. *Movement* Facts on File, 1993. Animals have adapted over many thousands of years to move successfully; man has studied and put to use the design of animals to make machines that move. The experiments provided in this book allow a better understanding of both animals and machines and the forces that affect their movement. An index, glossary, and answers to questions are included.

Suggested Reading List

Shafer, Mike and Scott Rutherford. *Roller Coasters* MBI Publishing, 1998. This book includes a history of roller coasters and sidebars explaining how they work, but primarily gives region-by-region information on the best coasters in the United States. Included are the location, length, age, and features of each. The authors also provide an unofficial top-twenty ranking of the best-of-the-best.

Wood, Robert W. *Mechanics Fundamentals* Learning Triangle Press/McGraw-Hill, 1996. Important principles of physics, specifically relating to the effect of forces on objects at rest or in motion, are explained through the simple-to-perform experiments in this book. Line drawings illustrate all experiments and a glossary explains new terms.

Internet Sites

Below is a list of sites that you may use to find more information about potential and kinetic energy. Due to routine web maintenance, not all of the links will be accurate at the time of access. If the link is not available, try to conduct a search on that topic from the main site or from a search engine.

Roller Coaster Physics - The Book

Tony Wayne tells us everything there is to know about the physics of energy transitions while experiencing the ups and downs on your favorite roller coaster ride.

http://www.rollercoaster.com/designers_corner/physics/physics_book_01.html

Amusement Park Physics: Roller Coaster

Read about the principles for designing roller coasters and then immediately apply this knowledge by designing and testing your own online roller coaster.

http://www.learner.org/exhibits/parkphysics/coaster.html

Inventing the Scream Machine

When were they invented? How have they changed? Who are the heroes of the roller coaster industry? Starting in the 18th Century, follow the historical evolution of the modern roller coaster on this clickable and informative roller coaster history timeline

http://coasters.eb.com/

Discovery Channel: Thrills, Chills & Spills

Top ten coasters, coaster webcam, coaster crosswords, coaster history, and design your own coaster. If you've got the stomach for such thrills, chills and spills, Discovery Online has it all.

http://www.discovery.com/exp/rollercoasters/thrills/thrills.html

Internet Sites

Disney's Coaster
A free download of Disney's "Coaster" design software is available at this weblink. After designing your coaster, jump on board your virtual creation and have a front row seat for the thrill of your life!

http://www.compusmart.ab.ca/remi/coaster/dcedit.html

Universal Gravitation
Teacher Tom Henderson provides us with an interactive physics textbook that helps students to understand gravity with text and animations.

http://www.glenbrook.k12.il.us/gbssci/phys/Class/circles/u6l3a.html

Exploring Gravity
An introductory, intermediate and advanced online tour of our understanding of gravity from ancient times to theoretical constructs like black holes. Check your knowledge of this phenomenon with the online gravity test.

http://www.curtin.edu.au/curtin/dept/phys-sci/gravity/index2.htm

Amusement Park Physics - Roller Coaster
Put your knowledge of gravitational potential energy to work and design and test drive your very own roller coaster at this hands on and "physics is phun" web site.

http://www.learner.org/exhibits/parkphysics/coaster.html

Word Splash

Responses will vary, but teachers should gain an understanding of the information students already own regarding this topic

mass

distance

potential

mechanical

chemical

electromagnetic

velocity

work

Heat

relativity

KINETIC

energy

nuclear

ANSWER KEY

ANSWER KEY

Where Is It?

Answers will vary, but may include anything from running water to brushing teeth to driving to school

