Penn State
College of Engineering
Continuing and Distance Education Office

FUTURE AHEAD

Energy Activities and Curriculum Handbook

FUTURE AHEAD

Renewable Energy and Conservation Education Program

YES!

Extend-a-Day Energy Program

Youth Energy & Science Energy Camps
Young Engineers and Scientists Workshop

Penn State University

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http://www.engr.psu.edu/etp/

Energy Education Handbook Index

Introduction

This handbook has been developed by the staff in Mechanical and Nuclear Engineering Department through a grant in cooperation with the Continuing and Distance Education program in Penn State University's College of Engineering.

The enabling grant came from the Berks County Community Foundation and the Community Foundation for the Alleghenies' Metropolitan Edison Company/Pennsylvania Electric Company Sustainable Energy Fund. The grant provided for two programs, the Renewable Energy and Conservation Education Program (RECEP) and the Extend-a-Day Energy Program.

RECEP and the Extend-A-Day Program provided services and materials to teachers in the community foundation counties throughout the Commonwealth of Pennsylvania. These services included a variety of energy related programs and activities. Some of these activities included: Energy Toolbox exchange program with activities and information; teacher workshops and in-service programs; week-long summer Youth Energy and Science Camps for middle school youth in Erie, Johnstown, Reading and York counties; a teacher summer workshop and optional graduate course in Science Education; promoting a Energy Science Fair; and providing grants to schools to test, run or develop energy curriculum programs slated for after-school or by running an energy club in schools where after-school programs were not practical. The Extend-A-Day Program grant lasted from the period of December 2003 through June 2004. Schools received a grant through a Memorandum of Understanding (MOU) with the stipulation that schools would report the findings.

This Handbook contains three sections:

- The first is an overview about teaching energy to youth.
- The second is a set of middle school energy curriculum activities.
- The third section is a set of high school energy curriculum activities. All energy-related curriculum activities have applied to specific Pennsylvania Academic Standards.

During the spring of 2004, under no associated grant, the Penn State's Mechanical and Nuclear Engineering Department staff developed new science and engineering curriculum, which have energy and technology implications. Guy E. Anderson, program staff person has developed several new secondary lessons that are suitable for high school students. The new activities will tested at an Young Engineers and Scientists workshop at Penn State Berks during the summer of 2004. The new activities include:

- Electricity Basics
- Watts Up Meter 2
- Electroplating
- How to Read a Resistor
- Combining Resistors
- Introduction to Radiation
- Counting Statistics
- Radiation Shield
- Thickness Gauging
- Micro density of Plastic
- Polymers in Our Daily Lives
- Polystyrene
- Testing Sunscreens

Renewable Energy and Conservation Education Program (RECEP) Goals

- To provide teachers and youth with energy activities and programs
- To provide Act 48 and graduate credit opportunities.
- To support and serve schools.

Extend-a-Day Energy Program Goals

• To learn something about energy • To appreciate conservation • To have fun doing energy projects.	• To have a field day with outside experiences or special guest • To do activities that relate to energy

Community Partnerships Developed in RECEP programs 2003-2004
RECEP Interactions

• **Asbury Woods Greenway Trail** • **Carpenter Technology Corporation** • **CertainTeed Corporation** • **East Penn Manufacturing Company** • **Exelon** • **First Energy Company** • **Green Mountain Wind Farm** • **Harley-Davidson Motor Company** • **Home Depot** • **Honda** • **Lowe's Home Improvement** • **Local Citizens** • **LWB Refractories**	• **Nike, Inc.** • **Osram-Sylvania** • **Pennsylvania Department of Education – Governor's School** • **Pennsylvania Department of Environmental Protection LEED Green Bldg – Ebensburg** • **Penn State University** College of Engineering College-Earth & Mineral Science Office of Physical Plant • **PJM Interconnection** • **SUNTEQ** • **The Hite Company** • **Toyota**

RECEP resources

- Energy Toolbox Loan Program
- Workshops – Courses – In-service
  - Youth Energy Science camps
  - Graduate course for teachers
  - Summer workshops for youth
  - Youth Energy Fair
  - Pilot – Extend-a-day Program in Erie
  - Web site resources
  - In-service day programs for schools

Pilot Project Reviewed

In 2003, Penn State provided a grant to the Millcreek Township School District, Erie, PA. The purpose of the grant was to test develop an Extend-A-Day Energy Program and test RECEP curriculum and report findings.

The program was led Jason and Christine Buto, pilot teachers

Time and Duration of Sessions-

- Asbury~ Elementary~ School- Students met on Mondays after school from 3:30-5:00p.m. The program started on January 13th and ended on March 3rd. (7 sessions)
- Grandview Elementary~ School- Students met on Tuesdays after school from 3:30-5:00 p.m. The program started on January 7th and ended on March 4th. (10 sessions)
- Millcreek Township School District Science Fair- Students from both elementary schools presented energy related science fair projects that were constructed during the last 4 sessions of the energy classes. The science fair was held at McDowell Intermediate High School on Saturday March 9th from 9:30-11:00 am. All students received certificates of participation.

Pilot Activities:

Activities Completed During~ Sessions-

- six different forms of energy and explored each through experiments
- set up batteries and light bulbs in different circuit configurations
- manual generator to make electricity light a light bulb
- combustion of peanut to heat water
- reaction to hydrochloric acid with zinc to see the temperature increase
- Geiger counter
- explored friction by rubbing blocks together
- drawings of power plants
- learned fuels used to run power plants
- searched the Internet to find 4 alternatives to producing power including hydroelectric, wind, solar, and geothermal power
- predicted which appliances would use the most electricity out of a given list of appliances
- tested different types of insulation while learning about energy conservation
- Watt Meter to examine the cost of using electricity
- measured the intensity of light using a light meter
- measured voltage using a multi-meter
- explored the scientific method and applied the scientific method to solve energy related problems
- created science fair projects on energy related topics using the scientific method

Teacher Evaluation of Pilot Program-

- The energy program was a big success!
- Students, parents, and teachers were all excited about the activities performed, science fair projects created, and overall result of the program.
- The Pre-Test given during the first session and Post-Test given during the last session clearly demonstrate that the students learned a lot about energy during the program.
- The Pre-Tests indicate that students knew little about energy before the program but, knew much more afterwards.
- Teachers of the energy program received many compliments from students, parents, and teachers throughout the course of the program. The thing the energy program teachers liked most about the program is the fact that they saw students getting excited about energy and science.
- Students took time after a long school day to stay and learn more.
- Students wanted to stay and enjoyed learning about energy.
- The Energy Toolbox was extremely helpful. Teachers of the energy program used several of the lesson plans included in the box. Much of the equipment was also utilized including the insulation, rings stands, multi-meter, watt meter, and light intensity meters.
- The only suggestion the teachers have for the toolbox is that it would contain some thermometers, perhaps digital thermometers that are very durable and can withstand temperatures above lOO°C.

Student Evaluation of Pilot Program:

Student Comments-

- Some of the student comments were taken verbally and some are written on the back of the Post- Tests. The following is a summary of student comments: 75% of the students who participated would recommend the program to other students.

<u>Some of the activities students liked the most:</u>

- Using a hand generator to light bulbs
- Seeing zinc react with hydrochloric acid
- Drawing the power plant and seeing how it works
- Creating the science fair project
- Burning the cheese balls (or peanut) to heat the water
- Finding alternative energy sources on the Internet

Energy is a very important tool or catalyst.

FIVE KEY CONCEPTS

- Energy

Understanding the basics of potential and kinetic energy and the types of energy in our world including heat, light, gravity, mechanical, chemical, atomic, and electrical energy.

- Risk/Toxicity

Understanding that all energy forms have a certain degree of risk or even danger related to poison or other related danger.

- Conservation

Understanding that the only way to improve energy use is to not only conserve it, but also improve the way we develop and apply energy. Through common sense application, science, engineering and technology, we can make conservation work better.

- Ecology

Understanding that daily, everyone impacts our environment, i.e., water-air-land. This is the field trip day. We go out to experience how we as humans interact with the environment in so many ways.

- Competition

Understanding "egg-drop team effort" and the solo effort of building a solar car and racing it within the rules to achieve the best that one can do. Understanding that working together as well as individually is important to fulfill what contributions we can make now and in the future.

RECEP - Equipment/Vendor/Price List				**October 2003 prices**
Activity	**Item**	**Source**	**Number**	**Price**
Cheese Ball Calorimetry	Food Samples	Local Purchase		
	Soft Drink Cans	Local		
	Stirring Rods (pkg. of 10)	Science Kit	61965-08F	4.20
	Ring Stand	Science Kit	63080-01	8.95
	Support Ring	Science Kit	63085-04	7.25
	Balance			
	Large Paper Clips	Local Purchase		
	Thermometers	Science Kit	63320-00	4.75
How Efficient is Insulation	Soft Drink Bottles	Recycled Bottles		
	Thermometers	Science Kit	633020-00	4.75
	Test Tubes (25X200 mm) 24	Science Kit	63256-10L	28.56
Garbology	Plastic Samples	Empty Containers		
Concept Map	Paper/Markers or	Local Purchase		
	Inspiration Software	www.inspiration.com		59.00
How Does a Potato Clock Work	Potato Clock	Science Kit	64373-00	23.95
	Lemons	Local Purchase		
	zinc electrode (pkg. of 10)	Science Kit	63680-00G	11.88
	or galvanized washers	Local Purchase		
	copper electrodes (pkg. of 10)	Science Kit	61235-00G	11.40
	or Pre-1982 pennies			
	Clip Leads (pkg. of 10)	Science Kit	47889	6.75
	Multi-Meter	Science Kit	63785-00	59.00
Electricity Basics	Multi-Meter	Science Kit	63785-00	59.00
	D-Cell Batteries	Local Purchase		
	"Dead Batteries"			
	Clip Leads (pkg. of 10)	Science Kit	47889	6.75
	1000 Ohm Resistors (pkg. of 10)	Science Kit	64532-00F	3.50
	Battery Holders	Science Kit	47223-03	0.99
Activity	**Item**	**Source**	**Number**	**Price**
RECEP - Equipment/Vendor/Price List				
Activity	**Item**	**Source**	**Number**	**Price**

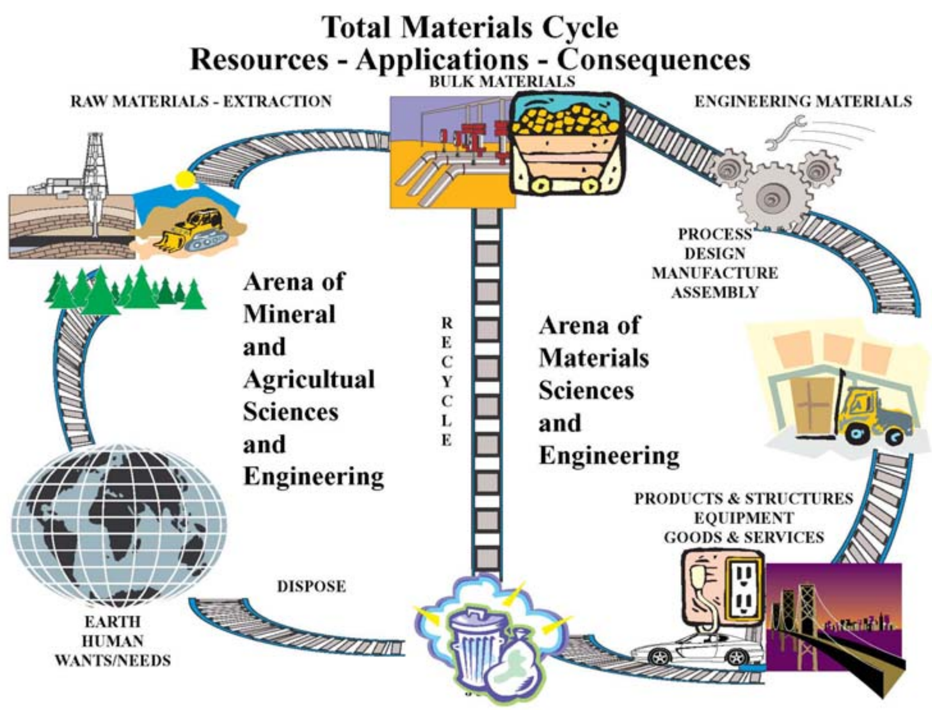
Energy From Sunlight	Solar Cells	Science Kit	62971-05	9.95
		PITSCO	U56851-188	4.95
	Multimeter	Science Kit	63785-00	59.00
	Clip Leads (pkg. of 10)	Science Kit	47889	6.75
	Black Construction Paper	Local		
	Gray Plastic Sheets	Local		
	Desk Lamps	Local Purchase		
	Incandescent Light Bulbs	Local Purchase		
	Fluorescent Light Bulbs	Local Purchase		
Energy from Fuel Cells	Methanol Fuel Cells	Fisher Scientific	S63151	49.00
	Air/Al Fuel Cell	Fisher Scientific	S63152	41.75
	Multimeter	Science Kit	63785-00	59.00
Measuring Electrical Power	Watts Up? Meter	Sargent Welch	WL1998	115.00
	Electrical Appliances	Local		
	Lamp - Regular Light Bulb	Local Purchase		
	- Fluorescent Light Bulb	Local Purchase		
	Power Strip	Local Purchase		
Using a Light Meter	Digital Light Meter	Science Kit	46255-00	135.00
	Lamp - Regular Light Bulb	Local Purchase		
	- Fluorescent Light Bulb	Local Purchase		
	Measuring Tape or Meter stick	Local Purchase		
	Brightly Colored Paper	Local		
Finding Fossil Fuels	Pennies	Local		
	Masking Tape	Local		
Mining for Coal	"Soft Bake" Cookies	Local Purchase		
	Frosting - Tinted Green	Local Purchase		
	Plastic Tooth Picks	Local Purchase		
	Wax Paper	Local Purchase		

RECEP - Equipment/Vendor/Price List

Activity	**Item**	**Source**	**Number**	**Price**
Appliance Survey	Clip Boards	Local Purchase		
Activity	**Item**	**Source**	**Number**	**Price**

How Much Does It Cost?	Glue Sticks	Local Purchase		
Saving Humpty Dumpty	Nike "Air to Earth" Kit	www.airtoearth.com		24.00
	refill kit	www.airtoearth.com		11.00
	milk jugs	Local		
	Measuring Cups	Local Purchase		
	Spatulas or mixing spoons	Local Purchase		
	Hard Boiled Eggs	Local Purchase		
	Measuring Tape or Meter stick	Local Purchase		
	Newspaper			
Solar Car Races	Sunzoon Kar Pak (25 kits)	PITSCO	U23665-185	295.00
General Materials	Pails - for clean up			
	Power Strips			
	Extension Cords			
Vendor Websites	www.sciencekit.com			
	www.PITSCO.com			
	www.sargentwelch.com			
	www.inspiration.com			
	www.fischersci.com	Catalogs - Science Education		

Energy Education Curriculum Outline:
Awareness of the Materials Cycle, Everything we do affects THE LAND, WATER, and AIR



Basic Questions

- What is energy?
- What are the two types of energy?
- What are the 7 forms or ways we transfer energy?
-

Awareness and Applications of the 7 forms

• **HEAT**	**LIGHT**	**GRAVITY**	**MECHANICAL**
• **CHEMICAL**	**ELECTRICITY**		**ATOMIC**

- How can we change the way we use and conserve energy?
    - **Habits**
    - **Purchases**
    - **Awareness**
    - **Education**
    - **Laws**
    - **Technology**
    - **Requiring efficiencies**
    - **Supporting sustainable fuels**

Who can make CHANGE?
- Federal Government
- State Government
- Local Government
- Business
- Industry
- Ex. Power Plants
- Schools---but the most important change agent is US – YOU & ME

Energy Topics to Study via Class – Library – Special Guests – Internet

• Air systems • Bio-mass • Clean-coal technology • Cogeneration • Efficiencies • Electricity– production & distribution • Fuel cells • Geo-thermal	• Green buildings • Insulation • Lighting • Hydroelectric-low & high head • Mass transportation • Motor efficiencies • Natural gas • Nuclear energy- fission & fusion • Ocean technology	• Oil • Product manufacturing • Recycling & recovery • Renewable/Sustainable • Solar-passive/active • Synthetic Fuels • Vehicle design • Water • Wind • Wood

Key parts to energy use:
- Sources and Resources
- Conversions
- Efficiency and Effectiveness

Learning about Energy through local history

INTRODUCTION

Energy can be made more interesting by inviting or assigning students to interview or study people who have lived in the past. We encourage this activity and the many possibilities of accomplishing it. The Youth Energy and Science Camp example:

At the York County Youth Energy and Science Camp Mr. J. Kerr Anderson was invited to speak to youth. Mr. Anderson was born in 1913, therefore, recounting what life was like as a 12 year old youngster in York County.

Notes from his talk:
Time: 1925
Margaret and Ross Anderson and their son, J. Kerr Anderson, lived on a farm south of Red Lion, Pennsylvania, near Winterstown, Pennsylvania.

Historical Outline: Areas of life and the implications of use, application and status of energy uses at that time.

Lighting	**Heat**	**Water**	**Communication**
School	**Transportation**	**Food - Clothing**	**Sanitation**
	Entertainment	**Work**	

In 1925, there were only two types of communities--RURAL and TOWN in York County. Early in Mr. Anderson's life, the Anderson family lived in Winterstown, PA where his father was a storeowner. Later his father took over a store in Airville and by the age of 12, his parents moved to a farm near Winterstown. The area had few residents. The largest town in York County was York, PA. It was the center of activity and business for the area.

Example of one topical area:
FOOD – Food was chore in those days. "We had to be self-sufficient then. We used wood for fuel and heat, raised our own animals, canned meat such as sausage or beef and used a cellar for potatoes and apples, mainly. We did not have variety as today and therefore food was eaten as necessity, not by choice. Salt, sugar and other spices had to be purchased from a store. Sugar was not very expensive in those days--$.05 per pound."

J. Kerr Anderson's daily responsibility was to carry water from the spring to the house each morning, and split wood and store it in the wood box. Sometimes the wood would be wet or worse, frozen in winter. His mother raised chickens and turkeys. The turkeys were "free range". His job was to know where the turkey nested and watch out for foxes and other predators that would want to steal and eat the baby chicks, called peeps.

Other on-line program resources at http://www.engr.psu.edu/recep/
- **Energy Subjects and Terminology**
- **Special Energy Links**
- **Energy Conservation Award Program (ECAP)**
- **Other Energy Subjects**

Special thanks to Guy E. Anderson, Bald Eagle Area High School teacher and program staff, especially for his work and development on the energy activities in this Handbook; Ruth Ruud, Principal, Ridgefield Elementary School, Millcreek Township School District and 2004 President of the Pennsylvania Science Teachers Association. Ruth has been an invaluable resource for this project and piloting the Extend-a-Day Energy Program in Pennsylvania; Gordon Sinclair, program staff, Youth Energy and Science Camps and the Deb, Terry, Tom, Bonnie and Missy at the Penn State's College of Engineering, Distance and Continuing Education office for their assistance and organization since the proposal was developed and awarded.

Curriculum Activities for Middle Schools
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Evaluation Tool: Can be used as a pre/post measurement – (Answers in bold)
Key Areas include ENERGY LEADERSHIP – TYPES – TERMS – USES

Energy Leadership

_____ 1. The President of the United States is:
a. Al Gore b. Bill Clinton c. **George Bush** d. Dick Cheney

_____ 2. The Governor of Pennsylvania is:
a. Tom Ridge b. Mark Schweiker c. **Ed Rendell** d. Mike Fisher

_____ 3. The executive department in the United States government that is concerned with issues related to electricity, heating, and automobile fuel use is:
a. **Energy** b. NASA c. Transportation d. Education

Energy Types

_____ 4. Energy found in flames, stoves or heaters is:
a. **thermal or heat** b. radiant or light c. electrical d. atomic

_____ 5. Solar energy can be thought of as a mix of:
a. atomic and gasoline b. **heat and light** c. gravity and alcohol
d. gas and coal

_____ 6. Which of the following best describes chemical energy?
a. light bulb b. **fuel cell** c. air dryer d. television

_____ 7. Which of the following relies on gravity to produce energy?
a. coal b. car brake c. refrigerator d. **a dam**

_____ 8. Which of the following involves geo-thermal energy?
a. a stream b. a river c. **a geyser** d. forest fire

_____ 9. Which of the following best describes mechanical energy?
a. solar cell b. **a wind mill** c. a rocket d. a dry cell battery

_____ 10. Which of the following best describes atomic energy?
a. fission b. fusion c. radioisotopes d. **all of these** e. none of these

Energy Terms

_____ 11. Energy is defined as:
a. **the ability to do work** b. kilowatts and ergs c. ohms and watts
d. measure of motion

_____ 12. Another name for a lighting fixture is:
a. candlepower b. bulbalator c. **luminaire**

_____ 13. The most basic forms of energy are:
a. electrical and radiant b. fossil and natural gas c. **potential and kinetic**

Evaluation Tool: Can be used as a pre/post measurement – (Answers in bold)
Key Areas include ENERGY LEADERSHIP – TYPES – TERMS – USES

_____ 14. A gap around a window can allow air to enter your house. This is called:
a. induction b. **infiltration** c. injunction

_____ 15. Water is a simple chemical compound made up of the gases:
a. hydrogen and ozone b. hydrogen and onyx c. **hydrogen and oxygen**

_____ 16. Electrical power is measured in units called:
a. feet b. barrels c. joules d. **kilowatts**

_____ 17. Coal, oil and natural gas are:
a. formulated fuels b. **fossil fuels** c. fabricated fuels

_____ 18. A light meter will record light levels in units called:
a. **footcandles** b. light bars c. watts

_____ 19. The term cogeneration is best described as:
a. solar power b. **waste heat reuse application** c. revolving door policy

Energy Uses

_____ 20. Pennsylvania's ability to generate more electricity that it uses allows us to:
a. **export energy** b. import energy c. deport energy

_____ 21. What fuel source provides 35 percent of Pennsylvania's electricity?
a. nuclear b. wind c. **coal** d. oil

_____ 22. Most residential peak loads for electricity take place between:
a. 7:00 am and 9:00 am b. **5:00 pm and 8:00 pm** c. Noon and 2:00 pm

_____ 23. The simplest way to reduce the amount of energy used by computer equipment is to:
a. **buy energy efficient models** b. don't use it too much c. turn it off when done

_____ 24. On average what percent of our energy is used to heat buildings?
a. 20 b. 60 c**. 40**

_____ 25. What is the best reason for recycling?
a. saves resources b. saves land c. saves energy d. **all of these** e. none of these

Extend-a-Day Energy Program Activities and related Pennsylvania Department of Education Academic Standards

Energy Conversions **Concept Map**	Science and Technology Inquiry and Design 3.2.7A Explain the parts of a simple system and their relationships to each other. Science and Technology Physical Science, Chemistry and Physics 3.4.7B Explain the conversion of one form of energy to another by applying knowledge of each form of energy.

Energy Conversions **Calorimetric Measurements** **Heat of Combustion** **Can We Heat Water with a Peanut or Cheese Ball?**	Science and Technology Physical Science, Chemistry and Physics 3.4.7B Explain the conversion of one form of energy to another by applying knowledge of each form of energy. Science and Technology Inquiry and Design 3.2.7 B Design controlled experiments, recognize variables and manipulate variables. Environment and Ecology Renewable and Nonrenewable Resources 4.2.7 A Identify resources used to provide humans with energy, food, housing and water.

Energy Consumption **Consumer Awareness** **Appliance Survey**	Environment and Ecology Renewable and Nonrenewable Resources 4.2.7B Determine how consumption may impact the availability of resources. Mathematics Mathematical Problem Solving and Communication 2.5.8B Invent, select, use and justify the appropriate methods, materials and strategies to solve problems.

Energy Consumption Consumer Awareness Appliance Energy Use How Much Does It Cost?	Environment and Ecology Renewable and Nonrenewable Resources 4.2.7B Determine how consumption may impact the availability of resources. Mathematics Mathematical Problem Solving & Communication 2.5.8B Invent, select, use and justify appropriate methods, materials and strategies to solve problems.
Energy Resources-Engineering-Economics Finding Fossil Fuels	Environment and Ecology Renewable and Nonrenewable Resources 4.2.7A Identify resources used to provide humans with energy, food, housing and water. Environment and Ecology Renewable and Nonrenewable Resources 4.2.7B Determine how consumption may impact the availability of resources.
Energy Resources Environment-Engineering-Economics Challenges of Coal Mining	Environment and Ecology Renewable and Nonrenewable Resources 4.2.7A Identify resources used to provide humans with energy, food, housing and water. Environment and Ecology Renewable and Nonrenewable Resources 4.2.7B Determine how consumption may impact the availability of resources.
Electricity: The Basics	Science and Technology Inquiry and Design 3.2.7B Measure materials using a variety of scales. Science and Technology Inquiry and Design 3.2.7B Design controlled experiments, recognize variables and manipulate variables. Science and Technology Physical Science, Chemistry and Physics 3.4.7B Explain the parts and functions in an electrical circuit.

Electricity: Power and Metering **Measuring Electrical Current**	Science and Technology Inquiry and Design 3.2.7B Measure materials using a variety of scales. Science and Technology Inquiry and Design 3.2.7B Design controlled experiments, recognize variables and manipulate variables. Mathematics Problem Solving and Communication 2.5.8B Verify and interpret results using precise mathematical notation and representations, including numerical tables and equations, simple algebraic equations and formulas, charts, graphs and diagrams

Electricity **Lighting Efficiency** **Operating Cost and Savings**	Environment and Ecology Renewable and Nonrenewable Resources 4.2.7B Determine how consumption may impact the availability of resources. Mathematics Mathematical Problem Solving & Communication 2.5.8B Invent, select, use and justify appropriate methods, materials and strategies to solve problems.

Electricity Generation **How Does a Potato Clock Work?**	Science and Technology Inquiry and Design 3.2.7B Measure materials using a variety of scales. Science and Technology Inquiry and Design 3.2.7B Design controlled experiments, recognize variables and manipulate variables. Science and Technology Physical Science, Chemistry and Physics 3.4.7B Explain the parts and functions in an electrical circuit.

Recycling **Garbage, Too Valuable to Burn or Bury**	Environment and Ecology Renewable and Nonrenewable Resources 4.2.7B Determine how consumption may impact the availability of resources. Mathematics Mathematical Problem Solving & Communication 2.5.8B Invent, select, use and justify appropriate methods, materials and strategies to solve problems.

Recycling Plastics **Garbology 101**	Environment and Ecology Renewable and Nonrenewable Resources 4.2.7B Determine how consumption may impact the availability of resources. Mathematics Mathematical Problem Solving & Communication 2.58 B Invent, select, use and justify appropriate methods, materials and strategies to solve problems.

Recycling Materials **Product Research** **Resource Recovery** **“Saving Humpty Dumpty”**	Environment and Ecology Renewable and Nonrenewable Resources 4.2.7B Determine how consumption may impact the availability of resources. Mathematics Mathematical Problem Solving & Communication 2.5.8B Invent, select, use and justify appropriate methods, materials and strategies to solve problems. Science and Technology Inquiry and Design 3.2.7B Design controlled experiments, recognize variables and manipulate variables.

Insulation **How Effective – How Efficient?**	Science and Technology Inquiry and Design 3.2.7B Measure materials using a variety of scales. Science and Technology Physical Science, Chemistry and Physics 3.4.7B Explain the conversion of one form of energy to another by applying knowledge of each form of energy. Science and Technology Inquiry and Design 3.2.7B Design controlled experiments, recognize variables and manipulate variables.

Insulation **Does It Make a Difference?**	Science and Technology Physical Science, Chemistry and Physics 3.4.7B Explain the conversion of one form of energy to another by applying knowledge of each form of energy. Science and Technology Inquiry and Design 3.2.7B Design controlled experiments, recognize variables and manipulate variables.

Lighting Survey **Using a Light Meter**	Science and Technology Physical Science, Chemistry and Physics 3.4.7B Know that the sun is a major source of energy that emits wavelengths of visible light, infrared and ultra violet radiation Science and Technology Inquiry and Design 3.2.7B Measure materials using a variety of scales.

Energy Generation **Mini Generators: The Basics**	Science and Technology Physical Science, Chemistry and Physics 3.4.7B Explain the conversion of one form of energy to another by applying knowledge of each form of energy. Science and Technology Inquiry and Design 3.2.7B Design controlled experiments, recognize variables and manipulate variables.

Energy Generation **Fuel Cells**	Science and Technology Inquiry and Design 3.2.7B Measure materials using a variety of scales. Science and Technology Inquiry and Design 3.2.7B Design controlled experiments, recognize variables and manipulate variables. Environment and Ecology Renewable and Nonrenewable Resources 4.2.7B Identify renewable resources and describe their uses.

Energy Generation **Solar Cells**	Science and Technology Inquiry and Design 3.2.7B Measure materials using a variety of scales. Science and Technology Inquiry and Design 3.2.7B Design controlled experiments, recognize variables and manipulate variables. Environment and Ecology Renewable and Nonrenewable Resources 4.2.7B Identify renewable resources and describe their uses.

Energy Conversions – Concept Map

Discussion:

All of us depend upon electricity in our homes to run a wide variety of appliances. Electrical energy is converted to other forms of energy when these appliances are run. Is this activity, you are asked to:

A. List 10 – 15 uses of electricity in your home.
B. Decide whether electricity is converted to mechanical, radiant, heat, or sound energy when these items are used.
C. Draw a concept map showing these energy uses.
D. Color code the concept map to indicate the energy conversions involved.

	Appliance	**Energy Conversion**	

Energy Conversions – Concept Map

Teacher notes

Objectives:
The students will identify common uses of electricity in their home and draw a concept map that shows what energy conversions are made. In some cases more than one conversion results. An incandescent light bulb is primarily used as a source of radiant (light) energy but also gives off a significant amount of heat or thermal energy. They may code their concept map for the main conversion or show that more than one energy conversion is taking place.

Academic Standards:

Science and Technology
Inquiry and Design 3.2.7.A
Explain the parts of a simple system and their relationships to each other.

Science and Technology
Physical Science, Chemistry and Physics 3.4.7.B
Explain the conversion of one form of energy to another by applying knowledge of each form of energy.

Sample Concept Map:

	Appliance	**Conversion**	
	Stove	Heat/Thermal	
	Water Heater	Heat/Thermal	
	Hair Dryer	Heat/Thermal	
	Washer	Mechanical	
	Stereo	Sound	
	Lamp	Radiant	
	Sweeper	Mechanical	
	Clothes Dryer	Heat/Thermal	
	Microwave	Radiant	
	Mixer	Mechanical	
	Garage Door Opener	Mechanical	
	Coffee Pot	Heat/Radiant	
	Radio	Sound	
	Refrigerator	Mechanical	

Energy Conversions – Heat of Combustion – Calorimetric Measurement

Can we heat water with a peanut or cheese ball?

Discussion:

This experiment allows you to measure the amount of heat (calories) liberated when a food sample burns. The heat released is used to heat a known amount of water. From the mass of the water and the change in temperature of the water, the heat absorbed by the water can be found. It is assumed that the heat absorbed by the water and the heat released by the food are the same.

Heat = Mass of water X Change in temp X Specific Heat

Heat of combustion = Heat ÷ Mass of food burned

Purpose:

The purpose of this experiment is to determine the amount of energy that is given off during the chemical change involved in the combustion (burning) of a food sample.

Procedure:

1. Attach the cheese ball to the paper clip and weigh them both. Record the mass as the mass of the original sample. Weigh the aluminum can and record its mass in the data table. Fill the can about half full with water. Weigh the can and water and record the mass in the data table. Place a stirring rod through the holes in the can and suspend it from a ring on a ring stand. Measure and record the temperature of the water in the can.

2. Place the cheese ball under the can and adjust the height of the can until the cheese ball is about 2 - 3 inches from the bottom of the can and directly under the center of the can. Light the cheese ball and heat the water until the cheese ball burns itself out.

3. Carefully extinguish the flame if necessary and gently stir the water with the thermometer. Record the final temperature of the water. Weigh the remains of the cheese ball on the same balance that was used before. Record the mass in the data table.

4. Repeat the procedure two more times using a fresh sample of water each time.

Energy Conversions – Heat of Combustion – Calorimetric Measurement

Data and Calculations

Sample Tested: ____

		Trial 1	Trial 2	Trial 3
1	Mass of Food Before			
2.	Mass of Food After			
3.	Mass of Food Burned			
4.	Mass of Can and Water			
5.	Mass of Can			
6.	Mass of Water			
7.	Temperature of Water After			
8.	Temperature of Water Before			
9.	Temperature Change			
10.	Heat Released			
11.	Heat Released Per Gram			
12.	Accepted Value			

Calculations:

1. Calculate the change in temperature, mass lost by the sample, and the mass of water for each trial.

2. Calculate the quantity of heat absorbed by water for each trial.

3. Calculate the heat of combustion of the sample for each trial.

4. How do your results compare with the accepted value?

5. Why do you think that the heat released by the cheese balls is less than the accepted value?

6. What are some sources of heat loss in this experiment?

Energy Conversions – Heat of Combustion – Calorimetric Measurement

Can we heat water with a peanut or cheese ball? – Teacher notes

Objectives:

1. The students will carry out an experiment to determine the amount of energy contained in a food sample.
2. The students will use the laws of thermodynamics to explain why the heat transfer is not 100% efficient.

Academic Standards:

Science and Technology
Physical Science, Chemistry and Physics 3.4.7 B
Explain the conversion of one form of energy to another by applying knowledge of each form of energy.

Science and Technology
Inquiry and Design 3.2.7 B
Design controlled experiments, recognize variables and manipulate variables.

Environment and Ecology
Renewable and Nonrenewable Resources 4.2.7 A
Identify resources used to provide humans with energy, food, housing and water.

This experiment shows that energy conversions are not 100% efficient. In this case, chemical energy is being is converted into heat energy. In most cases only one third of the energy is converted. This experiment uses a soft drink can for a calorimeter. The calculations are done in calories to make comparisons with the food packages easier. The calorie content and serving size may be found on most food packages. Note: One food calorie is 1000 small calories.

Materials Required:

Food Samples (cheese balls or other round or cylinder-shaped food items work best)
Soft drink can (punch holes near the top of the can)
Stirring rod
Ring stand and ring to support the can
Large paper clip bent to support the sample
Balance to weigh water and food samples

Calculations:

1. Calculate the change in temperature, mass lost by the sample, and the mass of water for each trial. ***Student responses***.
2. Calculate the quantity of heat absorbed by water for each trial.
   Student responses The specific heat constant for water is 1.0 cal/g ºC.
3. Calculate the heat of combustion of the sample for each trial.
   Student responses
4. How do your results compare with the accepted value?
   The cal per gram of food are usually less than the accepted values.
5. Why do you think that the heat released by the cheese balls is less than the accepted value?
   Energy conversions are not 100% efficient.
6. What are some sources of heat loss in this experiment?
   Heat is lost to the air and to the can. These are not accounted for in the calculations.

Energy Consumption – Consumer Awareness

Appliance Survey

According to the US Department of Energy (DOE), appliances account for about 20% of your household energy consumption. In 1992 the US Environmental Protection Agency (EPA) introduced ENERGY STAR as voluntary labeling program deigned to identify and promote energy-efficient products. In 1996 the EPA and DOE joined to concentrate on major appliances. Today, over 7,000 businesses and organizations promote the ENERGY STAR goal of improve efficiency. One example of improvement has been the use of LED technology in traffic lights and even holiday lights in and outside of the home. Search web for more information about Energy Star and the energy guidelines http://www.energystar.gov .

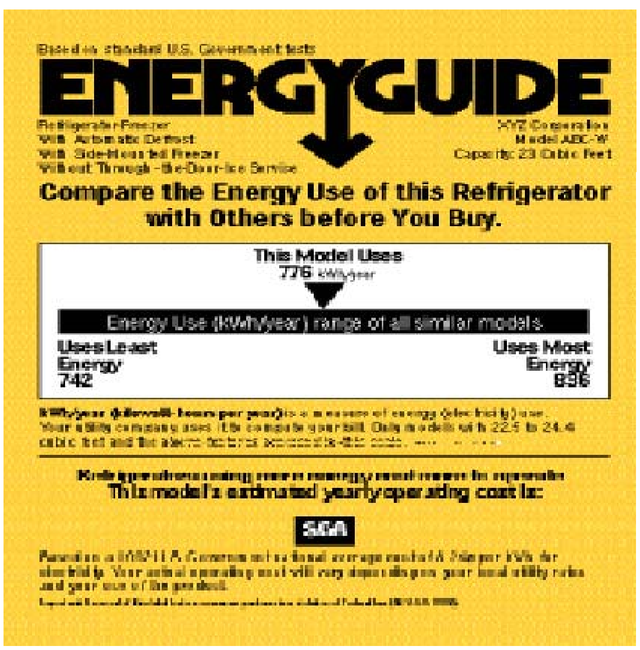
In this activity, you will compare different models of appliances to determine if there are significant differences in their energy usage. Every appliance you examine should have a yellow and black **ENERGYGUIDE** label. This label:

a. shows how this particular appliance compares with similar appliances.
b. gives an estimated cost for operating the appliance for one year.

This information along with the purchase price will allow you to estimate the cost of operating the appliance over its lifetime.

Such calculations allow the consumer to make more informed decisions.

Directions:
In this activity, you will examine appliances to determine their estimated energy usage for a year. This information can be found on the ENERGYGUIDE label that manufacturers places on the appliance. For examples, when selecting appliances such as refrigerators, select different styles such as top or bottom freezers, or side-by-side. When comparing appliances make sure that they are the same size or style. After filling in the appliance survey, determine which appliance is a better buy.