Example ONE

Example TWO

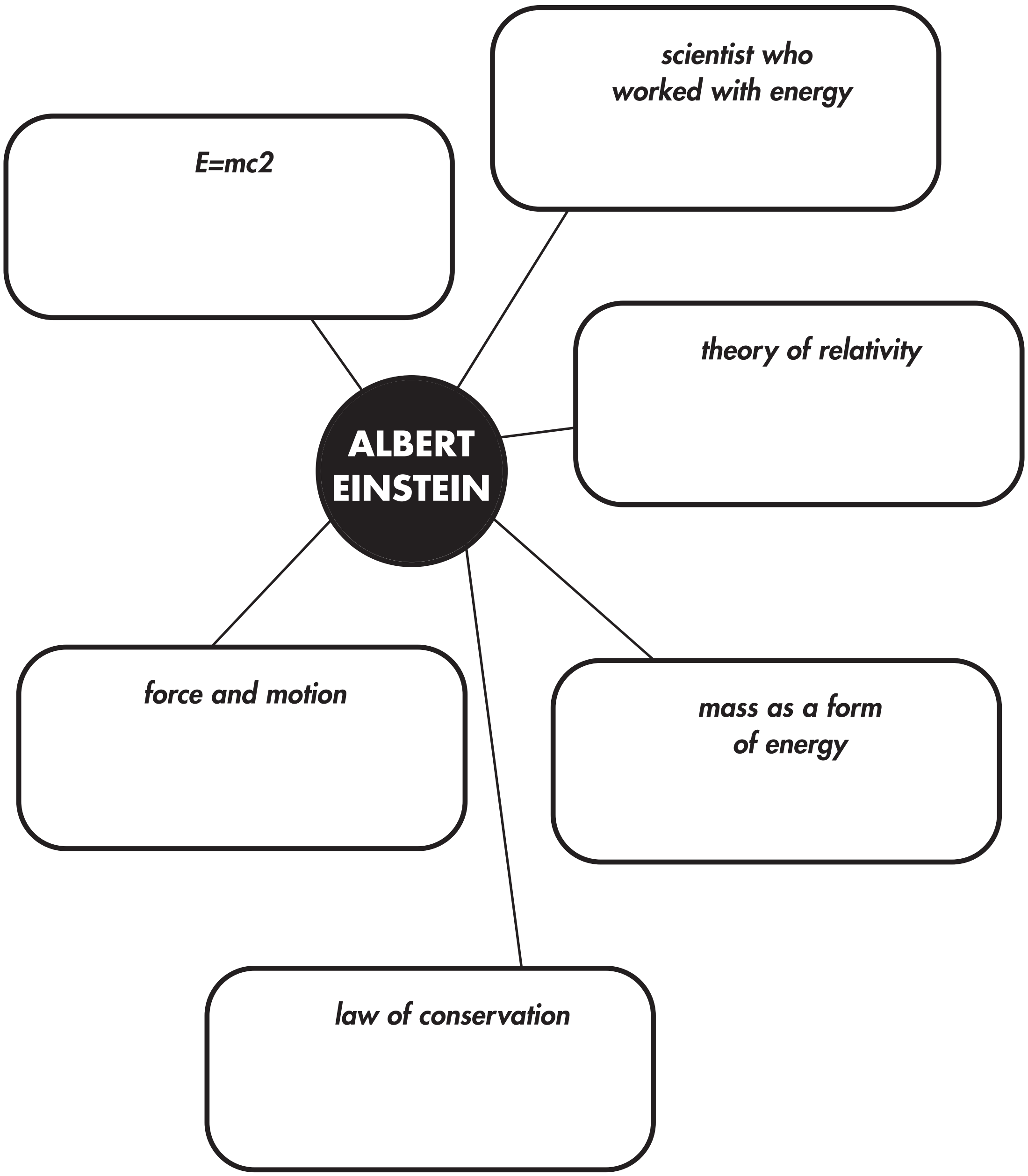
Example THREE

Example FOUR

Example FIVE

Albert Who?

Answers will vary, possible answers given



ANSWER KEY

ANSWER KEY

True or Untrue?

Each pair of statements below contains one true statement and one untrue statement. Put a check mark next to the true statement in each pair.

✔ 1. Any object with energy that moves is working.
___ 1. Work does not involve energy.

___ 2. Energy is equal to the speed of light divided by mass.
✔ 2. Energy is equal to mass times the speed of light squared.

___ 3. Einstein developed the theory of plate tectonics.
✔ 3. Einstein developed the theory of relativity.

___ 4. Newtons are units of energy.
✔ 4. Joules are units of energy.

✔ 5. Two forms of mechanical energy are potential and kinetic.
___ 5. Two forms of mechanical energy are heat and electromagnetic.

___ 6. Potential energy is energy in motion.
✔ 6. Kinetic energy is energy in motion.

___ 7. Everything does not have potential energy.
✔ 7. Everything has potential energy.

✔ 8. Velocity equals distance times time.
___ 8. Velocity equals time divided by distance.

Vocabulary Cloze

Vocabulary words that you will see and hear in the video are listed in the box below. Using the word bank, match each word with its corresponding sentence and fill in the blanks.