Energy Consumption – Consumer Awareness

Appliance Survey

Top-Freezer Refrigerators				
Brand	Size	Cost	Estimated kWH per year	Estimated Energy Cost
Side-by-Side Refrigerators				
Brand	Size	Cost	Estimated kWH per year	Estimated Energy Cost
Hot Water Heaters				
Brand	Size	Cost	Estimated kWH per year	Estimated Energy Cost

Top-Loading Washers				
Brand	Size	Cost	Estimated kWH per year	Estimated Energy Cost

Energy Consumption – Consumer Awareness

Appliance Survey

Front-Loading Washers				
Brand	Size	Cost	Estimated kWH per year	Estimated Energy Cost
Dishwashers				
Brand	Size	Cost	Estimated kWH per year	Estimated Energy Cost
Other				
Brand	Size	Cost	Estimated kWH per year	Estimated Energy Cost

Energy Consumption – Consumer Awareness

Appliance Survey

Questions/Analysis

1. Which electric hot water heater is predicted to be less expensive to operate? Why do you think this may be the case?

2. Which was the most economical washing machine to operate? Why do you think this may be the case?

3. In general, what happens to the energy costs when the size of refrigerators increase?

4. A “Consumer Reports” article states that top freezer refrigerators use less energy than side-by-side units. Did your observations support this?
(Hint: Try to compare two models of equal size.)

5. What does the Energy Star rating that is seen on some appliances mean?

6. Which type of appliance had the least variation in the predicted energy usage?

Energy Consumption – Consumer Awareness

Appliance Survey – Teacher notes

Objective(s):

1. The students will compare the annual operating costs of appliances.
2. The students will explain why a more expensive but more energy efficient appliance may actually save money over its lifetime.

Academic Standards:

Environment and Ecology
Renewable and Nonrenewable Resources 4.2.7 B
Determine how consumption may impact the availability of resources.

Mathematics
Mathematical Problem Solving and Communication 2.5.8 B
Invent, select, use and justify the appropriate methods, materials and strategies to solve problems.

Discussion

This activity was designed to show students that many of the appliances in their home are large users of electricity. They will also see that energy demands can vary widely between appliances of similar size. Encourage them to look for Energy Star appliances. During the pilot RECEP-PSU program, students traveled to a large building supply store to complete the survey. If this is not possible, much of the needed information could be obtained from "*Consumer Report*s" magazines.

Answers to Questions/Analysis

1. Which electric hot water heater is predicted to be less expensive to operate? Why do you think this may be the case?
A larger water heater that is better insulated may actually be less expensive to operate.

2. Which was the most economical washing machine to operate? Why do you think this may be the case?
Front loader washers were found to be less expensive to operate. They use less hot water which is included in their estimated operating costs,

3. In general, what happens to the energy costs when the size of refrigerators increase?
Larger units are generally more expensive to operate.

4. A "Consumer Reports" article states that top freezer refrigerators use less energy than side-by-side units. Did your observations support this? (Hint: Try to compare two models of equal size.)
This is generally true unless students compare one unit with an Energy Star rating and another one without.

5. What does the Energy Star rating seen on some appliances mean?
These appliances use less energy than other comparable appliances.

6. Which type of appliance had the least variation in the predicted energy usage?
During the initial survey, dishwashers had the least amount of variation.

Energy Consumption – Consumer Awareness

Appliance Energy Consumption – How Much Does It Cost?

The chart below lists 15 common appliances used in the home. Your task is to match the appliance with the estimated cost to run it for one year. The usage figures are from the U.S. Department of Energy. The costs are based on an electricity price of 8.8 cents per kilowatt-hour. Cut the last two sections off of the chart and match them to the appliance.

Appliance	kwh/year	Estimate Annual Cost
100 Watt Light Bulb (6 hours per day)	128	$11.26
26 Watt Light Bulb (6 hours per day)	144	$12.67
Coffee Maker	89	$7.83
Dishwasher (1 load/day)	175	$15.40
Electric Blanket	680	$59.84
Hair Dryer	57	$5.02
Microwave Oven	1034	$90.99
Portable Heater	2190	$192.72
Large Refrigerator Energy Star	219	$19.27
Large Refrigerator No Energy Star rating	540	$47.52
Television (4 hours/day)	432	$38.07
VCR	100	$8.80
Washing Machine (7-10 loads/week)	292	$25.70
Water Heater (40 gal.)	600	$52.80
Window Fan	30	$2.64

Energy Consumption – Consumer Awareness

Appliance Energy Consumption – How Much Does It Cost?
Teacher notes – Answer Key

Appliance	Kwh/year	Estimate Annual Cost
100 Watt Light Bulb 6 hours per day	219	$19.27
26 Watt Light Bulb 6 hours per day	57	$5.02
Coffee Maker	128	$11.26
Dishwasher (1 load/day)	432	$38.07
Electric Blanket	175	$15.40
Hair Dryer	100	$8.80
Microwave Oven	89	$7.83
Portable Heater	540	$47.52
Large Refrigerator Energy Star	680	$59.84
Large Refrigerator No Energy Star rating	1034	$90.99
Television (4 hours/day)	292	$25.70
VCR	30	$2.64
Washing Machine	600	$52.80
Water Heater (40 gal.)	2190	$192.72
Window Fan	144	$12.67

Source of Information: US Department of Energy - Based on Average cost of 8.8 cents per KWH

Objectives:

1. The students will determine which household appliances are the least/most expensive to operate.

Academic Standards:

Environment and Ecology
Renewable and Nonrenewable Resources 4.2.7 B
Determine how consumption may impact the availability of resources.

Mathematics
Mathematical Problem Solving & Communication 2.5.8 B
Invent, select, use and justify appropriate methods, materials and strategies to solve problems.

Data Information Source: 2001 spring edition of the PPL Newsletter, *PARTNERS* and from information found on the Department of Energy website. The purpose of this activity is to get students to think and talk about energy uses in their homes. Our intent was to have them identify the largest users. The students may work in groups. The last two columns should be cut off and matched with the correct appliance in the first column.

Energy Resources – Engineering - Economics

Finding Fossil Fuels

Discussion:
In this activity, pennies will be used to represent a fossil fuel (coal). It will be your job to find as much of this natural resource as possible in each time period. After the time periods are up, we will discuss how this activity is similar to mining for coal or drilling for oil in real life.

OBSERVATIONS AND DATA

Group Data: Name of your company____

Discovery or Mining Period	Number of pennies found in 30-second period
1st	
2nd	
3rd	
4th	
5th	

Class Data:

Discovery or Mining Period	Number of Pennies Found
1st	
2nd	
3rd	
4th	
5th	

Energy Resources – Engineering - Economics

Finding Fossil Fuels

Questions:

1. Do the pennies hidden in the discovery/mining area represent a renewable or a nonrenewable resource?

2. In which 30 second period were the most pennies found?

3. Why were fewer pennies found in each 30 second period as time passed?

4. What would happen if more people were looking for the pennies at the same time?

5. How is this simulation like looking for supplies of fossil fuels or other resources?

Energy Resources – Engineering - Economics

Finding Fossil Fuels – Teacher notes

Objectives:

The students will:

1. Complete an activity that simulates the search for natural resources.
2. Explain what is meant by renewable and nonrenewable resources.

Academic Standards:

Environment and Ecology
Renewable and Nonrenewable Resources 4.2.7 A
Identify resources used to provide humans with energy, food, housing and water.

Environment and Ecology
Renewable and Nonrenewable Resources 4.2.7 B
Determine how consumption may impact the availability of resources.

This activity has been successfully completed with both students and adults. The pennies are a favorite with students. They always enjoy activities that involve food. Have paper towels at each desk or table to make cleanup easier. With an adult group, you may wish to use pennies. Some simulations used peanuts in the shell (messy).

Hide 200 pennies around the room, using masking tape if necessary. Some may be in sight while others should be well hidden. This number represents a finite supply of a nonrenewable energy source – just like fossil fuels.

When you give the cue, the students have 30 seconds to collect as many pennies as possible. They should fill out their data sheets after each collection. The data should be combined on the Group Data list. This will also provide you with an idea of how many pennies are still in the room. This is OK – in real life a source may not be discovered or may be too expensive to recover. Winning teams usually had a strategy to find pennies.

Answers to Questions:

1. Do the pennies hidden in the room represent a renewable or a nonrenewable resource? ***A nonrenewable source***
2. In which 30 second period were the most pennies found? ***Usually in the first period***
3. Why were fewer pennies found in each 30 second period as time passed?

Less of the fossil fuel is available to be discovered.

4. What would happen if more people were looking for the pennies at the same time?

The resource may be depleted sooner. Each person (group) may find less.

5. How is this simulation like looking for supplies of fossil fuels or other resources?

As the resource is depleted, it is harder to find more.
It is possible to look for a natural resource and not find any, i.e. "dry wells".
It may take longer to find a resource as time goes by – making it more expensive.
In some simulations students charged others with violations of cheating or even being aggressive. This enabled a real-life discussion of why there are laws/rules

Energy Resources: Environment - Engineering - Economics

Challenges in Mining Coal

Purpose :

1. Simulate the strip mining of coal.
2. Discuss some of the factors involved in the strip mining of coal.

Did You Know?**

- Over 50% of America's electricity is generated by the burning of coal.
- Pennsylvania is one of the top coal producing states in the US.
- Nearly all of the US supply of anthracite (hard coal) is found in eleven northeastern Pennsylvania counties.
- The US has an estimated 250-300 year supply of coal.
- The US produces over one fifth of the world's coal.
- One fourth of all coal ever mined in the US came from Pennsylvania.
- Burning coal without controls can lead to air pollution and acid mine drainage.
- Coal science and technology are important to improve and safeguard our environment and provide electricity and other products from coal in the future.

Discussion:

Your company plans to strip mine 100 acres of coal that is in a 40-inch thick seam. You will pay the owners of the land royalties for the mineral rights on their property. Your company must also post bonds. This money ensures that the land will be restored if your company does not do so. Included in the fees is a 35 cent per ton charge to reclaim land that was not restored in the past. The following list outlines typical expenses that a coal operator must pay.

Bonds, permits and engineering		$ 650,000
Payroll		$ 3,500,000
Other employment costs (insurance, benefits)		$ 2,500,000
Equipment		$ 7,000,000
Transportation of Coal		$ 2,000,000
Royalties		$ 1,500,000
Taxes and Fees		$ 1,400,000
	Total Expenses	$18,550,000

Energy Resources: Environment - Engineering - Economics

Challenges in Mining Coal

To calculate your profit or loss, the following calculation will be used:
Number of unit trains X 10,000 ton/train X $30/ton = Income
A unit train could consist of 100 cars each holding 100 tons of coal for a total of 10,000 tons.

Procedure:

a. You will be given a portion of the strip mine. You must handle the mining equipment carefully. If it is damaged, you will be charged a fee for repairs.
b. Carefully remove the overburden and set it aside. If the land it not restored to its original appearance, you will forfeit the bonds that you posted.
c. Remove the "coal" from your mine site and set it aside to be weighed. Each gram of "coal" will equal one unit train of coal.
d. After you have removed all of the available coal, restore your site as close to the original conditions as possible.
e. Determine the total amount of coal mined and determine whether or not you were able to earn a profit for your company.

Calculations/Questions:

Profit/Loss Calculation
_____ Unit trains X 10,000 ton/train X $30/ton = ______________________

Income __________________minus Expenses _________________ equals Profit

Your Profit =________
Were you able to make a profit?

1. Were you able to remove all of the coal?

2. What could you do to improve profits?

Activity based on a presentation by Ms. Kathleen Kennedy at ENTER 2000, PSU, Summer 2000. Other sources www.dep.state.pa.us and www.eia.gov.kids

Electricity

Basics of Electricity

Discussion:

Scientists have discovered that atoms are made up of three basic particles – protons, neutrons and electrons. Electric current is a flow of electrons through a material. Some materials like metals let these electrons flow through them easily and are called conductors. When a material does not allow electrons to flow through it easily that material is said to be an insulator.

Much of the energy we use is in the form of electricity. The path these electrons take is referred to as a circuit. When electricity is used, three terms are often used in describing a circuit – voltage, current and resistance. In this experiment, you will use a multi-meter to measure these three variables.

Voltage or potential difference is the difference in energy between two points in a circuit. The unit for voltage is the **volt**. If an analogy is made with a garden hose, voltage could be compared to the force with which the water comes out of the hose.

Current is the rate that the charges (electrons) flow through the circuit. Current is measured in units called **amps**. In the garden hose analogy, current would be the amount of water that flows through the hose per second.

Resistance is the opposition to the flow of electrons in a circuit. It is measured in units called **ohms**. The better a material lets electrons flow through it, the lower the resistance. In the garden hose analogy, if the inside opening of the hose was very narrow or rough, it would be hard for the water to pass though the hose. The resistance to the flow of the water would be high. If another hose had smooth walls and a wide diameter, the resistance to the flow of the water would be much smaller.

Materials/Equipment:

Multi-meter Clip leads Batteries in holders Resistors

Procedure: Part I: Voltage

1. The black test lead should be in the COM port and the red lead should be in the V port (the far right one).
2. Turn the dial to the 2 V position.
3. Measure the voltage of a single D-cell battery. Record your value in the data table.
4. Obtain another D-cell battery. You will take two different readings with them.
    A. Using a clip lead attach the two batteries end-to-end. Connect the positive terminal of one battery to the negative terminal of another. Measure the voltage of the two batteries from the positive terminal of one to the negative terminal of the other. Record this voltage in the data table. You have measured the voltage of two batteries in series – end-to-end.

Electricity

Basics of Electricity

B. Use two clip leads to attach the positive terminal of one battery to the positive terminal of the other. Use a second clip lead to attach the two negative terminals. Measure the voltage of this setup by placing one probe on the positive terminal of one battery and the other on the negative terminal of the other battery. Record the voltage in the data table. You have measured the voltage of the two batteries in parallel – “side-by-side”

Part II: Resistance

1. Leave the test leads of the multi-meter in the same positions as they were in Part I. Turn the 20K scale of the resistance section – the symbol for resistance is Ω.
2. Attach a clip lead to each end of a resistor. Connect these to the probes of the multi-meter. What is the reading on the scale? **NOTE:** The K means that the reading is in thousands of ohms. Record the value in the data table.
3. Obtains another resistor. You will take two different readings with them.

A. Using a clip lead attach the two resistors end-to-end. Measure the resistance of the two resistors from the end of one to the end of the other. Record this value in the data table. You have measured the resistance of two resistors in series – end-to-end.

B. Use two clip leads to attach the ends of the resistors in a side-by-side setup. Measure the resistance of this setup by placing one probe on the far end of one resistor and the near end of the other. Record the value in the data table. You have measured the resistance of the resistors in parallel- side-by-side.

C. Repeat with three resistors.

Part III: Current

1. **Use the batteries especially labeled for this part of the experiment.** The black probe should remain in the COM port the red probe should be moved to the 10A port.
2. The dial should be turned to the 10A setting on the multi-meter.
3. Measure the current of a single D-cell battery.
4. Obtain another D-cell battery that has been used until we would say that it is “dead”. Measure the current produced by each battery.
5. If the second battery is “dead” what is its voltage? Return the probes to their original positions on the multi-meter and measure the voltage of each Record the values in your data table.

Electricity

Basics of Electricity

Data/Questions:

Part I:

Set-up	Voltage
Single Battery	
2 Batteries (end-to-end)	
2 batteries (side-by-side)	

Part II:

Setup	Resistance
Single Resistor	
2 Resistors (end-to-end)	
2 resistors (side-by-side)	
3 Resistors (end-to-end)	
3 Resistors (side-by-side)	

Part III:

Set-up	Current	Voltage
Single Battery		
"Dead battery"		

Questions:

1. What generalizations can you make about voltage, resistance and current when the measurements are made in series (end-to-end) or in parallel (side-by-side)

Set-up	Series	Parallel
Voltage		
Resistance		

2. An experimental device needs six volts of electricity to operate. You have a drawer full of 1.5 volt batteries. How would you arrange them to operate the device?

3. Which electrical measurement shows if a battery is "dead"?

Electricity

Basics of Electricity – Teacher notes

Objectives:

1. The students will become familiar with terms like circuit, volts, amps and ohms.
2. The students will make measurements with a multi-meter.

It is not the purpose of this experiment to teach electrical circuits or Ohm's Law.

Academic Standards

Science and Technology
Inquiry and Design 3.2.7 B
Measure materials using a variety of scales.

Science and Technology
Inquiry and Design 3.2.7 B
Design controlled experiments, recognize variables and manipulate variables.

Science and Technology
Physical Science, Chemistry and Physics 3.4.7 B
Explain the parts and functions in an electrical circuit.

Sample Data/Questions

Part I Set-up	**Voltage**
Single Battery	*1.61 volts*
2 Batteries (end-to-end)	*3.21 volts*
2 batteries (side-by-side)	*1.60 volts*

Part II Setup	**Resistance**
Single Resistor	*0.985 ohms*
2 Resistors (end-to-end)	*1.97 ohms*
2 Resistors (side-by-side)	*0.492 ohms*
3 Resistors (end-to-end)	*2.97 ohms*
3 Resistors (side-by-side)	*0.335 ohms*

Part III Set-up	**Current**	**Voltage**
Single Battery	*1.20 amps*	*1.59 volts*
"Dead Battery"	*0.30 amps*	*1.52 volts*

Questions

1. What generalizations can you make about voltage, resistance and current when the measurements are made in series (end-to-end) or in parallel (side-by-side)

Set-up	**Series**	**Parallel**
Voltage	*Increases*	*same*
Resistance	*Increases*	*less*

2. An experimental device needs six volts of electricity to operate. You have a drawer full of 1.5 volt batteries. How would you arrange them to operate the device? ***Connect them in series – end-to-end.***

3. Which electrical measurement shows if a battery is "dead"?
Current – current drops significantly for "dead" batteries*.*

Electricity: Power and Metering

Measuring Electrical Current

Discussion:

Energy may be converted from one form to another. Electrical energy may be converted to heat energy in water heaters,, dryers or toasters. Electrical lighting is the result of transforming electrical energy to radiant energy. Motors in vacuum cleaners and washing machines rely on the conversion of electrical energy to mechanical energy.

Electric power is the rate of conversion of electrical energy. Power is measured in units called watts. Because a watt is a relatively small unit, kW or kilowatts are usually used. When the electric bill comes each month, you are being billed for how much power – kilowatt hours – of electricity you have used.

Materials/Equipment:

Watts-Up Meter Various electrical appliances

Procedure:

Plug a series of electrical appliance into the Watts-Up meter. Record the type of appliance and the number of kW the appliance uses. Note that the meter readout is in kilowatts. A 100 watt light bulb would give a reading of 0.100 kW. A 60 watt device would give a reading of 0.060 kW.

Device	kW Used

Electricity: Power and Metering

Measuring Electrical Current

Results/Questions:

1. What types of electrical appliances used the most power? Can you make a generalization about this? If so, What?

2. How did the power use of regular (incandescent) and fluorescent lights compare?

3. Did you turn your lights off? Suppose that the cost of electricity in your area is 10 cents per kilowatt hour. You leave the following electrical devices on in your room:

   Desk lamp – 20 watts
   Ceiling light – 60 watts
   Computer – 100 watts
   TV – 100 watts

   a. How much would it cost to leave these on and unattended for one hour?

   b. How much would it cost if they were left unattended for five hoursa day ?

   c. What would the cost be for a month (assume 30 days)?