1. Energy is the ability to do *work* .

2. Work involves *movement* .

3. Five types of energy are
mechanical *electromagnetic*
heat *nuclear*
chemical

4. Albert Einstein developed the *Theory of Relativity* .

5. Energy is equal to *mass* times the speed of light squared.

6. The fact that energy can be changed from one form to another is part of the *Law of Conservation of Energy* .

7. *Joules* are units of energy.

8. *Newton-Meters* are units of work.

9. Two forms of mechanical energy are
potential *kinetic*

10. Potential energy is *stored* energy.

11. Kinetic energy is *motion* energy.

12. *Velocity* is equal to distance divided by *time* .

13. Potential energy is equal to mass times *gravity* times *height* .

time
potential
movement
motion
velocity
Newton-Meters
chemical
electromagnetic
work
heat
kinetic
Theory of Relativity
mechanical
stored
Law of Conservation of Energy
gravity
height
mass
nuclear
Joules

ANSWER KEY

Friction Facts

As you view the video, pay close attention to the information about the five types of energy. Write a short description about each type of energy in the charts below.

Chemical
chemical energy from chemicals

Heat
heat energy from heat

Mechanical
mechanical energy from a machine

Electromagnetic
electromagnetic energy from an electromagnet

Nuclear
nuclear energy from a nuclear reaction

******note to teacher - lead to discussion about examples found in the real world*

Energy Basics

In the video, demonstrations are presented which outline the basics of energy. Use the information presented in the video to complete the following organizers about energy.

TEMPERATURE AND KINETIC ENERGY

materials used: *thermometer, chocolate milk, blender*

demonstration diagram: *draw the set-up of the experiment*

what happened? *the increase in energy raised the temperature of the milk*

RELEASING POTENTIAL ENERGY

materials used: *water, small bag of unsalted, shelled peanuts, cork, needle, large coffee can with ends removed, soup can, can opener, hammer, nail, metal BBQ skewer*

demonstration diagram: *draw the set-up of the experiment*

what happened? *burning the peanut released its potential energy, converting it to kinetic or heat energy, heating the water*

CALCULATING KINETIC ENERGY

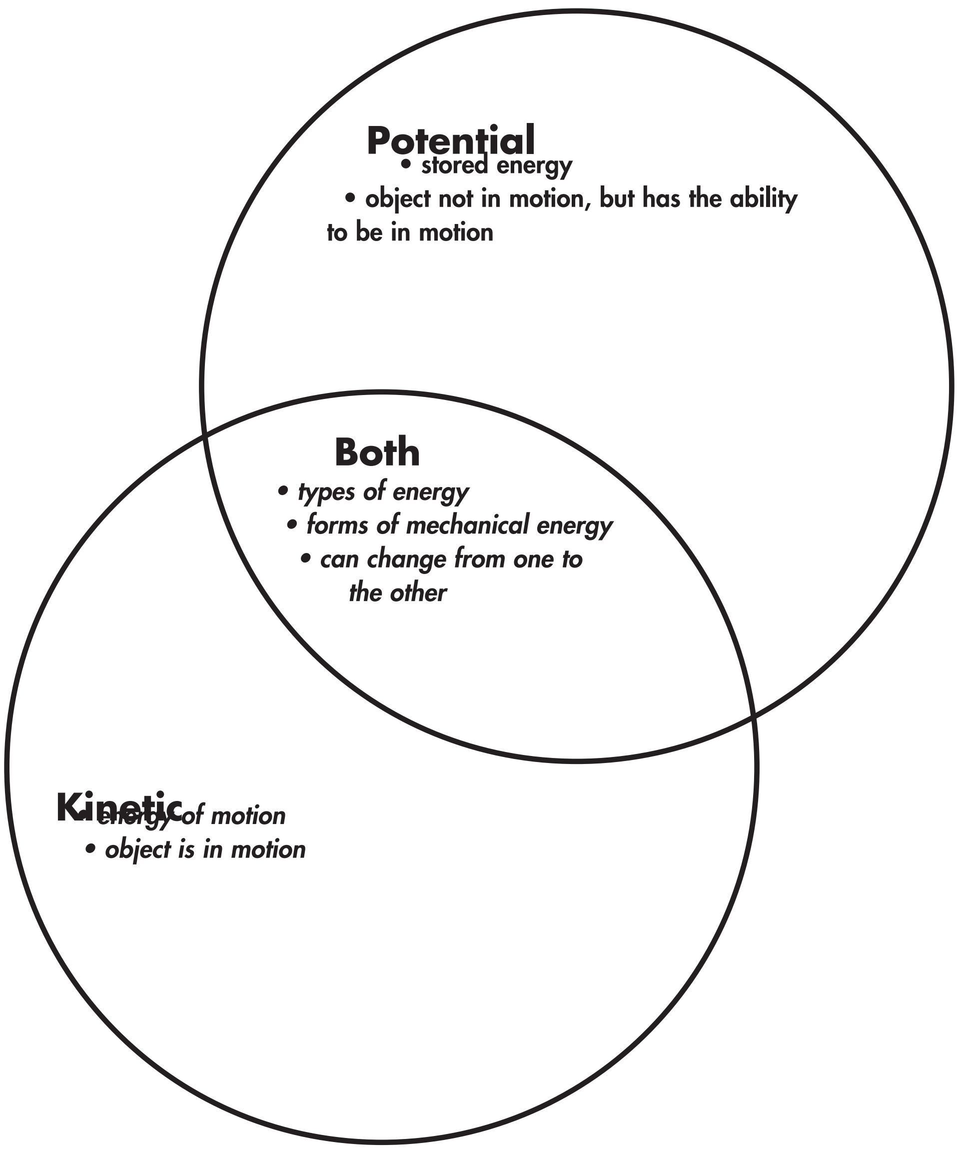
materials used: *basketball, golf ball, tennis ball, ramp, stopwatch*