Electricity: Power and Metering

Measuring Electrical Current – Teacher notes

Objectives:

1. The students will measure the amount of electrical power – kilowatts that various electrical devices use.
2. The students will calculate how much it costs to operate electrical when they are not in use.

Academic Standards:

Science and Technology
Inquiry and Design 3.2.7 B
Measure materials using a variety of scales.

Science and Technology
Inquiry and Design 3.2.7 B
Design controlled experiments, recognize variables and manipulate variables.

Mathematics
Problem Solving and Communication 2.5.8 B
Verify and interpret results using precise mathematical notation and representations, including numerical tables and equations, simple algebraic equations and formulas, charts, graphs and diagrams.

Sample Data:

Device	*kW Used*
Toaster	*0.84*
Hair Dryer	*1.01*
Mixer	*0.050*
Coffee Maker	*1.24*
Fluorescent light	*0.019*
Desk Lamp	*0.118*
Steam iron	*1.4*
Sweeper	*0.312*

1. What types of electrical appliances used the most power? Can you make a generalization about this? If so, What?

Those appliances that are used to create heat seemed to use the most power.

2. How did the power use of regular (incandescent) and fluorescent lights compare?

The fluorescent light used much less power.

3. Did you turn your lights off? Suppose that the cost of electricity in your area is 10 cents per kilowatt hour. You leave the following electrical devices on in your room:

Desk lamp 20 watts Ceiling light 60 watts Computer 100 watts TV 100 watts

a. How much would it cost to leave these on and unattended for one hour?

0.280 kWhr X 10 ¢/hr = 2.8¢

b. How much would it cost if they were left unattended for five hours a day?

2.8¢ X 5 hr = 14¢

c. What would the cost be for a month (assume 30 days)?

14¢/day X 30 days = $4.20

Electricity – Lighting Efficiency

Operating Cost and Savings

1. Sylvania produces both incandescent and fluorescent light bulbs. The fluorescent bulb uses 20 watts of power and has an expected life of 10,000 hours. The incandescent bulbs use 75 watts. How much would it cost to "burn" both types of bulbs for a total of 10,000 hours? Assume the cost of electricity is 10 cents per kilowatt-hour. How much can be saved by changing just one incandescent bulb to a fluorescent bulb?

2. The GE Profile 25.6 ft^3 refrigerator has an ENERGYGUIDE label rating of 1034 kwh/year. It is sold locally for $1397. A similar Whirlpool 25.5 ft^3 refrigerator has an ENERGYGUIDE label rating of 680 kwh/year and sells for $1647. The average life of a refrigerator is 20 years. Is the higher cost of the Whirlpool refrigerator justified? How long would it take for the more expensive refrigerator to make up the increased initial cost in energy savings?

Note: Products profiled were used for convenience only. Any brand with energy data is applicable.

Electricity – Lighting Efficiency

Operating Cost and Savings – Teacher notes

Objectives:

3. The students will calculate the energy savings when using a more efficient appliance.
4. The students will calculate the "pay back" for an appliance, i.e. how long it takes for a more expensive but more efficient appliance to pay for its additional cost in energy savings.

Academic Standards:

Environment and Ecology
Renewable and Nonrenewable Resources 4.2.7 B
Determine how consumption may impact the availability of resources.

Mathematics
Mathematical Problem Solving & Communication 2.5.8 B
Invent, select, use and justify appropriate methods, materials and strategies to solve problems.

Estimating Operating Cost - Answers

1. Sylvania produces both incandescent and fluorescent light bulbs. The fluorescent bulb uses 20 watts of power and has an expected life of 10,000 hours. The incandescent bulbs use 75 watts. How much would it cost to "burn" both types of bulbs for a total of 10,000 hours? Assume the cost of electricity is 10 cents per kilowatt-hour. How much can be saved by changing just one incandescent bulb to a fluorescent bulb?

10,000 hr X 20 Watts = 200,000 Watts
200,000 Watts = 200 kWH
200 kWH X $.10 = $20.00

10,000 hr X 75 Watts = 750,000 Watts
750,000 Watts = 750 kWH
750 kWH X $.10 = $75.00 $75.00 - $20.00 = $55.00

2. The GE Profile 25.6 ft^3 refrigerator has an ENERGYGUIDE label rating of 1034 kwh/year. It is sold locally for $1397. A similar Whirlpool 25.5 ft^3 refrigerator has an ENERGYGUIDE label rating of 680 kwh/year and sells for $1647. The average life of a refrigerator is 20 years. Is the higher cost of the Whirlpool refrigerator justified? How long would it take for the more expensive refrigerator to make up the increased initial cost in energy savings?

Electricity usage difference = 354 kHW/year
Cost difference = $250
354 kWH X $.10/kWH = $35.40
$250/ $35.40/year = 7.06 years
The higher price is recovered in energy savings in a little over 7 years.

Electricity Generation

How Does a Potato Clock Work?

Discussion:
In this activity we discuss the generation of electricity from energy sources and energy conversions. Batteries are an important portable energy source. When a battery operates chemical energy is being converted to electrical energy. After you have completed this activity you should be able to:

1. Describe the components of a battery.
2. Explain how a battery produces electricity
3. Explain how a potato clock works.

Purpose:
The purpose of this activity is to describe the parts of a battery and how they produce electricity.

Equipment/Materials:

lemon	clip leads	zinc metal
blinking LED	copper metal	multi-meter

Procedure:
1. You will be given the materials in the equipment list above. Using this equipment, assemble a device that will generate electricity and causes the LED to blink.
2. Draw and label your device on the answer sheet.
3. Use your multi-meter to measure the number of volts produced. Compare this with the number of volts produced by a regular flashlight battery.

Electricity Generation

How Does a Potato Clock Work?

Questions:

1. In the space below, draw your device. Label each of the components.

2. a. How much voltage did your device produce?

b. How does this compare with a regular battery?

3. What is needed to construct a battery?
   a.

   b.

   c.

4. Now that you have built a battery, how do you think a potato clock works?

Electricity Generation

How Does a Potato Clock Work? – Teacher notes

Objectives:

1. The students will build a working battery in this inquiry-based activity.
2. The students will describe the components of a battery.
3. The students will use what they have learned in this experiment to explain how a potato clock works.

This activity is purposely open ended. It allows students to use the inquiry process to complete a task and answer the title question.

Academic Standards:

Science and Technology
Inquiry and Design 3.2.7 B
Measure materials using a variety of scales.

Science and Technology
Inquiry and Design 3.2.7 B
Design controlled experiments, recognize variables and manipulate variables.

Science and Technology
Physical Science, Chemistry and Physics 3.4.7 B
Explain the parts and functions in an electrical circuit.

Questions

2. a. How much voltage did your device produce?

Copper – zinc cells should produce about 1.1 volts.
Technically, this is an electrochemical cell.
A battery results when several of these cells are connected.

b. How does this compare with a regular battery?

Regular C or D cell batteries should produce 1.5 volts.

3. What is needed to construct a battery?

a. 2 different metals – electrodes. Students will see that if two pieces of Cu (or Zn) are used, no voltage results.
b. An electrolyte – the juice of the lemon serves as the electrolyte.
c. Wires to complete the circuit

4. Now that you have built a battery, how do you think a potato clock works?

The potato clock works because:

2 different metals are used.
The moisture in the potato serves as the electrolyte.
The wires complete the circuit and allow the clock to work.

Recycling-Resource Recovery

Garbage: Too Valuable to Burn or Bury

Discussion:

In Pennsylvania, many communities encourage and practice recycling. Instead of burying materials in landfills or burning them in incinerators, some materials can be used to make new items. Commonly recycled materials include glass, metal cans, newspapers and plastics.

In this activity you will examine a variety of plastics that might be found in someone's trash. You will sort these items and describe some of the materials formed from different types of recycled plastics.

On the bottom of most plastic containers a code is used to indicate the type of plastic. Currently seven different types of plastics are used. The code is used in separating the plastics before they are recycled. When different types of plastics are mixed, a useless mixture can result. The plastics code looks like this

Examine the plastics samples that might be found in someone's trash. Look for the plastic code numbers and write the name of the product in the data table.

Questions:

1. What types of plastics seem to be used most often?

2. What types of plastics were used for shampoo and cream rinse bottles? Why is this plastic a good choice for this use?

3. What are some materials made when these materials are recycled?

Recycling-Resource Recovery

Garbage: Too Valuable to Burn or Bury

Data Sheet

Type of Plastic	Examples
1 PETE	
2 HDPE	
3 PVC	
4 LDPE	
5 PP	
6 PS	
7 OTHER	

Recycling-Resource Recovery

Garbage: Too Valuable to Burn or Bury – Teacher notes

Objectives:
The students will examine a collection of empty plastic containers. They will sort the plastics by the plastic packaging resin codes on the containers. The students will then examine some materials fabricated in part or whole from recycled materials.

Academic Standards:

Environment and Ecology
Renewable and Nonrenewable Resources 4.2.7 A
Identify resources used to provide humans with energy, food, housing and water.

Environment and Ecology
Renewable and Nonrenewable Resources 4.2.7 B
Determine how consumption may impact the availability of resources.

Answers to Questions:

1. What types of plastics seem to be used most often?
PETE used for soft drink bottles and HDPE used for milk jugs, shampoo and detergent bottles are usually found in the largest volume.

2. What types of plastics were used for shampoo and cream rinse bottles? Why is this plastic a good choice for this use?
HDPE is used because it is very flexible. Some forms of PS are very brittle and would crack the first time they were squeezed.

3. What are some materials made when these materials are recycled?
Polar fleece is made from recycles soft drink bottles. Deck lumber is made from recycled grocery store bags.

Recycling-Resource Recovery

Garbology 101: Understanding Material Separation

Your community has begun curbside recycling. Each home will be provided with a bin in which the homeowner may place:

Glass containers – any color
Aluminum cans
Steel cans
Newspapers
#1 and #2 Plastic containers

Products that come in plastic containers have a number code on them. The code indicates the type of plastic used – see the sheet with the plastic codes. When plastics are recycled, they must be separated by type of plastic. If different types of plastics are mixed when recycled, the resulting mixture is unusable. While nearly all plastics can be recycled, only those types for which there is a ready market are usually collected.

You will be given a sample of plastics discarded by a family for a week. Your task is to sort the plastics, classify them and determine the percentage that can be recycled.

Questions:

1. What reasons would you give someone for why we should recycle?

2. What types of plastic is used for shampoo and cream rinse bottles?
3. Why is this a good choice?

4. Why should we avoid items coded #7 plastic?

5. What happens to items that are not recycled?

6. What are some products made from recycled plastics?

Recycling-Resource Recovery

Garbology 101: Understanding Material Separation

Recycling Plastics – Data

Plastic Item	Code Number	Recyclable? (#1 or #2)

No. Plastic Items Observed _________ No. of #1 and #2 Plastics __________

% of Recyclable Items _______________

Recycling-Resource Recovery

Garbology 101: Understanding Material Separation – Teacher notes

Objectives:
The students will examine a collection of empty plastic containers. They will sort the plastics by the plastic packaging resin codes on the containers. The students will then examine some materials fabricated in part or whole from recycled materials.

Academic Standards:

Environment and Ecology
Renewable and Nonrenewable Resources 4.2.7 A
Identify resources used to provide humans with energy, food, housing and water.

Environment and Ecology
Renewable and Nonrenewable Resources 4.2.7 B
Determine how consumption may impact the availability of resources.

Answers to Questions:

1. What reasons would you give to someone for why we should recycle?
   Reducing the amount of waste going to landfills, conserving nonrenewable resources, etc.

2. What types of plastics were used for shampoo and cream rinse bottles? Why is this plastic a good choice for this use?
   HDPE is used because it is very flexible. Some forms of PS are very brittle and would crack the first time they were squeezed.

3. Why should we avoid items coded #7 plastic?
   This is a mixture of plastics or a type other than #1 - #6

4. What happens to items that are not recycled?
   These materials end up in land fills.

5. What are some materials made when these materials are recycled?
   Polar fleece is made from recycles soft drink bottles. Deck lumber is made from recycled grocery store bags.

Recycling Materials

Product Research – "Saving Humpty Dumpty"

Discussion:

In every experiment, controls and variables must be used. Controls are those parts of the experiment that are not changed. The control may also serve as a reference for the experiment. They allow us to see what difference the variables made. The variables are the parts of the experiment that are changed. In this experiment, you will make a pad of recycled shoe material to simulate a sports surface. The control will be made using the recipe suggested by Nike. This pad will be compared to regular surfaces and to the recipe your group creates. You will then determine which formula provides the greatest protection.

Purpose:

In this experiment, you will construct a sports surface from recycled athletic shoe materials. You will try to determine what mixture of materials provides the best cushioning.

Materials/Equipment:

Part I	measuring cups	glue	recycled shoe material	paint stirrer
	bucket/container	spatula	newspapers	
Part II	meter stick	hard boiled eggs	plastic baggies	

Procedure: Day 1

- Prepare a basic recipe following the instructions on the data sheet. Combine the materials thoroughly and smooth the top of the mixture with a spatula. Place the pad you formed in the place designated by you instructor. The pad needs to dry for a couple of days before it can be used. Label it as the control.
- Prepare a recipe in which the amounts differ from the control recipe. Record the amounts of each material used on the data sheet. List your reasons for using your mixture and write how you think it will help cushion – your hypothesis.

Day 2

- Using PVC pipe or dryer hose drop a hard boiled egg from various lengths and record each height drop until the egg shell shows signs of breaking.
- Repeat Step 1 on the control pad. Be sure to record the results.
- Repeat Step 1 on the experimental pad. Be sure to control the results.
- Compare the class results. Which mixture seemed to be the best? Why do you think this is the case?

Questions:

Do you think this is a useful way to recycle used athletic shoes?
Can you think of other items that could be developed?

Note: This activity comes from the unique and conservation oriented program from NIKE. Conservation is the primary effort. This project promotes team work.

Insulation

How Effective? How Efficient?

Discussion:
In this experiment, you will try to keep some water hot. Each group will surround their sample of water with a different type of insulation. The temperature of the water will be taken over time and the results will be graphed. The graphs will tell us which type of insulation is the most efficient.

Materials/Equipment:

2-liter soft drink bottles	insulation samples
thermometer	large test tubes or bottle pre-forms
hot water	graph paper or graphing program

Procedure:

1. The tops of the soft drink bottles have been cut off so that you can place the test tube of water and insulation inside. One group should do a trial with no insulation in the bottle.

2. Select a type of insulation and record it on your data sheet. Stand an empty test tube in the soft drink bottle and use enough insulation so that the space between the test tube and soft drink bottle is full. Some insulation should also be placed under the test tube. Do not pack the insulation too tightly.

3. Add 50 mL of hot (not boiling) water to the test tube. Insert the thermometer and begin taking temperature readings every minute for 20 minutes.

4. At the end of the 20 minutes, graph your data and share your findings with the other groups.

Insulation

How Effective? How Efficient?

Type of Insulation Used ______________________________________

Data:

Notes:

Time	Temperature

How Efficient Is Your Insulation?
Data:

Type of Insulation	Temperature after several minutes			
	5 min	10 min	15 min	20 min
Control				

Insulation

How Effective? How Efficient?

Questions:

Which type of insulation did the best job of keeping the water hot?

Which type of insulation did the worst job of keeping the water hot?

Why was a sample run with no insulation?

These trials showed the effect of keeping a sample warm by using insulation. How would using insulation affect cold samples? Give an example.

What characteristics do you think are common to good insulating materials?

Many hardware stores sell insulation kits to wrap around a hot water heater. After completing this activity, do you think this is a good choice for a homeowner?

Insulation

How Effective? How Efficient? – Teacher notes

Objectives:

1. The students will carry out an experiment to determine which materials are the most efficient insulators.

Academic Standards:

Science and Technology
Inquiry and Design 3.2.7 B
Measure materials using a variety of scales.

Science and Technology
Physical Science, Chemistry and Physics 3.4.7 B
Explain the conversion of one form of energy to another by applying knowledge of each form of energy.

Science and Technology
Inquiry and Design 3.2.7 B
Design controlled experiments, recognize variables and manipulate variables.

This activity was designed to show students that insulation can prevent heat loss. They should also see that not all materials work equally well. It was decided not to have students touch unfaced fiberglass insulation. A variety of common materials (packing peanuts, shredded newspaper, bubble wrap, plastic grocery store bags, fiberfill, cotton balls, etc.) were used instead. The insulation was placed in a cut off 2-liter soft drink bottle. Half gallon milk containers could also be used. This served as a control so that all set ups would have the same amount of insulation around the test tube. One set up did not receive any insulation to show the effect of not using insulation. Hot – not boiling water was used. In 20 minutes there can be a 20 degree difference between the best insulator and the set up with no insulation.

1 Which type of insulation did the best job of keeping the water hot?
Which type of insulation did the worst job of keeping the water hot?

Student responses

2. Why was a sample run with no insulation?

To serve as a control

3. These trials showed the effect of keeping a sample warm by using insulation. How would using insulation affect cold samples? Give an example.

The cold samples would stay cold longer. Ice chests, refrigerators

4. What characteristics do you think are common to good insulating materials?

Most students will describe the light weight of the material. Good insulators have air trapped in them or prevent the flow or movement of air.

5. Many hardware stores sell insulation kits to wrap around a hot water heater. After completing this activity, do you think this is a good choice for a homeowner?

The heat would be retained longer in the tank – requiring the heating elements to operate less often.

Insulation

Does Insulation Make a Difference?

Discussion:

We depend on refrigeration for many comforts of life. Having ice readily available is something we take for granted. In this experiment, you will make a portable refrigerator by insulating a container to preserve ice cubes. Heat can be transferred by conduction through materials. Heat energy flows from warmer areas to cooler areas. Insulation is used to slow the movement of the heat. Select materials that you feel will be good insulators.

Materials/ Equipment:

½ pint size milk or juice container for each student
one ice cube for each student
one zip lock bag for each student
two large paper clips for each student (to hold container closed)
insulation materials (provided by teacher and students)
guide for recording observations

Procedure:

1. Examine the materials and select two that you will use for your milk carton. Try to choose materials that are different from those selected by the students around you.
2. Record your choices and your reasons for selecting them on your observation sheet.
3. You will place your ice cube in the plastic bag at the same time as the rest of the class. Record the time.
4. Check your ice cube every 15 minutes until it is completely melted.
5. Record the time and calculate how long it lasted.
6. Complete the remaining questions on your observation sheet.

Insulation

Does Insulation Make a Difference?

Data and Questions:

1. The two materials used were:

   a.

   b.

2. These materials were selected because:

3. Time the ice cube was placed in the container: _______________

4. Time the ice cube was completely melted: _______________

5. Calculate how long the ice lasted:

6. Which type of insulation did the best job of keeping the ice from absorbing heat?

7. Which types of insulation were not very effective?

8. How could you have kept your ice frozen longer?

9. Would you use the same insulating materials for an oven as you would a refrigerator? (Explain why or why not.)

10. What were the controls and variables in this experiment?

Insulation

Does Insulation Make a Difference? – Teacher notes

Objectives:

The students will:

1. Carry out an experiment to determine what common materials make the best insulators.
2. Discuss control and variables in an experiment.