demonstration diagram: *draw the set-up of the experiment*

what happened? *kinetic energy equals .5 times mass times velocity squared*

Potential or Kinetic?

Suggested answers below.



Energy Math

Potential and Kinetic energy can be equated to numerical equations. As you watch the video, record the equations you see. You will be using these at a later time. Write each equation numerically and in words.

ANSWER KEY

Theory of Relativity

numeric equation *$E = MC^2$*

written equation *Energy is equal to the mass times the speed of light squared.*

Kinetic Energy

numeric equation *$KE = .5 \times m \times v^2$*

written equation *Kinetic Energy is equal to one-half the mass times the velocity squared.*

Velocity

numeric equation *V = d divided by t*

written equation *Velocity is equal to the distance divided by the time.*

Potential Energy

numeric equation *$PE = m \times g \times h$*

written equation *Potential Energy is equal to the mass times the gravity times the height.*

ANSWER KEY

Stepping Through Energy

While watching the video, look for the experiment that shows a release of potential energy. The steps to this experiment are listed below. Number the steps to show the correct order in recreating this experiment.

7 Slide the BBQ skewer through the holes on the small can

1 Gather materials - small bag of unsalted and shelled peanuts, a cork, a needle, a large coffee can with both ends removed, a soup can, a can opener, a hammer, a nail, a metal BBQ skewer, and water.

15 Take the temperature of the water in the can after the peanut has gone out.

2 Carefully push the eye of the needle into the end of the cork.

10 Take the temperature of the water with the thermometer.

16 Record the second temperature and compare

6 Use the hammer and nail to punch 2 holes near the top of the soup can, opposite each other.

12 Light the peanut with matches

8 Fill the soup can about half full with water.

11 Place the cork and peanut on a nonflammable surface like tin foil.

3 Push the pointed end of the needle into the peanut.

13 Once the peanut is lit, immediately place the large can over it.

5 Remove the top end of the soup can.

14 Take the small can with the skewer through it and balance it on the large can that has been placed on top of the burning peanut.

9 Let the water sit so that it is at room temperature.

4 Use the hammer and nail to punch holes around the bottom of the large can.

Energy Law

In the space below, draw and label a diagram to show the egg experiment as seen on the video. Be sure to include all labeled parts in your diagram. At the bottom of the page, write the conclusion that was drawn from completing this experiment.

All diagrams should include the specific materials used for the experiment - egg, string, sticky tape, and ring stand.

The egg should be connected to the string with the stick tape and the string should be connected to the ring stand.

The pendulum arrangement should be clearly shown.

Conclusion

when the pendulum swings back and forth its potential energy has been converted to kinetic energy and vice versa. When the pendulum is pulled up against the wall the egg isn't moving so it is in maximum potential energy. Once the pendulum is released into motion, its potential energy is quickly converted to kinetic energy. The pendulum has different amounts of potential and kinetic energy throughout its entire swing. These different amounts of energy always add up to the original amount of energy the pendulum started with.

ANSWER KEY

Heads Up!

Follow the steps to experiment with potential and kinetic energy.

1. Gather materials -A metal weight or rock with a mass of roughly 5 kilograms. (10 pounds), a soda bottle filled with water, a wooden plank about 2 meters long. (2" x 4" – or smaller), 2 tennis balls – one cut in half, wood screw and washer to fix half tennis ball onto plank at one end.

2. Rest the plank on the soda bottle. The water inside the bottle prevents it from collapsing.

3. Place the tennis ball on the half tennis ball at one end of the plank.

4. Drop the weight onto the other end of the plank to launch the tennis ball upwards.

5. Vary the distance between the fulcrum of the lever (the soda bottle) and one end of the plank to increase or decrease the amount of leverage applied to the tennis ball when launched.

6. Vary the height from which the weight is dropped onto the other end of the plank.

7. Determine the best position for the fulcrum to provide maximum altitude for the tennis ball.

8. Describe how the gravitational potential energy of the weight is converted to kinetic energy as it falls and how the kinetic energy of the tennis ball is converted to gravitational potential energy as it travels upwards – and back to kinetic energy as it falls.

Although answers will vary, students should correctly identify transfers of energy.

9. Theoretically, the tennis ball should gain the most kinetic energy when it is launched as far as possible from the fulcrum when the weight is dropped onto the other end of the plank. How does the mass of the plank affect the best position for the fulcrum?

Students should be able to demonstrate their answer, and prove it with the materials.

Vocabulary Match-Up

Draw a line to match each word with its correct definition.

- Heat Energy
- Joule
- Kinetic Energy
- Elastic Energy
- Energy
- Kinetic Energy
- Mechanical Energy
- Nuclear Energy
- Gravity
- Potential Energy
- Chemical Energy

- capacity to do work
- unit of energy and of work
- energy resulting from motion
- energy resulting from position in a force field
- force that results from a force field that exists around objects
- energy of an object due to speed
- energy of an object due to position or motion
- stored in the food we eat, gives us energy, cars run on it
- stored in a stretched spring, can do work when released
- stored in the nucleus of an atom, runs the Sun, hydrogen bomb
- depends on the energy of the molecules

ANSWER KEY

ANSWER KEY

Fact Quiz

Fill in the missing words

1. The two main forms of mechanical energy are:

   potential

   kinetic

2. Kinetic energy is the energy of *motion* .

3. What equation is used to represent kinetic energy? *KE = .5 x m x v²* → $KE = .5 \times m \times v^2$

4. Explain what the formula means.

   one-half the mass times the velocity squared

5. The standard metric unit of measurement for kinetic energy is the *Joule* .

6. Potential energy is *stored energy* .

7. What equation is used to represent potential energy? *PE = mgh*

8. Explain what the formula means.

   mass times gravity times height

9. What is the energy of an object as a result of its motion called? *kinetic energy*

Fact Quiz (cont.)

Answer the following questions.

10. If a person tries to push a car that has its hand brake on and the car doesn't move, is work being done on the car?

No. Work is force x distance. However, if the car or the person's hands become deformed while pushing, some work is done but it's difficult to measure.

11. If the person manages to move the car a distance of 2 meters in 2 seconds by applying a force of 300 N in the direction of movement: How much work is done?

2m x 300N = 600 Joules

12. Gravitational potential energy is always measured in terms of an object's position relative to another position. Relative to the floor, what is gravitational potential energy associated with a 10 Kilogram mass that is 2.5 meters above the floor?

gravitational potential energy = mgh where m is the mass of the object in kg, g is the gravitational acceleration = 9.81 m/s and h is the height above a reference point

245.25 Joules

13. If the potential energy stored in a spring is equivalent to 300 Joules, how much work could it do?

300 Joules

14. If 200 Joules are used to wind up the spring of a clockwork motor, neglecting friction, how much work is done?

200 Joules

Script

Cast

Tony "Thrill" Hill ....host
June Sifuentes ....experimenter
Chris ....volunteer
Frankie ....volunteer
Ashunta ....volunteer

TONY
Welcome to Thrilling Experiments. Hello, I am Tony "thrill" Hill and I hope you are as ENERGETIC as I am because we are going to be doing some very thrilling experiments on ENERGY.