Academic Standards:

Science and Technology
Physical Science, Chemistry and Physics 3.4.7 B
Explain the conversion of one form of energy to another by applying knowledge of each form of energy.

Science and Technology
Inquiry and Design 3.2.7 B
Design controlled experiments, recognize variables and manipulate variables.

Insulation can be used to keep our homes warm in winter and cool in the summer. The students will determine what insulation materials keep their ice frozen the longest. They will use controls in their experiment by using approximately the same amount of ice, using the same volume of insulation, and by checking their samples at regular intervals. The main variable will be the type of insulation used. Any material can be used. Some suggestions are: shredded newspaper, plain popcorn, plastic or foam packing peanuts and cotton balls. Fiberglass insulation is not recommended because some students are easily irritated when touching it. Share data from the various groups before answering the questions.

Answers to Questions (where applicable)**:**

1. The two materials used were:
2. These materials were selected because:
3. Time the ice cube was placed in the container:
4. Time the ice cube was completely melted:
5. Calculate how long the ice lasted:

This is often a very difficult calculation for the students if the experiment starts before lunch and ends in the afternoon.. Calculate the time from the beginning of the experiment until noon. Convert to minutes. Calculate the time from noon until the ice is completely melted. Convert to minutes. Add the times together. The total time may be left in minutes.

6. Which type of insulation did the best job of keeping the ice from absorbing heat?
7. Which types of insulation were not very effective?
8. How could you have kept your ice frozen longer?

More insulation could have been used and the container could have been opened less often. Keep the refrigerator and freezer doors closed when the power goes off.

9. Would you use the same insulating materials for an oven as you would a refrigerator? (Explain why or why not.)

The insulation must be heat resistant or fire resistant if used in an oven. A plastic or foam insulation may not hold up in a hot environment. Nonflammable fiberglass insulation could be used in either application.

10. What were the controls and variables in this experiment?

The amount of ice, the volume of insulation and the times between inspections were the same for everyone – and were the controls. The types of insulation were the variables.

Lighting Survey

Using a Light-Meter

Part I

In order to complete the lighting survey of a room or a building, you must learn to use a light meter properly and efficiently. In this activity, light reading will be taken under a series of different conditions or backgrounds. Follow your instructor's directions for operation of the light meter. Handle it carefully. It is a delicate instrument. When taking measurements, be careful not to stand too close to the meter. Keep the light meter at a consistent (6 to 8 inches) distance from the paper. Important--when taking reading from the light bulbs, measure them from the same distance each time.
Note: Reflection from your clothes may affect the reading.

Color Backgrounds	Meter Reading
White	
Red	
Orange	
Yellow	
Green	
Blue	
Purple	
Black	
Desk Top Readings	
All lights on – blinds open	
All lights on – blinds closed	
½ lights on – blinds open	
½ lights on – blinds closed	
Regular Light Bulb	
Fluorescent Light Bulb	

Lighting Survey

Using a Light-Meter

Part II

Data Review and Questions:

1. Which color background gave the highest meter reading?

2. Which color background gave the lowest meter reading?

3. What units does the light meter express its readings in?

4. What do you think was the origin of the footcandle unit?

5. For a regular classroom, what footcandle range is suggested?

6. Was this light level provided when some of the lights in the room were turned off?

7. Happy Valley Middle School plans to renovate the school library. The librarian would like a color scheme that uses dark green walls and walnut stained shelves and reading tables. What impact does this have on the light levels in the proposed library?

Lighting Survey

Using a Light-Meter

Part II

You have discussed some of the factors that affect lighting levels. Now it is time to take some readings around the building. After taking these readings, compare them with the Light Level Chart* to determine if the readings are adequate.

Area Tested	Meter Reading	Suggested Level	Adequate?

LIGHT LEVEL CHART

	Typical Space	Light Level (footcandles)	
	Basement, utility rooms	2-5	
	Lobby, Storage rooms	5-10	
	Classrooms	50-80	
	Offices, Work Areas	50-100	
	Auditorium	15-70	
	Gym	40-60	
	Hallway	15-20	
	Science Lab	70-75	
	Restroom	25-30	
	Library	50-75	

Lighting Survey

Using a Light-Meter – Teacher notes

Objectives:

1. The students will use a light meter to measure light levels under different conditions.
2. The students will determine how various variables can effect light meter readings.

Academic Standards:

Science and Technology
Physical Science, Chemistry and Physics 3.4.7 B
Know that the sun is a major source of energy that emits wavelengths of visible light, infrared and ultra violet radiation

Science and Technology
Inquiry and Design 3.2.7 B
Measure materials using a variety of scales.

Answers to Questions:

1. Which color background gave the highest meter reading?
   Student responses Generally light backgrounds
2. Which color background gave the lowest meter reading?
   Student responses Generally dark backgrounds
3. What units does the light meter express its readings in?
   Footcandles (or lux)
4. What do you think was the origin of the footcandle unit?
   This is the standard unit for luminescence. It is probably the amount of light at 1 foot from a "standard candle".
5. For a regular classroom, what footcandle range is suggested?
   50 – 80 foot-candles
6. Was this light level provided when some of the lights in the room were turned off?
   Student responses This question shows that lighting levels may be adequate without having all of the lights on.
7. Happy Valley Middle School plans to renovate the school library. The librarian would like a color scheme that uses dark green walls and walnut stained shelves and reading tables. What impact does this have on the light levels in the proposed library?
   Additional lighting may be required.

Energy Generation

Mini-Generators: The Basics

Discussion:

Much of the energy we use is generated from another source of energy. Electricity may be generated from the burning of coal or by nuclear reactors. In some parts of the country, it is generated by wind or hydroelectric energy. In this activity, you will observe energy conversions. Regardless of how electricity is generated, energy conversions are involved.

Procedure:

- Attach the rubber band to the small nail at the end of the wooden spool.
- Thread the rubber band through the wooden spool.
- Thread the rubber band through the small colored wooden bead at the opposite end.
- Pull the rubber band out through the end of the colored bead and thread the straw through it.
- Wind the large straw about 10-20 turns, place on a flat surface, and release. The spool should move forward at a slow rate.

Questions:

- What is meant by potential energy? Kinetic energy? When are these observed in this experiment?
- Why does the spool move?
- What is the source of its energy?
- What can you do to increase the speed of the spool?
- How does the number of turns affect the distance that the spool moves?
- How steep (in degrees) an incline plane will the spool climb?
- How is the mini generator similar to a real power plant?
- How could you use wind and water to move your mini generator?
- What energy conversions are involved in:
  a. burning coal to generate electricity?
  b. using wind energy to generate electricity?

Energy Generation

Mini-Generators: The Basics

Objectives:

The students will:

1. complete an experiment and observe energy conversions.
2. investigate how variables can affect how far the mini generator will travel.

Academic Standards:

Science and Technology
Physical Science, Chemistry and Physics 3.4.7 B
Explain the conversion of one form of energy to another by applying knowledge of each form of energy.

Science and Technology
Inquiry and Design 3.2.7 B
Design controlled experiments, recognize variables and manipulate variables.

Answers to Questions:

1. What is meant by potential energy? Kinetic energy? When are these observed in this experiment?
   Energy due to position or stored energy. Energy due to motion. Potential –when the rubber band is wound. Kinetic – when the mini generator is moving.
2. Why does the spool move?
   Potential energy is being converted into kinetic energy.
3. What is the source of its energy?
   The twisting of the rubber band stores potential energy in the mini generator.
4. What can you do to increase the speed of the spool?
   Increase the number of winds of the rubber band.
5. How does the number of turns affect the distance that the spool moves?
   It increases
6. How steep (in degrees) an incline plane will the spool climb?
   Student answers
7. How is the mini generator similar to a real power plant?
   Energy conversions are taking place.
8. How could you use wind and water to move your mini generator?
   They could be used as the energy source to twist the rubber band.
9. What energy conversions are involved in:
   a. burning coal to generate electricity?
      Chemical → heat → mechanical → electrical
   b. using wind energy to generate electricity?
      Mechanical → electrical

Energy Generation

Fuel Cells

Discussion:

Electrical current is the flow of electrons through a circuit. These electrons may originate in a generator at a power plant, from a photovoltaic or solar cell, from a chemical reaction in a flashlight battery or from fuel cells.

Many chemical reactions involve the transfer of electrons from one atom to another. If we “sidetrack“ these electrons and pass them through a circuit, we can get these electrons to do useful work for us. This is what happens in a regular flashlight battery.

In the original fuel cells, the fuels were hydrogen and oxygen. Often air is the source of the oxygen used in fuel cells. The hydrogen atoms give up electrons to the oxygen atoms. By keeping the fuels separate and passing the electrons through a circuit, a good source of electrons and electrical current is found. The product of this reaction is water. No other pollution is formed. NASA uses fuel cells on the space shuttle to generate electricity. The fuel cells have many benefits. They are portable – no pipelines are needed to connect them to a fuel source. They produce little pollution and are much lighter than other batteries. Much research is being done to improve the efficiency of fuel cells and to increase the amount of current that they can produce.

You will examine two types of fuel cells in this experiment. Since tanks of hydrogen gas are sometimes difficult to work with, you will look at a methanol fuel cell and an aluminum/air cell. Methanol is a simple alcohol (which means it is a carbon compound with an –OH group in its structure) which can be produced from biomass. The products to the reaction are electrons, water and carbon dioxide. In the aluminum/air cell, each aluminum atom gives up three electrons when it reacts with oxygen from the air.

Equipment/Materials:

Methanol fuel cell	Aluminum/Air cell	Methanol	KOH solution
Salt solution	multi-meter	Clip leads	

Safety Note: The KOH solution used for the methanol fuel cell can cause eye damage. Safety glasses must be worn. If any of the solution gets on your skin it should be washed off with lots of cold water.

Energy Generation

Fuel Cells

Procedure:
For both of the fuel cells, measure the voltage and current produced. Record the values in the data table.

Data:

Fuel Cell	Measurement
Methanol	Volts
Methanol	Amps
Aluminum/Air	Volts
Aluminum/Air	Amps

Questions:

1. How did the fuel cells compare with other sources of electricity that you have measured?

2. What are some advantages of fuel cells?

3. What are some disadvantages of fuel cells?

4. The international space station uses solar panels to generate electricity. Why are solar panels not a good choice for the space shuttle?

Energy Generation

Fuel Cells – Teacher notes

Objectives:

1. The students will recognize fuel cells as a method of generating electricity.
2. The students will compare the voltage and current produced by fuel cell with other energy sources –dry cell batteries & photovoltaic cells.

Academic Standards:

Science and Technology
Inquiry and Design 3.2.7 B
Measure materials using a variety of scales.

Science and Technology
Inquiry and Design 3.2.7 B
Design controlled experiments, recognize variables and manipulate variables.

Environment and Ecology
Renewable and Nonrenewable Resources 4.2.7 B
Identify renewable resources and describe their uses.

Data:

Fuel Cell	Measurement
Methanol	***Various Results 0.58*** **Volts**
Methanol	***Various Results 0.045*** **Amps**
Aluminum/Air	***Various Results 1.65*** **Volts**
Aluminum/Air	***Various Results 1.2*** **Amps**

Questions:

1. How did the fuel cells compare with other sources of electricity that you have measured?
   Student answers – usually less current than flashlight batteries.
2. What are some advantages of fuel cells?
   Hydrogen/oxygen fuel cells produce no pollution. The fuel cells are portable. Methanol can be generated from biomass, allowing it to be recycled.
3. What are some disadvantages of fuel cells?
   Cost--Efficiency needs to be improved.
4. The international space station uses solar panels to generate electricity. Why are solar panels not a good choice for the space shuttle?

The solar panels are a permanent fixture. They would probably not survive reentry through the earth's atmosphere. If stored inside the cargo hold, they would take up valuable space. For deep space applications where the intensity of sunlight is very low, solar cells are not useful. In these cases small nuclear generators produce electricity and help keep equipment warm.

Energy Generation

Solar Cells

Discussion:

Electrical current is a flow of electrons. This electrical current can be generated in a power plant, by a chemical reaction in a battery or from a solar cell.

Most solar cells used today depend upon the element silicon. Silicon is one of the most common elements on earth. You have seen silicon in the form of silicon dioxide – sand. To build a solar cell, a “sandwich” of silicon wafers is made. The top layer of silicon atoms is doped with a small amount of an element like phosphorus. Phosphorus has one more electron than silicon. The bottom layer of silicon atoms is doped with elements like boron or gallium which have fewer electrons than silicon in their outer shell. Doping is the addition of foreign atoms to improve the conductivity of silicon. Silicon is normally a poor conductor. The solar cell is coated with a material to make it reflect less (or absorb more) light. This coating is responsible for the dark blue color of the solar cells.

When sunlight hits the solar cell, electrons from the top electron rich layer can flow to the bottom electron poor layer. We can use this flow of electrons to run a variety of electrical devices. In this experiment you will compare the current and voltage produced by solar cells under various conditions.

Materials/Equipment:

Solar cells	desk lamp
Multi-meter	clip leads
Gray plastic sheets	black construction paper

Procedure:

Part I: Voltage

1. Check the multi-meter to make sure the probes are in the proper positions. The black probe should be in the Com port and the red probe should be in the V (voltage) port. Set the dial to the 2 V setting.
2. Use clip leads to connect the solar cell to the multi-meter. Adjust the desk lamp so that it is 8 to 10 inches above the solar cell. Record the voltage.
3. Place the light gray sheet of plastic on the solar cell. This sheet will simulate the effects of a pertly cloudy day. Record the voltage.
4. Place the dark gray sheet of plastic on the solar cell. This sheet will represent a very cloudy day. Record the voltage.
5. Place the piece of black construction paper over the solar cell to represent night time conditions. What happens to the voltage?

Energy Generation

Solar Cells

Part II: Current

1. Reset the multi-meter to read current. Move the red probe to the A (current) port. Set the dial to the 200 mA setting.
2. Measure the current generated by the solar cell with no plastic, the light gray, and the dark gray plastic. In each case record the current generated in the data table.

Data/Questions:

Conditions	Readings
Full Sun (no plastic)	Volts
"Partially Cloudy" (light gray plastic)	Volts
"Overcast" (dark gray plastic)	Volts
Night time (black paper)	Volts
Full Sun (no plastic)	Amps
"Partially Cloudy" (light gray plastic)	Amps
"Overcast" (dark gray plastic)	Amps
Night time (black paper)	Amps

Questions:

1. Solar cells are also referred to as photovoltaic cells. What do you think the term "photovoltaic" means?
2. How many of these solar cells would be needed to produce the same voltage as a D-cell battery?
3. What was the effect of placing the gray plastic or black construction paper over the solar cells?
4. What are some advantages and disadvantages of solar cells?
5. In 1995 the cost of electricity from solar cells had been reduced to 32 cents a kilowatt hour. How does this compare to the costs calculated earlier?

Energy Generation

Solar Cells

Part III: Efficiency of Solar Cells

Solar cells or photovoltaic cells allow us to convert radiant or light energy into electrical energy. How well do they convert this energy? In this section of the experiment, you will determine the efficiency of the solar cells we are using.

The unit of electrical power is defined as the watt (more about that later). The watt is defined as:

Electric power (watts) = current (amps) X potential difference (volts)
To determine the efficiency, you must know the wattage of the light sources and the wattage produced by the solar cells. In the table below, record the current (amps) and the volts when the solar cell is placed under the lamp. In each case, keep the lamp the same distance from the solar cells. For sunlight, use the value of 0.135 Watt/cm^2 – the solar constant for the wattage. We will have to convert this value for the size of the solar cells we are using.

Light Source	Wattage	Solar Cell	Amps	Volts	Watts	Efficiency
Sun	0.135 Watt/cm^2					

1. At a power plant, the efficiency may be 30 to 40%. How does this compare to the efficiency of the solar cells?

2. If solar cells are to be used more widely, what changes in the cells will have to be made?

3. What are some of the applications where it makes “sense” to use solar cells?

Energy Generation

Solar Cells – Teacher notes

Objectives:

1. The students will recognize solar cells as a source of electricity.
2. The students will discuss advantages and disadvantages of solar cells as a source of electricity.

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Science and Technology
Inquiry and Design 3.2.7 B
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Environment and Ecology
Renewable and Nonrenewable Resources 4.2.7 B
Identify renewable resources and describe their uses.

Sample Data/Questions:

Conditions	Readings
Full Sun (no plastic)	**0.499 Volts**
"Partially Cloudy" (light gray plastic)	**0.430 Volts**
"Overcast" (dark gray plastic)	**0.260 Volts**
Night time (black paper)	**0 Volts**
Full Sun (no plastic)	**35.4 mA 0.0354 Amps**
"Partially Cloudy" (light gray plastic)	**274. mA 0.0274 Amps**
"Overcast" (dark gray plastic)	**13.4 mA 0.0134 Amps**
Night time (black paper)	**0 Amps**

Questions:

1. Solar cells are also referred to as photovoltaic cells. What do you think the term "photovoltaic" means?
   Electricity made from light.
2. How many of these solar cells would be needed to produce the same voltage as a D-cell battery?
   Three solar cells would be needed to make 1.5 volts.
3. What was the effect of placing the gray plastic over the solar cells?
   The voltage and current was greatly reduced.
4. What are some advantages and disadvantages of solar cells?
   The solar cells are portable, last a long time, and generate no pollutants once produced. The solar cells are expensive and a large area of them is needed to generate a sizable amount of electricity. A storage system is also required to store electricity for night or cloudy days.
5. In 1995 the cost of electricity from solar cells had been reduced to 32 cents a kilowatt hour. How does this compare to the costs calculated earlier?
   At 8 to 10 cents a kilowatt hour, electricity generated by solar cells is much more expensive.

Penn State
College of Engineering
Continuing and Distance Education Office

Energy Activities
and
Curriculum Handbook

FUTURE AHEAD

Renewable Energy and Conservation Education Program

YES!

Extend-a-Day
Energy Program

Young Engineers and Scientists
Section for Secondary Students with Teacher Notes

Electricity Basics	Watts Up Meter 2	Electroplating	*ACTIVITIES*	How to Read a Resistor	Combining Resistors	Introduction to Radiation
Counting Statistics	Radiation Shield	Thickness Gauging	Microdensity of Plastic	Polymers in Our Daily Lives	Polystyrene	Testing Sunscreens

Renewable Energy and Conservation Education Program (RECEP)
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COMBINING RESISTORS

Introduction:

Resistors are used in a circuit to control the amount of current that flows through it. Resistors come in a wide variety of sizes, but you may have an application that requires a specific resistance you don't have. It is possible to create new resistors by combining the ones you have. This may be done by combining them in two ways – parallel and series.

Purpose:

The purpose of this activity is to determine the rules for calculating the total resistance when two or more resistors are combined and to combine resistors and determine if the total resistance is the same as the predicted resistance.

Equipment/Materials:

Circuit board
resistors
Multimeter

Part 1.

1. Measure the resistance of a 1000 ohm resistor.

   Actual resistance ____________

   If the actual resistance is more or less than expected, this may be due to the tolerance of the resistor, i.e. some resistors are more precise than others.