But first we need to know what energy is and why it is so important. Energy is the ability to do work. Work involves a change in position, movement, if you will. Any object that has energy, and moves or changes position, is working.

For instance, the oil in a diesel engine that helps it run is a form of energy. A bulldozer pushing sand is also a form of energy. There are 5 types of energy. Mechanical, heat, chemical, electromagnetic, and nuclear. The oil in the diesel is a form of chemical energy. The bulldozer is a form of mechanical energy.

One of the first scientists to work with energy was **Albert Einstein**. In his studies, he came up with a formula. You may have heard of the theory of relativity. You know, E= MC?. You know, energy is equal to mass times the speed of light squared. In his revolutionary theory, Einstein stated that mass (M) and energy (E) are interchangeable. He said that mass was a form of energy, and even more, that a little mass was equal to a lot of energy. His theory also followed the law of conservation of energy. And everyone knows what the law of conversation of energy says, right?

The law of conservation of energy states that energy can be changed from one form to another, but cannot be created or destroyed. This is happening all around you. Look in your house. Electrical energy to heat your house is a form of electromagnetic energy and the light energy inside your toaster, which toasts your bread, is a form of heat energy.

Script

Now energy is measured in units called **Joules** and the units for work are called **Newton-Meters**. One joule is the amount of work done when the applied force of a Newton produces a displacement of one meter.

Today, we are going to focus on 2 forms of mechanical energy, **potential** and **kinetic.** Potential energy is energy stored within an object that is not in motion, but has the ability to be. Potential energy is converted into kinetic energy when the object begins to move, or work. Potential energy is known as "stored energy," while kinetic is known as "energy of motion."

TONY
All right, it is almost time to get to our thrilling experiments. But, we need to review the safety rules of the laboratory first. Always have an adult present when doing experiments. And always have your safety goggles available at all times when you're in the laboratory.

The last thing we need before we get started is an expert to help us. Here she comes now - June Sifuentes. Hello, June, welcome to the show.

JUNE
Hello, Tony! How are you?

I'm great! I'm energized to start our experiments. What is the first one we're going to cover?

Experiment #1: Temperature & Kinetic Energy

JUNE
The first thing we are going to work with are the basics of energy. Remember kinetic energy?

TONY
I sure do. It is the energy of motion, right?

JUNE
Exactly! Kinetic energy can increase the temperature of an object, which we are going to see in our experiment using chocolate milk.

TONY
Sounds cool. What are we going to need to complete this experiment, June?

Script

JUNE
This experiment need: a thermometer, some chocolate milk, a blender, and a volunteer.

TONY
Here is our volunteer. What is your name?

CHRIS
Chris.

JUNE
Ok, here's what you're going to do. Take the temperature of the chocolate milk and record it. Fill the blender with the milk. Next, place the lid on the blender. Blend on high for 15 minutes. Now take another temperature reading.

CHRIS
It feels warmer.

JUNE
Is there any difference?

CHRIS
Yes there is. The temperature of the milk has increased. It started at 50 degrees and now it's 115 degrees.

TONY
The action of the blender increased the chocolate milk's kinetic energy. It was the increase in that energy that raised its temperature, right June?

JUNE
Yes, that's correct! Thanks for your help!

CHRIS
You're welcome. Bye.

Script

Experiment #2: Releasing Potential Energy

JUNE
Let's move on to our next experiment. It deals with potential energy. Everything has potential energy stored in it. The task is releasing it so that the energy can be used as kinetic energy. In this experiment we are going to release the potential energy of a peanut, turning it into kinetic energy so it can heat up water.

TONY
Peanut power! This sounds cool. What are we going to need?

JUNE
There is quite a list for this experiment. You will need a small bag of unsalted, shelled peanuts, a cork, a needle, a large coffee can with the ends removed, a small metal can like a soup can, a can opener, a hammer, a large nail, a metal BBQ skewer, a thermometer, some matches or a lighter, and a cup of water.

TONY
Wow! That is a long list. This is getting better and better every minute. What do we do, June?

JUNE
carefully push the eye of the needle into the end of the cork. Then push the pointed end of the needle into the peanut. If you push too hard the peanut will break. It helps to hold the peanut at an angle.

TONY
All right, I have my needle through the cork and peanut. What is next?

JUNE
Using the hammer, take the nail and punch holes around the bottom of the large can.

TONY
Sort of like a chimney. Right?

JUNE
Yeah, exactly like a chimney. This will help focus the heat. Next remove the top end of the small can. Using the hammer and nail, punch 2 holes near the top opposite each other. Now slide the BBQ skewer through the holes on the small can. Fill the can about half full with water. Let the water sit so that it is at room temperature. Take the thermometer and take a reading of the water.

Script

TONY
All right I have the temperature of the water. It is 68 degrees. What is the next step?

JUNE
Place the cork and peanut on a nonflammable surface like tin foil. Now be very careful with this next step. Take the matches or lighter and light the peanut. Have an adult help you! Sometimes the peanut is hard to light so a lighter would be much easier.

TONY
Yeah, it is very important to be safe when doing this part. Fire is not a toy. All right, I am about to light the peanut.

JUNE
Once you have the peanut lit, immediately place the large can over the peanut. Then take the small can with the skewer through it and balance it on the large can. Take the thermometer and put it in the small can. Allow the peanut to burn until it goes out. As soon as it goes out take a reading on the thermometer. Has it changed, Tony?

TONY
Mine has changed a little from earlier. The temperature has gone up. It's now 105 degrees. Let me see if I get his right. We burned the peanut and released its potential energy. It was then converted to kinetic or heat energy, which in turn heated up the water.

JUNE
Very good, Tony. I bet you didn't know a peanut had all that energy.

TONY
No I didn't, June. That was a cool experiment. I don't want to stop experi-menting. What's next?

Experiment #3: Calculating Kinetic Energy

JUNE
Well, in our next thrilling experiment, I thought we could calculate kinetic energy. In order to do so, we need to know the equation. It is: Kinetic Energy equals (.5) x mass x velocity squared. Mass is the product of an object's density time volume, and velocity is the distance the object travels divided by the time it takes to get from point A to point B.

Script

TONY
So we can calculate the kinetic energy it takes me to run across this room. (Starts to run)

JUNE
We could, but we need to get to the experiment. Here's what we'll need. Do we have all of that, Tony?

TONY
Yes, we do. Here are our volunteers. What are your names?

FRANKIE and ASHUNTA
I'm Frankie. And I'm Ashunta.

HOST
Thanks for helping today. (to June) What are we going to do with all these balls, June?

JUNE
We are going to find out the kinetic energy that each ball has by rolling them down a ramp. Ashunta, you are going to roll the balls, and Frankie, you will record the times. The first thing we need to do is set up your ramp on a platform. Make sure it is not too steep. You need to calculate the time it takes for each ball to travel from the top to the end of the ramp. Use the stopwatch for this. Start with the basketball. Place it on the ramp and let it go. You may need to do this several times to get an average time.

Script

You need to repeat these steps with each ball. Remember to record all your times for each ball. Once you have rolled each ball several times, you need to find the average time it took the ball to travel down the ramp, you will be able to insert that average into your own kinetic energy equation.

FRANKIE
Kinetic Energy, KE equals .5 x mass x velocity squared.
June 4M
Exactly! We are going to demonstrate how to calculate the kinetic energy of the basketball, you might want to perform you own equations for the other 2 balls. The formulas are the same. Before we can insert the data into our equation we need to calculate the velocity. Velocity is distance divided by time. The distance is the length of the ramp, which is 1 meter. The time is the average number of seconds you recorded on your trials. For our equation, the basketball took 2.71 seconds to roll down the ramp. Take the distance, 1 meter, and divide it by the time, 2.71 seconds. The velocity for our basketball is .37 meters per second. Now, back to the kinetic energy equation.

ASHUNTA
OK, Kinetic Energy equals (1/2) x mass x velocity squared. Where do we find the mass for each ball?

JUNE
Good question, Ashunta. For mass, we are going to use the weight of each ball in grams. Now, it is important to note that weight is NOT the same as mass. Mass is actually the density of an object times its volume, or the area it takes up. But because mass is very difficult to calculate, we are going to use weight instead. So, let's weigh the basketball.

ASHUNTA
The basketball weighs (602) grams. (Frankie writes down the weight, as Ashunta places the golf ball on the scale). The golf ball only weighs ___ grams. (replaces golf ball with tennis ball) And the tennis ball weighs ___.

Script

JUNE
Now, we have the mass for each ball. So, we're ready to figure the kinetic energy of the basketball. The mass of the basketball is 590 grams. We have determined the velocity to be .37 meters per second. Don't forget to square the velocity, that becomes .137. Now take our mass of 590 and multiply it times .137, our product is 80.83. .5 times this amount will give us 40.42, the kinetic energy of the basketball!