2. Place two 1000 ohm resistors in series (end to end).

   Measured resistance ___________

3. Repeat with three 1000 ohm resistors in series.

   Measured resistance ____________

4. When connecting resistors in series, the total resistance cab be found by:

   How can we write this as an equation?

Part 2.

Making larger resistors from smaller ones is relatively easy. Connect them in series and add their resistances together. But, what if you need a smaller resistor? This can be done but it takes a little more work.

5. Connect two of the 1000 ohm resistors in parallel (side by side).

   Measured resistance ____________

6. Connect three of the 1000 ohm resistors in parallel.

   Measured resistance ____________

7. What pattern have you observed? How can we write this as an equation? Why do you think the resistors behave this way?

Part 3.

You have a tray full of the following resistors:

1000 ohm   500 ohm   200 ohm   150 ohm   100 ohm

How would you combine these resistors to create the following resistances? Some may have more than one possible solution.

25 ohms

75 ohms

175 ohms

133 ohms

375 ohms

625 ohms

2125 ohms

Part 4.

Using the circuit board, assemble the resistors you suggested in Part 3. Record the measured resistances. Remember that variation will be observed due to the scales selected and the tolerances of the resistors.

	Resistance Desired	Measured Resistance	
	25 ohm		
	75 ohm		
	133 ohm		
	175 ohm		
	375 ohm		
	625 ohm		
	2155 ohm		

Part 5.

Suppose you have a light with an on/off switch. You would like to use the light, but have it dimmer. To do this a 180 – 185 ohm resistor needs to be placed in the circuit. You have 500, 250, 100, and 50 ohm resistors but no 180 ohm ones. Suggest a combination of the available resistors that would allow you to control the circuit.

Suggested arrangement of resistors:

Measured resistance _______________

Combining Resistors
Teacher Notes

Standards

3.2.10.B Apply process knowledge and organize scientific and technological phenomena in varied ways.

- Describe materials using precise quantitative and qualitative skills based on observations.

3.2.10.C Apply the elements of scientific inquiry to solve problems.

- Conduct a multiple step experiment.

3.4.10.B Analyze energy sources and transfers of energy.

- Explain resistance, current, and electromotive force (Ohm's Law).

3.7.10.B Apply appropriate instruments and apparatus to examine a variety of objects and processes.

- Describe and use appropriate instruments to gather and analyze data.

Part 1

When resistors are placed in series, the total resistance is equal to the sum of the resistance of the resistors used.

$R = R_1 + R_2 + R_3 \ldots R_n$

Part 2

When resistors are placed in parallel, the reciprocal of the total resistance is equal to the sum of reciprocals of the resistances of all of the resistors.

$1/R = 1/R_1 + 1/R_2 + 1/R_3 \ldots 1/R_3$

The total resistance of a set of resistors in parallel is always less than the resistance of the smallest resistor. When resistors are placed in parallel, the current has multiple paths in which it can more through the circuit. Thus, the resistance to the flow of electrons is less.

Part 3	Possible Solutions
25 ohms	two 50 ohm in parallel
75 ohms	two 50 ohm in parallel plus one 50 ohm in series
175 ohms	two 250 ohm in parallel plus one 50 ohm in series
133 ohms	three 100 ohm in parallel plus one 100 ohm in series
375 ohms	250 ohm plus 100 in series plus two 50 ohm in parallel
625 ohms	two 250 ohm in parallel plus one 500 ohm in series
2125 ohms	1000 ohm plus 100 ohm in series plus two 50 in parallel

STATISTICS OF COUNTING

Introduction:

The disintegration of radioactive atoms is a random event. Given a sample of radioactive atoms, you can only estimate the number of atoms that will undergo decay during a period of time. In this experiment you will observe this random nature of radioactivity and use basic statistics to evaluate your data.

Purpose:

The purpose of this experiment is to observe the random nature of radiation and to evaluate a set of data using basic statistics.

Equipment / Materials:

Beta source	calculator
scaler & G-M tube	forceps

Safety:

- This lab presents no unusual safety hazards. It is good technique to use forceps to handle any radioactive source - including sealed sources.

Procedure:

1. Place the beta source on the shelf in the sample holder so that count readings of 1000 to 2000 cpm are obtained. If the readings are too high on the second shelf, move the source to a lower shelf.

2. The operating voltage should be set to the value you previously determined or to the one supplied by your teacher.

3. Care should be taken so that the operating voltage and position of the source do not change during the course of the readings.

4. Take 20 one minute readings of the beta source.

5. Calculate $\bar{n}$, the mean or average value of the individual counts, n. To do this determine the sum of the individual counts and divide by 20.

6. Subtract $\bar{n}$ from each value and record this value in the second column of the data table. The sum of these values for the 20 readings should be zero. If the value for the mean is rounded, this may not happen.

7. Square each value for $(n - \bar{n})$ and record these values in the third column. It will save time if this value is calculated when the original $n - \bar{n}$ value is on your calculator display.

8. Sum the 20 values in the $(n - \bar{n})^2$ column.

9. Calculate the value for standard deviation by finding the sum of the values in the $(n - \bar{n})^2$ column, divide by 19 and take the square root of this value.

10. According to statistics, if your set of data represents a "normal" distribution, 68% of the values should lie within the range of $\bar{n}$ +\- 1 standard deviation. Try this for your data. Add one standard deviation on to the mean. Subtract one standard deviation from the mean. Examine your data and count the number of data points that fit within this range.

11. Sometimes a data point appears to be out of place when compared to the rest of the data. A "2 standard deviation" rule can be used to determine if this piece of data should be kept or eliminated. If this data point is more than 2 standard deviations from the mean it can be eliminated. Try this for your data point that is furthest from the mean.

Data / Calculations:

Observation	n	$n - \bar{n}$	$(n - \bar{n})^2$
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			

___________**A** ___________**B** ___________**C**

$\bar{n}$ = mean = A\20 = ___________

Standard deviation = $\sqrt{C/19}$

Questions:

1. What percent of your values lie within +/- 1 standard deviation of your mean? Show your range and the number of values.

2. Pick the value furthest from the mean and use the "2 standard deviation rule" to determine if this value should be kept. Show your work.

Teacher Notes

Lab Time: The collection of data takes about one lab period, but the calculations may take some time out of the classroom.

Preparations:

V: The equipment needed for this lab are available upon request from the van.

Considerations:

Counting times may be reduced to half minute counts to save time and allow more time for calculations in lab.

This lab is designed to show the random nature of radiation. The students will use the *same* source on the *same* shelf with the scaler set to the *same* voltage as 20 readings of the *same* length of time are taken. You can probably get many of the students to predict that the counts obtained will be the same also. Stress that we will be able to predict about how many counts will be obtained but never the exact number.

Another use for this lab is to introduce basic statistics to students. This provides a method for analyzing data when a large number of measurements are collected. If you wish, scientific calculators can be used to do the calculations. Spreadsheets are another method to easily "crunch" the numbers.

Electricity Basics

Discussion:

Scientists have discovered that atoms are made up of three basic particles – protons, neutrons and electrons. Electric current is a flow of electrons through a material. Some materials like metals let these electrons flow through them easily and are called conductors. When a material does not allow electrons to flow through it easily that material is said to be an insulator.

Much of the energy we use is in the form of electricity. The path these electrons take is referred to as a circuit. When electricity is used, three terms are often used in describing a circuit – voltage, current and resistance. In this experiment, you will use a multi-meter to measure these three variables.

Voltage or potential difference is the difference in energy between two points in a circuit. The unit for voltage is the **volt**. If an analogy is made with a garden hose, voltage could be compared to the force with which the water comes out of the hose.

Current is the rate that the charges (electrons) flow through the circuit. Current is measured in units called **amps**. In the garden hose analogy, current would be the amount of water that flows through the hose per second.

Resistance is the opposition to the flow of electrons in a circuit. It is measured in units called **ohms**. The better a material lets electrons flow through it, the lower the resistance. In the garden hose analogy, if the inside opening of the hose was very narrow or rough, it would be hard for the water to pass though the hose. The resistance to the flow of the water would be high. If another hose had smooth walls and a wide diameter, the resistance to the flow of the water would be much smaller.

Materials/Equipment:

Multi-meter
Batteries in holders
clip leads
resistors

Procedure:

Part I: Voltage

5. The black test lead should be in the COM port and the red lead should be in the V port (the far right one).
6. Turn the dial to the 2 V position.
7. Measure the voltage of a single D-cell battery. Record your value in the data table.
8. Obtain another D-cell battery. You will take two different readings with them.
   A. Using a clip lead attach the two batteries end-to-end. Connect the positive terminal of one battery to the negative terminal of another. Measure the voltage of the two batteries from the positive terminal of one to the negative terminal of the other. Record this voltage in the data table. You have measured the voltage of two batteries in series – end-to-end.
   B. Use two clip leads to attach the positive terminal of one battery to the positive terminal of the other. Use a second clip lead to attach the two negative terminals. Measure the voltage of this setup by

placing one probe on the positive terminal of one battery and the other on the negative terminal of the other battery. Record the voltage in the data table. You have measured the voltage of the two batteries in parallel – "side-by-side"

Part II: Resistance

4. Leave the test leads of the multi-meter in the same positions as they were in Part I. Turn the 20K scale of the resistance section – the symbol for resistance is Ω.
5. Attach a clip lead to each end of a resistor. Connect these to the probes of the multi-meter. What is the reading on the scale? **NOTE:** The K means that the reading is in thousands of ohms. Record the value in the data table.
6. Obtains another resistor. You will take two different readings with them.

A. Using a clip lead attach the two resistors end-to-end. Measure the resistance of the two resistors from the end of one to the end of the other. Record this value in the data table. You have measured the resistance of two resistors in series – end-to-end.

B. Use two clip leads to attach the ends of the resistors in a side-by-side setup. Measure the resistance of this setup by placing one probe on the far end of one resistor and the near end of the other. Record the value in the data table. You have measured the resistance of the resistors in parallel- side-by-side.

C. Repeat with three resistors.

Part III: Current

6. **Use the batteries especially labeled for this part of the experiment.** The black probe should remain in the COM port the red probe should be moved to the 10A port.
7. The dial should be turned to the 10A setting on the multi-meter.
8. Measure the current of a single D-cell battery.
9. Obtain another D-cell battery that has been used until we would say that it is "dead". Measure the current produced by each battery.
10. If the second battery is "dead" what is its voltage? Return the probes to their original positions on the multi-meter and measure the voltage of each Record the values in your data table.

Electricity Basics

Data/Questions:

Part I:

Set-up	Voltage
Single Battery	
2 Batteries (end-to-end)	
2 batteries (side-by-side)	

Part II:

Setup	Resistance
Single Resistor	
2 Resistors (end-to-end)	
2 resistors (side-by-side)	
3 Resistors (end-to-end)	
3 Resistors (side-by-side)	

Part III:

Set-up	Current	Voltage
Single Battery		
“Dead battery”		

Questions:

4. What generalizations can you make about voltage, resistance and current when the measurements are made in series (end-to-end) or in parallel (side-by-side)

Set-up	Series	Parallel
Voltage		
Resistance		

5. An experimental device needs six volts of electricity to operate. You have a drawer full of 1.5 volt batteries. How would you arrange them to operate the device?

6. Which electrical measurement shows if a battery is “dead”?

Electricity Basics

Teacher Notes:

Objectives:

3. The students will become familiar with terms like circuit, volts, amps and ohms.
4. The students will make measurements with a multi-meter.

It is not the purpose of this experiment to teach electrical circuits or Ohm's Law.

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Measure materials using a variety of scales.

Science and Technology
Inquiry and Design 3.2.7 B
Design controlled experiments, recognize variables and manipulate variables.

Science and Technology
Physical Science, Chemistry and Physics 3.4.7 B
Explain the parts and functions in an electrical circuit.

Sample Data/Questions:

Part I:

Set-up	Voltage
Single Battery	*1.61 volts*
2 Batteries (end-to-end)	*3.21 volts*
2 batteries (side-by-side)	*1.60 volts*

Part II:

Setup	Resistance
Single Resistor	*0.985 ohms*
2 Resistors (end-to-end)	*1.97 ohms*
2 Resistors (side-by-side)	*0.492 ohms*
3 Resistors (end-to-end)	*2.97 ohms*
3 Resistors (side-by-side)	*0.335 ohms*

Part III:

Set-up	Current	Voltage
Single Battery	*1.20 amps*	*1.59 volts*
"Dead Battery"	*0.30 amps*	*1.52 volts*

Questions:

4. What generalizations can you make about voltage, resistance and current when the measurements are made in series (end-to-end) or in parallel (side-by-side)

Set-up	Series	Parallel
Voltage	*increases*	*same*
Resistance	*increases*	*less*

5. An experimental device needs six volts of electricity to operate. You have a drawer full of 1.5 volt batteries. How would you arrange them to operate the device? *Connect them in series – end-to-end.*

6. Which electrical measurement shows if a battery is "dead"?

Current – current drops significantly for "dead" batteries.

ELECTROPLATING

Introduction:

Electricity and chemical reactions may be related in two ways. In the first case, a chemical reaction may be used to produce electricity. This is what happens when you use a flashlight battery or when a car battery is used to start a car. A battery operating in this way is called a voltaic or electrochemical cell.

It is also possible to use electricity to bring about a chemical change. When a car or flashlight battery is recharged, an outside source of electricity is being used to bring about a chemical change inside the battery. When this occurs, the battery is acing as an electrolytic cell.

A popular use of electrolytic cells is electroplating. Electroplating is the process where a thin layer of one metal is deposited or plated onto another.

Purpose:

The purpose of this activity is to electroplate a base metal with copper.

Equipment/Materials:

Copper electrode
Metal to be electroplated
Beaker
Copper solution
lantern battery
clip leads
multimeter

Procedure:

1. Set up the cell as directed by your instructor. Make a sketch of the cell on your data page.
a. Weigh the copper strip and metal object to be plated. Record the values on the data page.
b. Fill the beaker 2/3 full with the copper solution.
c. The metal to be electroplated will be connected to the positive terminal of the battery with a clip lead.
d. A strip of copper will be connected to the negative terminal of the battery.
e. The metal object and the copper strip should be placed in the copper solution so that they do not touch. This will cause a “short circuit”.
f. Connect the multimeter to the circuit. Use an additional clip lead to place it in the circuit. The multimeter will act as an ammeter and will monitor the flow of electrons, the current, through the circuit.
g. Have your circuit checked and, when ready, make the connections to complete the circuit. Let the cell run for about 20 minutes. Take a reading of the current (amps) every four minutes.
2. At the end of the 20 minutes, break the circuit and remove the metal electrodes. Record any changes you observe.
3. Dip the electrodes in acetone or alcohol and air dry them. Weigh them and record the values on the data page.

Electroplating
Data and Questions:

1. Make a sketch of your cell in the space below. Label all of the parts.

2. Record the masses of the electrodes before and after the experiment.

Cu electrode Before ______________ After ______________

Metal Object Before ______________ After ______________

3. Describe the changes in the appearance of the electrodes before and after the cell was run.

4. You can predict the mass of copper that should be deposited on the metal object. Use the equation below.

Mass Copper = Time (sec) X Current (amps) X Constant for Copper (0.000329 g/sec amp)

How did your value compare with the change in mass in Question 2 above?

Questions:

1. Why do we electroplate metals?
2. What happened to the masses of the two electrodes?
3. What do you think happened to the copper electrode? Is there an advantage to using copper for this electrode?

Electroplating
Teacher Notes

Standards

3.2.10.B Apply process knowledge and organize scientific and technological phenomena in varied ways.

- Describe materials using precise quantitative and qualitative skills based on observations.

3.2.10.C Apply the elements of scientific inquiry to solve problems.
- Conduct a multiple step experiment.

3.4.10.B Analyze energy sources and transfers of energy.
- Explain resistance, current, and electromotive force (Ohm's Law).

3.7.10.B Apply appropriate instruments and apparatus to examine a variety of objects and processes.
- Describe and use appropriate instruments to gather and analyze data.

Materials/Equipment:

The copper sulfate solution used in this experiment is a 0.5 M solution. It was prepared by dissolving about 125 grams of copper sulfate to enough water to make a liter of solution. The copper solution may be recycled.

Data/Calculations

2. The copper electrode should lose mass. The other electrode should gain mass. The mass changes will be small – only a few tenths of a gram.

3. Students may notice that the surface of the copper electrode looks grainy. It is dissolving as the cell operates. The other electrode should have an obvious layer of copper on the surface. Electroplating is easy – getting a product with an attractive finish is an art.

4. A cell running at about 0.5 amps for 20 minutes (1200 seconds) should produce a mass of about 0.2 grams of copper. The actual calculation – Faraday's Law calculation from Physics – is:

1200 s X 0.50 coulomb/s X 1 mole e-/96,500 coulomb X 1 mole Cu/2 mole e-

X 63.5 g Cu/ 1 mole Cu = 0.197 g Cu

Questions:

1. Why do we electroplate metals? *Electroplating is done to reduce cost. Gold plating is cheaper that solid gold. It is also done to form a protective layer over a more reactive metal. Chrome plating on bumpers of cars from years ago.*

2. What happened to the masses of the two electrodes? *The copper electrode – the anode – lost mass. The other metal object – the cathode- gains mass*.

3. What do you think happened to the copper electrode? Is there an advantage to using copper for this electrode? *Any object that conducts electricity could be used in place of the copper strip. As it reacts the copper strip replaces the copper ions that are plating out – thus the concentration of the copper ions in the solution remains constant.*

This activity is an adaptation of an experiment that appeared in the *Journal of Chemical Education* Anderson, G. E., *J. Chem. Educ*. 1996, 73, A172

HOW TO READ A RESISTOR

Introduction:

When looking at a collection of resistors, the first impression is that they all look alike. Upon closer examination, you will notice that the colored bands differ from one resistor to another. A code has been established that allows you to determine the resistance regardless of where the resistor is found. This coding is important because the resistance may vary from a few ohms to thousands of ohms – even though the resistors are similar in size. The code is read by observing the colors of the bands from the end of the resistor **opposite** the gold band. The first two bands are numbers and the third is used to indicate the number of zeroes to add after the first two numbers.

Color	1st Band	2nd Band	Band 3	
Black	0	0	-	10^0
Brown	1	1	0	10^1
Red	2	2	00	10^2
Orange	3	3	000	10^3
Yellow	4	4	0000	10^4
Green	5	5	00000	10^5
Blue	6	6	000000	10^6
Violet	7	7	0000000	10^7
Gray	8	8	00000000	10^8
White	9	9	000000000	10^9

Purpose:

The purpose of this activity is to learn to read the code on a resistor and predict its resistance.

Equipment/Materials:

Set of labeled resistors Multimeter

Procedure:

1. Suppose you found these six resistors. What resistance would you expect them to have?

a. red,green,brown ________________

b. brown,black,brown ________________

c. gray,black,black ________________

d. yellow,blue,orange ________________

e. black,orange,black _______________

f. violet,black,red _______________

2. Observe the resistors in the bag. Decode them and predict their resistances. Use you Multimeter to measure the resistance of each. How did the values compare?

Color of bands	Predicted Resistance	Measured Resistance
A.		
B.		
C.		
D.		
E.		