Very good, everybody! That number is measured in Joules or Newton Meters. The largest number will indicate which ball has the most kinetic energy. Now with the same data from this experiment you can figure out the potential energy too.

TONY
OK lets insert our data into this equation. The masses are the same. Gravity is always 9.8 meters per second per second. The height is the height of our ramp.

JUNE
Correct Tony. Let's find the potential energy of the basketball. The mass was 590 grams. Gravity, as you said, is 9.8 meters per second. The height of our ramp is .10 meters. Multiply 9.8 times .10, and we come up with .98. Now multiply 590 times .98 and we have our potential energy of 578.2! Try it yourself!

TONY
Yeah, that experiment was filled with tons of interesting information. Now we know how to calculate kinetic and potential energy.

JUNE
Moving on, do you remember The Law of Conservation of Energy, Tony?

TONY
Yes I do. The law basically says that energy cannot be created or destroyed. It can be changed into another form of energy, but the amount of energy never changes.

Experiment #4: Understanding the Law of Conservation of Energy

JUNE
In our next experiment, we will produce a pendulum to illustrate the Law of Conservation.

Script

TONY
Just like the one in my grandfather clock! (does the pendulum with his arms)

JUNE
Exactly. The items you will need to perform this experiment are; an egg, some string, some sticky tape, And a ring stand or tall support.

First, tie the string around the egg. Use the sticky tape to make sure the egg is securely attached to the string. Next connect the string to a ring stand or similar support. Make sure that the egg will clear the surface of the table as it swings. The idea is to allow the egg to swing freely without any obstructions.

TONY
Now you need to correctly position your experiment. Place the pendulum near a wall. Adjust this distance to a point where the string holding the egg is nearly horizontal when extended to the wall.

JUNE
What do you think will happen when the egg is released?

TONY
That's the thrilling part! Will the egg pendulum swing away from the wall and then come back and smash into the wall? We're about to find out! But, I've convinced June to make our version of this experiment a little more elaborate.

JUNE
That's certainly no exaggeration! Instead of an egg, we are going to use a bowling ball. I wouldn't recommend you trying this version of the experiment at school or home. However, the principle is the same. (to Tony) Tony, while you set this experiment up, I'll explain a little bit about potential and kinetic energy.

When a pendulum swings back and forth its potential energy is converted to kinetic energy and vice versa. When the pendulum is pulled up against the wall the egg isn't moving, so it is in maximum potential energy. Once the pendulum is released into motion, its potential energy is quickly converted into kinetic energy, but not all at once. You see, the pendulum has different amounts of potential and kinetic energy throughout its entire swing. These different amounts of energy always add up to the original amount of energy the pendulum started with.

TONY
Hey, that's the law of conservation! There is always the same amount of energy, which cannot be destroyed or created, just converted.

Script

OK, I'm ready to conduct our experiment. I still like the idea of using an egg, so I taped one to the wall, just at the point of our pendulum's impact.

JUNE
All right, let's bring our pendulum right up to the edge of the egg. We'll see if the bowling ball will smash the egg on its return swing. Anytime you're ready Tony!

TONY
Here goes! It has reached the highest point on the other side. Here it comes back. Hey it didn't hit the wall! But it sure was close. That was cool! And no damage to our brave little egg!

See, when the pendulum is at its highest point after it is released it actually stops for a short amount of time. It isn't in motion there, so the kinetic energy is converted back into potential energy for that time.

JUNE
You got it! That is one of my favorite experiments. I like to see the excitement when students try out the pendulum. They always think it is going return all the way back. But you see, there is no way the pendulum could've hit the wall because, according to the law, energy cannot be created or destroyed, only changed in form..

TONY
That was a really cool experiment! Well, that's all we have today! What a great way to end the show!

JUNE
I agree. Now remember, energy is the most important concept of physical science. Even though the concept of energy is relatively new to science, it is a major part of our modern world.

TONY
Exactly. People, places, and things all have energy, but we observe only the effects of energy when something is happening. The next time you are outside or with a group, observe the forms of energy around you and how they're converted into the different types of energy! Well, that is our show. Thanks, June, for the expert advice.

Script

JUNE
You got it, Tony. I really enjoyed myself today.

BOTH
See you later. Bye!