How to Read a Resistor

Teacher Notes

Standards

3.2.10.B Apply process knowledge and organize scientific and technological phenomena in varied ways.

- Describe materials using precise quantitative and qualitative skills based on observations.

3.2.10.C Apply the elements of scientific inquiry to solve problems.

- Conduct a multiple step experiment.

3.4.10.B Analyze energy sources and transfers of energy.

- Explain resistance, current, and electromotive force (Ohm's Law).

3.7.10.B Apply appropriate instruments and apparatus to examine a variety of objects and processes.

- Describe and use appropriate instruments to gather and analyze data.

Note: The gold band on the resistor is an indication of the tolerance of the resistor +/- 5% for gold and +/- 10% for silver. The students should measure values close to those expected, but some variation is to be expected. The resistances read will depend upon the scale used and the tolerance of the resistor.

1. a. 250 ohm
   b. 100 ohm
   c. 80 ohm
   d. 46000 ohm
   e. 3 ohm
   f. 7000 ohm

Color of bands	Predicted Resistance	Measured Resistance
A.	Various Answers	
B.		
C.		
D.		
E.		

INTRODUCTION TO RADIATION

Introduction:

This experiment is designed to allow you to use a nuclear scaler to collect some data for three types of radiation. Before designing applications for radiation, you must understand the basic properties of the various types of radiation. The scalar contains a Geiger-Muller tube (G-M tube) that detects radiation emitted from atoms. After you have collected the data, you will analyze it to determine what effects, if any, each variable has on the number of counts.

Purpose:

The purpose of this experiment is to collect data for three radioactive sources and describe the effects of time, distance, and shielding.

Equipment/Materials:

sealed sources (alpha, beta, and gamma)	scalar and G-M tube
absorber materials	forceps

Safety:

- This experiment presents no unusual safety hazards. It is good technique to handle all radioactive sources with forceps.

Procedure:

Part I: *TIME*

1. Plug in the scalar and press the POWER button if this has not already been done. Press STOP and RESET to clear the display. Set the voltage at the value you determined in an earlier lab or at the value supplied by your teacher.
2. Obtain a sealed source and place it on the second shelf of the sample holder.
3. Set the timer to 0.5 minutes. Push the COUNT button and record the value when the STOP light goes on. Press the RESET button, set the timer to 1.0 min, and take another reading. Repeat, taking a 2.0 minute reading.

Part II - *DISTANCE*

1. Place a sealed source on the top shelf of the sample compartment and take a one minute reading. Lower the source to the next shelf and take another one minute reading. Remember to record your data and to reset the scalar between measurements. Continue until readings are taken on all the shelves.
2. Repeat the procedure in Step 1 with the other sealed sources. The order in which they are used does not matter.

Part III - *SHIELDING*

1. Take a one minute reading with no sample in the sample compartment.

   This will serve as the *background* reading.
2. Place a sealed source on shelf 2. It will remain on this shelf for the entire experiment. Take a one minute reading.
3. Place the index card over the sealed source sample and take another one minute reading. Repeat the procedure with the other materials indicated on the data sheet.
4. Repeat Step 2 and 3 for the other sealed sources.
5. Take another one minute background reading.

Name ______________________

Introduction to Radiation
Data Sheet

Part I - *TIME*

0.5 minute count ____________

1.0 minute count ____________

2.0 minute count ____________

Part II - *DISTANCE*

Alpha Source

Shelf 1 ____________

Shelf 2____________

Shelf 3____________

Shelf 4____________

Shelf 5 ____________

Shelf 6____________

Beta Source

Shelf 1 ____________

Shelf 2 ____________

Shelf 3 ____________

Shelf 4 ____________

Shelf 5 ____________

Shelf 6 ____________

Gamma Source

Shelf 1 ____________

Shelf 2 ____________

Shelf 3 ____________

Shelf 4 ____________

Shelf 5 ____________

Shelf 6 ____________

Part III - *SHIELDING*

Background ______________		
Alpha Source	Air	______________
	Paper	______________
	Al Foil	______________
	Al Metal	______________
	Lead	______________
	Other	______________
Beta Source	Air	______________
	Paper	______________
	Al Foil	______________
	Al Metal	______________
	Lead	______________
	Other	______________
Gamma Source	Air	______________
	Paper	______________
	Al Foil	______________
	Al Metal	______________
	Lead	______________
	Other	______________
Background		______________

Questions:

1. What were the three independent variables studied in this experiment?

2. Describe the relationship you observed between count rate and time in Part I.

3. a. Describe the relationship you observed between distance and count rate in part II.
   b. What term is used to describe this relationship?.

4. Were there any differences between the sealed sources in Part II? What does this tell you about the ability of different forms of radiation to travel through air?

5. What happened when the distance between the beta source and the detector doubled?

6. How do you know if a shielding material has completely stopped a particular type of radiation?

7. From your data, what substance would be required to stop each of the three types of radiation?

Teacher Notes
Introduction to Radiation

Stanndards:

Sample Data/Results:

Introduction to Radiation
Data Sheet

Part I - *TIME*

0.5 minute count ___251________
1.0 minute count ___494________
2.0 minute count ___1002_______

Part II - *DISTANCE*

Alpha Source

Shelf 1 ____1002______
Shelf 2 _____300______
Shelf 3 ______45______
Shelf 4 ______15______
Shelf 5 ______15______
Shelf 6 ______15______

Beta Source

Shelf 1 _2006_______
Shelf 2 _1707_______
Shelf 3 __998_______
Shelf 4 __853_______
Shelf 5 __511_______
Shelf 6 _398_______

Gamma Source

Shelf 1 ____3018____
Shelf 2 ____2104____
Shelf 3 ____1523____
Shelf 4 _____747____
Shelf 5 _____364____
Shelf 6 _____203____

Part III - *SHIELDING*

Background _________15__

Alpha Source	Air	_______1999__
	Paper	_________16__
	Al Foil	_________17__
	Al Metal	_________15__
	Lead	_________16__
	Other	_________15__
Beta Source	Air	____2000_____
	Paper	____2000_____
	Al Foil	____2000_____
	Al Metal	____1000_____
	Lead	_____100_____
	Other	depends on substance
Gamma Source	Air	____3000_____
	Paper	____3000_____
	Al Foil	____3000_____
	Al Metal	____3000_____
	Lead	____1600_____

Background _______15____

<u>Sample Calculations:</u> No calculations are required for this lab.

<u>Answers to Questions</u>:

1. Time, distance, and shielding
2. Count rate should increase as time increases (direct relationship)
3. a. Count rate decreased as distance increased

   b. Inverse relationship
4. Yes Alpha radiation drops off more quickly as the distance increases. Gamma and beta travel through air more easily than alpha.
5. The count rate should drop to one fourth of the original count rate.
6. The count rate should drop to background. Because of background, the count rate will never drop to zero.
7. *Alpha* - index card (or air if the distance is great enough)
   Beta - usually thicker Al or thin Pb
   Gamma - several inches of lead may be required to completely stop the gamma radiation

MICRODENSITY OF PLASTICS

Introduction:

Density is defined as the mass per unit volume of a substance. It is one of the most important properties used in the identification of substances. However, if the sample of material is very small and of irregular shape, determination of mass and volume may be difficult to accomplish with precision.

Usually, density is found by massing the object, measuring its volume, and then dividing mass by volume. However, this lab demonstrates a different technique of determining density. It uses the relative densities of substances and the properties they demonstrate. An object with a low relative density will float on top of a liquid with a high relative density. But if the liquid's density is somehow lowered, a point could be reached where the densities are equal. At this point, the object will be suspended in the liquid, neither sinking nor floating. This same idea is used for a relatively low density liquid and a high density object, only the liquid's density must be increased to suspend the material. Once the object is suspended, the object and the liquid possess exactly the same density. The density of the object can be determined indirectly by measuring the density of the liquid in which the object is suspended.

Purpose:

The purpose of this experiment is to find the density of a small piece of plastic and to use the density to identify the type of plastic.

Equipment / Materials:

small pieces of plastic	forceps
test tube	alcohol
50 mL beaker	stirring rod
saturated NaI (sodium iodide) solution	Beral Pipet
automatic pipet (1000 micro liter)	balance
plastic weighing dishes	

Safety:

- **Always** wear safety glasses in the chemistry lab.
- **Never** eat or drink in the chemistry lab.

Procedure:

1. Fill a test tube half full with water.

2. Obtain a piece of plastic from container marked “known sample”.

3. Bubbles can form on the plastic and change its apparent density. Use the stirring rod to dislodge these bubbles.

If the plastic floats:

- Add alcohol - a few drops at a time - to the test tube, and carefully swirl or stir the solution until the liquid is homogeneous.
- Repeat this step until the plastic is suspended in the solution.

If the plastic sinks:

- Obtain a small bottle of mL NaI solution.
- Add the NaI - a few drops at a time - to the test tube, and carefully swirl or stir the solution until the solution is homogeneous.
- Repeat this step until the plastic is suspended in the solution.

4. When the plastic is suspended in the solution, the density of the plastic should equal that of the solution. Place a weigh boat on the analytical balance and tare. Remove 1.000 mL of the solution with an automatic pipet, and place it in the weigh boat. Repeat two more times. Record the mass of the solution.

Plastic		**Density (g/mL)**
1 = PETE	polyethylene terephtalate	1.39
2 = HDPE	high density polyethylene	0.95 - 0.97
3 = PVC	polyvinyl chloride	varies
4 = LDPE	low density polyethylene	0.92 - 0.94
5 = PP	polypropylene	0.90 - 0.91
6 = PS	polystyrene	1.05 - 1.07
7 = Other	(often a mixture)	varies

Data Table: Known plastics

	Trial 1	**Trial 2**
Type of Plastic		
Mass of 1 ml		
Average Mass		
Accepted Value		

Unknown plastic

Unknown plastic # ______

Mass of solution ________________

____

____

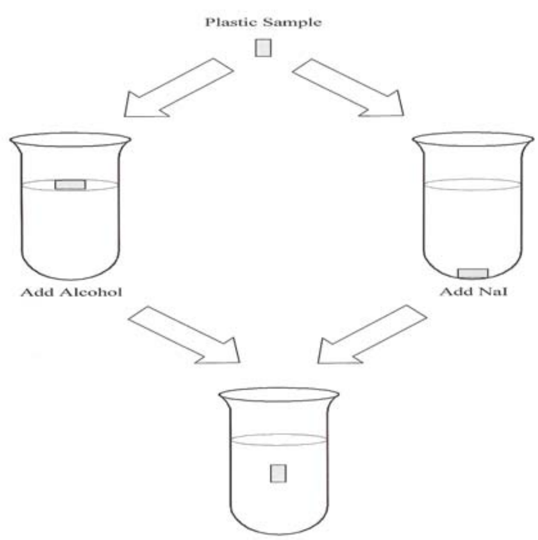
Density of plastic ________________

Identity of unknown plastic ____________

Questions:

1. Why is this method of determining density referred to as an indirect method?
2. What is the relative density of a piece of plastic if, when it is placed in water, the piece of plastic is suspended?
3. What is the relative density of a piece of plastic if, when it is placed in water, the piece of plastic floats?
4. If the plastic piece sinks in water, why is a saturated solution of sodium iodide added?

Why is it important to know the type of plastic that an object is composed of?



MICRODENSITY OF PLASTICS
TEACHER NOTES

STEE Standards:

3.4.12.A Apply concepts about the structure and properties of matter.

- Quantify the properties of matter (e.g., density, solubility coefficients) by applying mathematical formulas.

3.1.12.D Analyze scale as a way of relating concepts and ideas to one another by some measure.

- Analyze and apply appropriate measurement scales when collecting data.

4.2.12.D 1 Evaluate solid waste practices.

- Examine and explain the path of a recyclable material from collection to waste, reuse or recycling.

Answers to Questions:

1. Why is this method of determining density referred to as an indirect method?
The density of the plastic is being found but not by actually measuring the mass and volume of the piece of plastic.

2. What is the relative density of a piece of plastic if, when it is placed in water, the piece of plastic is suspended?
It has the same density as the water.

3. What is the relative density of a piece of plastic if, when it is placed in water, the piece of plastic floats?
It has a density less than that of water.

4. If the plastic piece sinks in water, why is a saturated solution of sodium iodide added?
Sodium iodide is used to increase the density of the water, thus causing the piece of plastic to become suspended.

5. Why is it important to know the type of plastic that an object is composed of?
Plastics can be recycled only if combined with samples of the same type. Combining plastics of different types could result in a "useless mixture".

This activity was originally published in the *Journal of Chemical Education.*

A Simpler Small Scale Method for the Identification of Plastics, Anderson, Guy E., *J. Chem. Educ.,* 1996, 73,A713.

Polymers in Our Daily Lives

Introduction:

We sometimes ask, “How does this affect me?” In this activity, you will identify those items that you have come into contact with in the past week. It is hoped that you will have an understanding of how pervasive polymers are in our daily lives.

garbage bags * foam cups * gallon milk jugs * toothpaste tubes * salad containers from fast food restaurants * shoe strings * snack food bags * 2-liter soft drink bottles *bottled water * sport bottle * motor oil bottles * plastic flatware * shampoo bottles * shower cap * shoe string tips * food wrap * grocery store bags * disposable razors * egg cartons * disposable diapers * coffee stirrers * foam insulation * caulking * beverage boxes * shrink wrap * bubble wrap * Silly String® * Silly Putty® * Slime® * cellophane tape * hot glue * Super Glue® * dishpan * plastic glasses or cups * plastic dishes * Teflon® * food storage containers * comb * toothbrush * ceiling light covers * kitchen counter tops * disposable cutting boards * chair seats * carpet * refrigerator * telephone * floor tile * nylon jacket * shoe soles * bicycle and automobile paint * bicycle and automobile tires * car windshields * car dashboards * floor mats * bicycle hand grips * storage containers * sweater box * vinyl wall covering * glasses * makeup containers * contact lenses * pencil cases * lipstick tubes * Chapstick® tube * hair spray * Gore-Tex® windbreaker * Polartec® fleece jacket * rain poncho * panty hose * sport shoes * umbrella * sweater * Nerf® ball * Frisbee * snorkel * swim fins * wet suit * goggles * wind surfer * volleyball and net * basketball * racquetball * tennis ball * tennis racquet and strings * guitar strings * balloons * rubber band (gum band if you are from Pittsburgh) * credit card * compact disc * compact disc player * computer * calculator * watch faces * safety glasses * dentures * hearing aids * fabric lunch bag * coffee mug * thermos bottle * lunch tray * flower pot * supermarket meat trays * microwave cookware * lawn chair * welcome mat * Astroturf® * Velcro * football helmet * football pads * hockey puck * skateboard * buttons * erasers * thread * wig * false eyelashes * surfboards * parachute * sailboat * Corvette * Saturn automobile * playing cards * floor wax * furniture polish * sousaphone * clarinet * DVD disc * DVD player * videotape * video tape recorder * computer discs * luggage * laptop computer * mouse * mouse pad * printer * printer cartridge * Mylar balloon * flea collar * index tabs * life raft * model plane * model car * Colorforms® * Lego® blocks * pacifier * baby bottles * furniture cushions * foam pillow * exercise mat * photographic film * photographs * film canisters * synthetic flowers * mannequins * street signs * store signs * backpack * mechanical pencils * gel pen * classroom desk top * ruler * three ring binder * protractor * scissors * overhead transparencies * extension cord * dustpan * test tube brush * Tygon® tubing * test tube rack * fishing line * tackle box * waders * string trimmer * Nike or Reebok shoes * vitamin capsules * sponge * particle board * hair dryer * coffee maker * iron * toaster * hand mixer * electric can opener * lifesaver * vacuum cleaner * curling iron * ping-pong balls * tent * windshield wipers * shower curtain liner * electrical tape * garbage cans * Rubbermaid® bins * bubble gum * disposable cameras * band-aids – IV bag * prescription vial * pot handle * house paint * ice chest * car battery * toilet seat * PVS pipe * zipper * awning * yarn * shoe polish * fan belt * paint brush * paint tray * checkers * rubber duckie * headphones * cell phone * motorcycle helmet * coaster * ice cube trays * hang gliders * butane lighter * mini blinds *

Polymers in Our Daily Lives

Discussion Questions

1. What percentage of the items would you estimate that you circled?

2. What materials have these polymers replaced. Give some examples.

3. Why do you think these materials are used in certain applications?

4. Interview someone who grew up before World War II. What materials would have been used to construct most consumer items? What fibers would have been used in clothing manufacture?

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Polymers in Our Daily Lives

Teacher Notes

This activity can be assigned before the unit is begun. It is hoped that students will appreciate how often we use polymers on a daily basis.

STEE Standards

3.1.12.E 4 Evaluate change in nature, physical systems and man made systems.

- Evaluate the patterns of change within a technology.

4.2.12.A 1,2 Analyze the use of renewable and nonrenewable resources

- Explain the effects on the environment and sustainability through the use of nonrenewable resources.
- Evaluate the advantages and disadvantages of reusing our natural resources.

Answers to Questions:

1. What percentage of the items would you estimate that you circled?

Various answers

2. What materials have these polymers replaced. Give some examples.

Polymers replace wood, glass and metal once used to make consumer products. Many food containers are now plastic – one they were glass or metal.

3. Why do you think these materials are used in certain applications?

They are often lighter and have become less expensive the natural materials.

4. Interview someone who grew up before World War II. What materials would have been used to construct most consumer items? What fibers would have been used in clothing manufacture?

Many items would have been made of wood, metal or glass. Before WW II the only common plastic would have been Bakelite (telephones and cases for table radios). Most clothing would have been made of fibers like cotton, linen, wool or silk.

You Can't Drink Coffee from a Styrofoam Cup
A Closer Look at Polystyrene

Introduction:

Every year *Chemical and Engineering News* publishes a list of the top chemicals produced in the United States. Styrene, always on this list, is the monomer used to produce polystyrene. Polystyrene is unique in that it is widely used in two different forms. Clear rigid polystyrene is used for clear plastic drinking glasses, jewel boxes for compact discs and cellophane tape dispensers.

The other type of polystyrene is expanded polystyrene – sometimes referred to as Styrofoam. Styrofoam is Dow's trademark name for the blue insulation board seen at many construction sites. Technically this is the only product that should be referred to as Styrofoam. All other items are composed of "expanded polystyrene". Over the years the terms Styrofoam and expanded polystyrene have been used synonymously. In the same regard, tissues are called Kleenex and photocopies are referred to as Xerox copies. So the next time you ask for a hot drink, remember you can't drink from a Styrofoam cup – because there is no such thing.

Purpose:

The purpose of this activity is to compare the properties and uses of the two types of polystyrene.

Safety:

- Safety glasses must be worn when working with chemicals.
- Acetone can only be used in a well ventilated area.

Procedure:

Part I:

All plastics are polymers. Polymers are huge molecules made up of thousands of repeating units called monomers. Use the model kit to build the model of styrene – the monomer polystyrene is built from. Build as many models as the kits allow.

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Once the monomer units are built, join them together to build a polymer chain. Remember that real polymers have tens to hundreds of thousands of these repeating units.

Part I:

Examine the samples of polystyrene products. Record the various uses and applications in the table below. Are the samples molded polystyrene (PS) or expanded polystyrene (EPS)?

Sample	PS or EPS	Sample	PS or EPS
1.		11.	
2.		12.	
3.		13.	
4		14.	
5.		15.	
6.		16.	
7.		17.	
8.		18.	
9.		19.	
10.		20.	

Part II:

Compare the properties of the two kinds of polystyrene products.

	Molded Clear PS	Expanded PS

Density		
Buoyancy		
Hardness		
Brittleness		
Transparency		
Solubility, Water		
Solubility, Acetone		

Part III: Compare the properties of these common building materials: wood, iron, aluminum, and expanded polystyrene.

	Wood	Iron	Aluminum	Expanded Polystyrene
Prone to Corrosion				
Soluble in Acetone				
Reacts with Acids				
Density/ Buoyancy				
Melting Point				
Easily Molded				
Heat Insulator				

Part IV: Changing the Physical Properties of Polystyrene

Materials/Equipment:

100 mL beaker
stirring rod
2 EPS cups
250 mL beaker
25 mL acetone
forceps

1. Add 25 mL of acetone to the 100 mL beaker.
2. Shred the two cups into small pieces. Add them to acetone and stir until a uniform mixture results.
3. Add 25 mL of water to the 250 mL beaker. Pour the acetone – polystyrene mixture over the water.
4. Let the 250 mL stand in a well ventilated place overnight.
5. Remove the top layer and dry completely.
6. Describe the appearance of the product obtained.

You Can't Drink Coffee from a Styrofoam Cup

Teacher Notes:

STEE Standards:

4.2.12.A 1,2 Analyze the use of renewable and nonrenewable resources
- Explain the effects on the environment and sustainability through the use of nonrenewable resources.
- Evaluate the advantages and disadvantages of reusing our natural resources.

3.4.12.A 8 Apply concepts about the structure and properties of matter.
- Quantify the properties of matter (e.g. density, solubility coefficients) by applying mathematical formulas.

Part I:

Various answers

Part II:

	Molded Clear PS	Expanded PS
Density	Sinks in water	Floats in water
Buoyancy	Less buoyant	More buoyant
Hardness	Hard	Soft
Brittleness	Brittle	Somewhat flexible
Transparency	Clear	Opaque
Solubility, Water	Not Soluble	Not Soluble
Solubility, Acetone	Soluble	Very Soluble

Part III:

	Wood	Iron	Aluminum	Expanded Polystyrene
Prone to Corrosion		**X**		
Soluble in Acetone				**X**
Reacts with Acids		**X**	**X**	
Density/ Buoyancy	Sinks	Sinks	Sinks	Floats
Melting Point	High	High	High	Low
Easily Molded				**X**
Heat Insulator	**X**			**X**

Part IV:

The expanded polystyrene is converted to clear polystyrene. The disk formed should be very brittle when dry.

This activity has been adapted from one found in *Polymer Chemistry*, R. Lipscomb, Ed., National Science Teachers Association, 1989.

Designing a Radiation Shield

Introduction:

Previous experiments have shown how radiation is absorbed as it travels through matter. Another experiment involved a simulation of thickness gauging. The count rate of a beta source was measured as the number of index cards on top of the source is increased. A calibration graph was prepared and the number of cards in an unknown sample will be determined.

In this activity, you will design a plastic shield to protect laboratory workers from beta radiation. In the health, life and agricultural sciences much research is completed using isotopes of common elements that emit beta radiation. In many procedures, it is important for the researchers to clearly see their work – thus a clear plastic shield is desirable.

When designing a radiation shield, it is important to use enough material to limit the researcher's exposure. On the other hand, if too much material is used the shield can be very heavy and becomes more expensive. You task is to design a shied that reduced the exposure to the body to background levels.

Purpose:

The purpose of this experiment is to design a plastic shield for beta radiation.

Equipment/Materials:

G-M tube and scaler

source Sr-90

Sheets of plastic film

Safety:

- Wear safety glasses while working in the lab.
- Use tweezers or forceps to handle the sealed sources.

Procedure:

1. Refer to the procedure for Thickness Gauging when completing this activity.

1. Plug in the scaler, and allow it to warm up for a few minutes. Set the voltage to the operating voltage.

2. With no sample in the sample holder, take a one-minute background count. Record the value in the data table. Repeat for a second one-minute background count.

3. Place the Strontium-90 source on the second shelf. Obtain a one-minute count.

4. Place one or two plastic sheets on top of the Sr-90 source, and take a one-minute count.

5. Repeat step 4, adding a known number of plastic sheets each time until the count rate approaches background. It is important that the total number of plastic sheets used for each trial is known.

7. Plot a curve of count rate vs. the number of plastic sheets.

8. Given the thickness of one sheet of the plastic film and the number of sheets required to reduce the radiation to background, determine the appropriate thickness of the shield.

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Data Table:

Background count = ______________CPM ______________ CPM

Ave. background count = _________________ CPM

Number of shields	Counts per min.	Corrected CPM

Number of sheets needed to reach background ___________

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Questions:

1. Why would beta emitters like P-32 be of interest to researchers in the life sciences?

2. Another method to describe shielding is in terms of half-thickness. Half-thickness is the amount of material required to reduce the radiation levels to one-half of the original level. From your graph, what is the half-thickness of the plastic?

3. If a shield was two half-thicknesses thick, by what factor would the radiation level be reduced? What if three half-thicknesses were used?

4. Suppose your shield were manufactured with twice the material that you recommend. Would there be any advantage to this design?

Thickness Gauging

Teacher Notes:

STEE Standards:

3.4.12.A 2, 3 Apply concepts about the structure and properties of matter.

- Classify and describe, in equation form, types of chemical and **nuclear** reactions.
- Explain how radioactive isotopes that are subject to decay can be used to estimate the age of materials.

3.2.12.B 3 Evaluate experimental information for appropriateness and adherence to relevant science processes.

- Interpret results of experimental research to predict new information or improve a solution.

3.2.12.C 3 Apply the elements of scientific inquiry to solve multi-step problems.

- Design an investigation with adequate control and limited variables to investigate a question.

3.2.12.D 2 Analyze and use the technological design process to solve problems.

- Propose, develop and appraise the best solution and develop alternative solutions.

3.7.12.B 1 Evaluate appropriate instruments and apparatus to accurately measure materials and processes.

- Apply and evaluate the use of appropriate instruments to accurately measure scientific and technologic phenomena within the error limits of the equipment.

Answers to Questions:

1. Why would beta emitters like P-32 be of interest to researchers in the life sciences?

   They are found in living systems.

2. Another method to describe shielding is in terms of half-thickness. Half-thickness is the amount of material required to reduce the radiation levels to one-half of the original level. From your graph, what is the half-thickness of the plastic?

   Student answers

3. If a shield was two half-thicknesses thick, by what factor would the radiation level be reduced? What if three half-thicknesses were used?

   One fourth one eighth

4. Suppose your shield were manufactured with twice the material that you recommend. Would there be any advantage to this design?

   No, it would be heavier but would not reduce exposure significantly.

Radiant Energy

Testing Sunscreens – UV Sensitive Beads

Introduction:

Not all forms of energy are visible to the naked eye. Ultraviolet light, found in sunlight, is a good example of this. Ultraviolet (UV) sensitive beads contain pigments that change color when exposed to sunlight or other sources of UV radiation. Exposure to UV rays is harmful to skin cells. Sunscreens contain substances that absorb UV radiation and their sun protection factor (SPF) indicates how effective they are. These beads can be used to compare the ability of different sunscreens to absorb ultraviolet radiation.

Purpose:

The purpose of this experiment is to rate sunscreens on their ability to absorb ultraviolet radiation.

Equipment/Materials:

UV Beads (melted into disks)	sunscreens	(different brands – same SPF)
UV light source (black light)		(same brand – different SPF)
Cotton swabs	timing device	
Rubbing alcohol	paper towels or tissue	

Procedure:

1. Obtain a set of UV sensitive beads. These beads have been melted into disks so that it will be easier to apply sunscreen to them.
2. Expose the beads to direct sunlight or place them under an UV light source (black light). Note which beads change color more quickly or appear to become darker in color. Select one of the colors that change more rapidly for the rest of the experiment.
3. Select four beads of the same color. Line them up on a small piece of paper. Use one bead for a control. Apply a **small** amount of a

different sunscreen (same SPF – different brand) to each of the other three beads. It is important that the sunscreen be applied evenly. Write the name of the brand on the paper beside the disk.

4. Expose the disks to direct sunlight or place them under an UV light source for the same amount of time. Remove the disks from the light. Quickly wipe off any excess sunscreen from the disk so that you can observe the color changes more easily. Describe their appearance. Remember the darker the color – the less UV radiation that the sunscreen absorbed. Clean the sunscreen off of the disks with rubbing alcohol.
5. Repeat steps 3 & 4 four using sunscreens of different SPF factors. Note the results in the data table. Clean the sunscreen off of the disks with rubbing alcohol and return them to the appropriate place.

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Name ____________________________

Testing Sunscreens

UV Sensitive Beads

Data

Bead Color	Appearance after UV Exposure	Rank

Brand of Sunscreen	Appearance after UV Exposure	Rank
Control		

SPF Factor	Appearance after UV Exposure	Rank
Control		

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Questions:

1. Which color disk did you select to test the sunscreens? Why did you select this color?

2. How do you know which sunscreen is the best at blocking UV radiation?

3. Were all brands of sunscreen with the same SPF values equally effective in blocking UV radiation?

4. What other piece of information might you wish to know before selecting one of the sunscreens that have the same SPF factor?

5. Which SPF was the best at blocking UV radiation? Does this agree with the rating on the package?

TESTING SUNSCREENS
UV SENSITIVE BEADS
TEACHER NOTES

Preparation:

The plastic beads work best if they have been melted into disks. The beads are placed on a cookie sheet that has been lined with aluminum foil. The beads are heated in a 350-degree oven for 10 – 15 minutes.

PA State Standards

3.1.10.E Describe patterns in nature, physical and man made systems.

- Describe changes to matter caused by heat, cold, **light**, or chemicals using a rate function.

3.2.10.B Apply process knowledge and organize scientific and technological phenomena in varied ways.

- Describe materials using precise quantitative and qualitative skills based on observations.

3.2.10.C Apply the elements of scientific inquiry to solve problems.

- Conduct a multiple step experiment.

3.4.10.C Distinguish among the principles of force and motion.

- Describe light effects.

Considerations:

This activity appeared as JCE Classroom Activity #36 in the May 2001 issue of the Journal of Chemical Education. The purple and blue beads seem to work well for this experiment. A 30 second exposure with a UV light source produced definite color changes.

Questions:

1. Which color disk did you select to test the sunscreens? Why did you select this color?

Student answers. Generally, the darker colors are easier for students to monitor.

2. How do you know which sunscreen is the best at blocking UV radiation?

The best sunscreen will absorb the most UV radiation. Therefore, the disk will have the lightest color.

3. Were all brands of sunscreen with the same SPF values equally effective in blocking UV radiation?

Usually, the more expensive brands are better.

4. What other piece of information might you wish to know before selecting one of the sunscreens that have the same SPF factor?

Cost, ingredients - Some people are allergic to PABA which was a common ingredient of older sunscreens. If this were an ingredient, this brand might not be desirable.

5. Which SPF was the best at blocking UV radiation? Does this agree with the rating on the package?

Usually, higher SPF numbers absorb better.

THICKNESS GAUGING

Introduction:

Radiation gauging is the term that describes the use of ionizing radiation for the measurement of properties of a system such as thickness or density. In radiation gauging, a source of radiation is placed on one side of the material to be tested, and a detector is placed on the other side. One advantage of radiation gauging over methods in which contact gauges are required is that no contact with the material is required; thus no contamination takes place. Another advantage is that the instrumentation can be automated and can provide a very fast response. Thickness gauging, as in determining the thickness of materials such as aluminum, is one of the most common uses of radiation gauging.

Previous experiments have shown how radiation is absorbed as it travels through matter. This experiment involves a simulation of thickness gauging. The count rate of a beta source will be measured as the number of index cards on top of the source is increased. A calibration graph will be prepared and the number of cards in an unknown sample will be determined.

Purpose:

The purpose of this experiment is to use thickness gauging to determine the number of index cards in an unknown stack.

Equipment/Materials:

G-M tube and scaler
index cards
source Sr-90
unknown index card samples

Safety:

- Wear safety glasses while working in the lab.
- Use tweezers or forceps to handle the sealed sources.

Procedure:

1. Plug in the scaler, and allow it to warm up for a few minutes. Set the voltage to the operating voltage.

2. With no sample in the sample holder, take a one-minute background count. Record the value in the data table. Repeat for a second one-minute background count.

3. Place the Strontium-90 source on the second shelf. Obtain a one-minute count.
4. Place one or two index cards on top of the Sr-90 source, and take a one-minute count.

5. Repeat step 4, adding a known number of index cards each time until the count rate approaches background. It is important that the total number of cards used for each trial is known.

6. Place an unknown sample of index cards on top of the Sr-90 source, and take a one-minute reading.

7. Plot a curve of count rate vs. the number of index cards.

8. Determine the number of cards in the unknown sample from the graph.

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Data Table:

Background count = ______________CPM _______________ CPM

Ave. background count = _________________ CPM

Number of cards	Counts per min.	Corrected CPM

Unknown count rate = ____________counts per min. = _____________CPM

Corrected CPM ______________________

Unknown # ____________ Number of cards in unknown ___________

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Thickness Gauging

Teacher Notes:

STEE Standards:
3.2.12.C 3 Apply the elements of scientific inquiry to solve multi-step problems.

- Design an investigation with adequate control and limited variables to investigate a question.

3.4.12.A 2, 3 Apply concepts about the structure and properties of matter.

- Classify and describe, in equation form, types of chemical and **nuclear** reactions.
- Explain how radioactive isotopes that are subject to decay can be used to estimate the age of materials.

3.7.12.B 1 Evaluate appropriate instruments and apparatus to accurately measure materials and processes.

- Apply and evaluate the use of appropriate instruments to accurately measure scientific and technologic phenomena within the error limits of the equipment.

Electricity

Conserving Electricity

Discussion:

When your family receives the monthly electric bill, you are charged for the number of KWH (kilowatt hours) used in the last month. A watt is the unit of electrical power and is the product of the voltage (volts) and current (amps). A kilowatt hour would result when an appliance used 1000 watts for a period of one hour. The cost of a kilowatt hour varies from one utility to another. For the purpose of this activity we will use the rate of $.10 per KWH (kilowatt hour).

There are many ways to reduce electric consumption. One is to use electrical appliances or devices for fewer hours. If you only use you desk lamp for two hours a day, should you leave it on for six hours? Another method is to use electrical devices that are more energy efficient. Fluorescent light fixtures can provide the same amount of light (lumens) for fewer watts. Energy Star appliances receive that rating because they consume less energy than comparable appliances. You can also conserve electricity through other conservation measures. If a coffee maker is left on for two hours after the coffee is brewed, a significant amount of electricity is used to keep it hot. If the coffee is transferred to an insulated carafe, it remains hot while using no electricity. Insulation blankets help hot water heaters save energy by preventing heat loss. The water does not have to be reheated as often because the tank loses less heat.

In reality, energy payback calculations should also be done when calculating energy savings. Fluorescent light bulbs are more expensive than regular incandescent bulbs but save a considerable amount of energy over their lifetimes. The additional cost of the fixture should be subtracted to indicate the true savings. For this activity, these additional calculations will not be included.

In this activity, the projections you make should be realistic. You can't say that you will use your desk lamp 1000 fewer hours next month when there are only 720 hours in a month (24 hours/day X 30 days) in a month.

Purpose:

The purpose of this activity is to devise a plan to reduce your family's electric bill by five dollars a month.

Materials/Equipment:

Watts-Up? Meter

Various electrical appliances

Procedure:

1. Using the Watts Up? Meter, determine the number of watts used by common household appliances. You may also list the savings method here – i.e. converting a 75 watt incandescent bulb for a 20 watt fluorescent bulb. Record the device and the energy used/saved in the data table.
2. Another method is to examine the product label found on most electrical appliances. Multiply the volts by the amps to determine the watts used.
3. Convert the number of watts to kilowatts. Divide the watts by 1000 to determine the number of kilowatts.
4. Estimate the number of hours that the actions listed in your data table will be carried out for the next month. Three hours a day for thirty days would equal 90 hours.
5. Calculate the number of kilowatt hours saved and record these values. Using $.10 per KWH, calculate the energy savings.
6. Total the savings for all of the devices to determine the total savings.
7. Optional: Use an Excel spreadsheet to complete your calculations. This method makes it very easy to change the variables in this activity,

Conserving Electricity

Results/Questions:

1. What types of electrical appliances used the most power? Can you make a generalization about this? If so, What?

2. What were the largest energy savers in your plan?

3. Other than your immediate energy savings, why should we want to reduce energy consumption?

4. A hot water heater is estimated to use 4800 KWH a year. An insulation blanket claims to reduce energy costs by 20%. What energy savings would be expected? If the blanket costs $12.95, is it a good investment?

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Conserving Electricity

Data Table

Appliance or Savings Plan	Watts	Kilo watts	Time (hr)	KWH	Rate	Savings

Total ___________

Conserving Electricity

Teacher Notes:

Objectives:

4. The students will measure the amount of electrical power – kilowatts that various electrical devices use.

5. The students will calculate how much can be saved when the appliances or devices are not in use or more energy efficient ones are used.

Academic Standards:

Science and Technology
Inquiry and Design 3.2.10 B
Develop appropriate scientific experiments: raising questions, testing, recognizing variables, manipulating variables, interpreting data, and producing solutions.

Inquiry and Design 3.2.10 B
Describe materials using precise quantitative and qualitative skills based on observations.

Physical Science 3.3.12 B
Evaluate mathematical formulas that calculate the efficiency of specific chemical and mechanical systems.

3.7.10.B Apply appropriate instruments and apparatus to examine a variety of objects and processes.

Questions - Possible Answers

1. Those appliances that are used to create heat seemed to use the most power. Since incandescent light bulbs produce a lot of waste heat, they can be big energy users.

2. Answers will vary

3. Nonrenewable resources can be saved. Utilities will not have to build additional facilities to meet energy demands which could raise rates in the future. More expensive generating methods will not have to be used during peak demand hours. Utilities would not have to purchase more expensive electricity on the open market to meet peak hour needs.

4. 4800 KWH X $.10/KWH = $480
$480 X .20 = $96
Yes, the insulating blanket would pay for itself in only a month or two.

Conserving Electricity

Sample Data Table

Appliance or Savings Plan	Watts	Kilo watts	Time (hr)	KWH	Rate	Savings
Replace 4 40 watt bulbs in bathroom with 12 watt bulbs	112	.112	150	16.8	$.10	$1.68
Turn off computer at night (in place of sleep mode)	50	.050	240	12	$.10	$1.20
Turn off TV 2 hrs a day	80	.080	60	4.8	$.10	$.48
Replace 2 100 watt bulbs in bedroom with 26 watt bulbs	148	.148	180	26.6	$.10	$2.66
Turn off computer 2 hrs a day when not used.	100	.100	60	6.0	$.10	$.60

Total ___________