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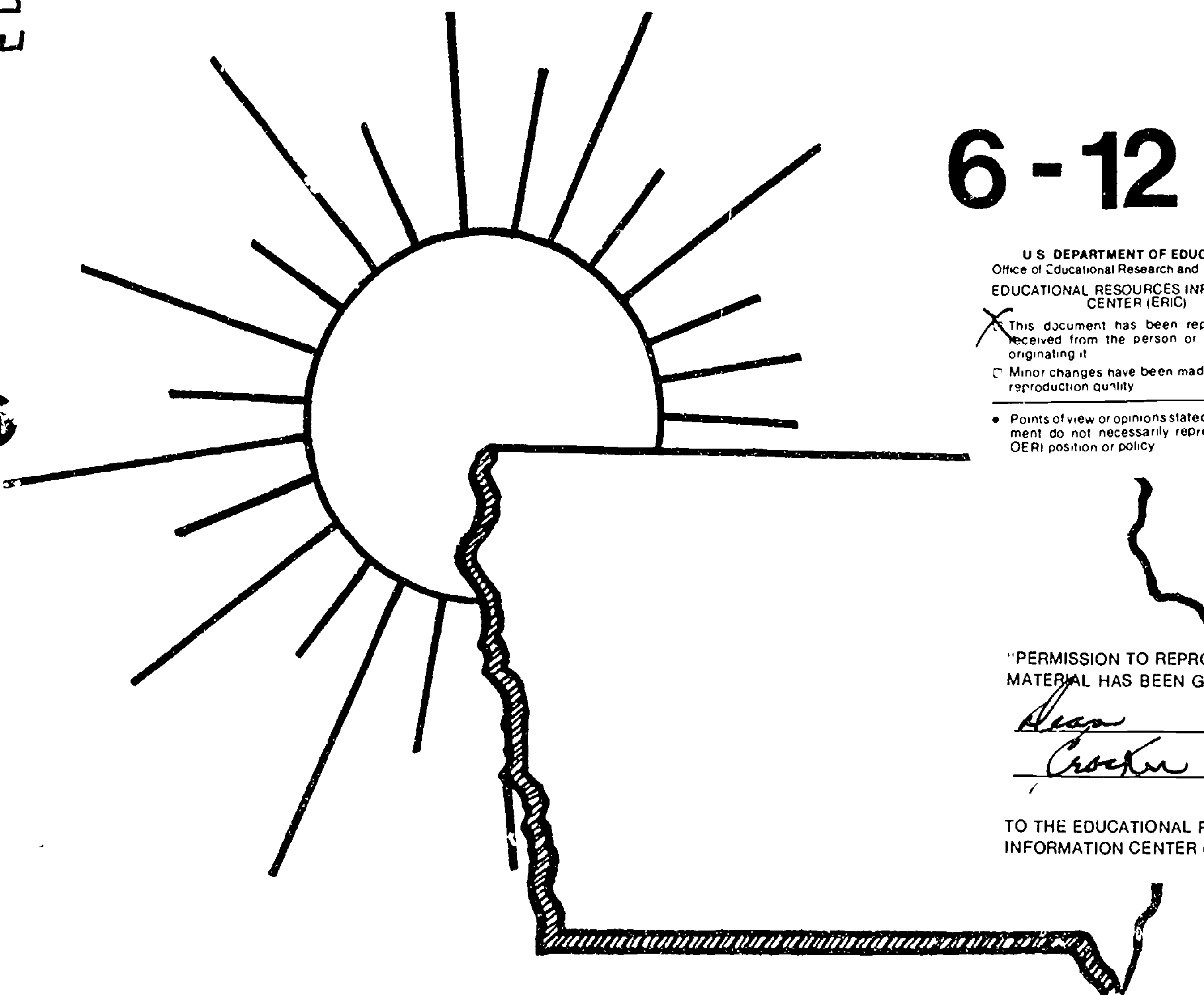
ABSTRACT

The revised Iowa Developed Energy Activity Sampler (IDEAS) was compiled using the original IDEAS program and the Energy Conservation Activity Packets (ECAPS). This document is one of the series of revised IDEAS booklets, and provides activities for teaching mathematics. The activities are intended to present energy principles in an interesting manner and to develop student skills in acquiring information and making well-informed decisions about energy issues. Each of the 25 activities in this document includes: (1) the subject area for which the activity was written; (2) the grade level; (3) a brief statement about the activity itself; (4) the objective(s) of the activity; (5) a list of materials needed; (6) the approximate amount of time needed for the activity; (7) a more complete description of the activity, including the various components of the activity and their relationship to Jean Piaget's learning cycle (awareness, concept development, application); and (8) some follow-up/background information. In some activities the original source of the activity is also given. The focal points of the entire document are energy concerns, impacts, choices, challenges, and conservation. (TW)

IOWA DEVELOPED ENERGY ACTIVITY SAMPLER

6 - 12



MATHEMATICS

Revised 1987

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DEPARTMENT OF EDUCATION
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Table of Contents

MATHEMATICS

REVISED IOWA DEVELOPED ENERGY ACTIVITY SAMPLER - IDEAS

INTRODUCTION TO IDEAS

The revised IDEAS were developed from the Energy Conservation Activity Packets, (ECAPS), by Ruth Bakke, and Iowa Developed Energy Activity Sampler (IDEAS), developed by Dr. Doris G. Simonis under the auspices of the Iowa Energy Policy Council and the Iowa Department of Public Instruction, now the Iowa Department of Education. An "infusion model" was used as a basic framework which recognized the interdisciplinary nature of energy education concepts. These included:

1. Energy is basic.
2. Energy usefulness is limited.
3. Environment is impacted by energy exchanges.
4. Energy conservation is needed.
5. The future of energy is ours to shape and share.

The revised IDEAS adheres to these concepts and provides activities that utilize a learning cycle to develop a knowledgeable student population concerning energy matters. Decision-making skills are emphasized and developing an energy conservation ethic is a major goal.

Under the joint sponsorship of the Iowa Department of Education, Duane Toomsen, Environmental and Energy Education Consultant, and the Energy Division of the Iowa Department of Natural Resources, Dr. W. Tony Heiting, Coordinator; the revised Iowa Developed Energy Activity Sampler (IDEAS) was created to meet the continuing need for energy education from the 1980's into the twenty-first century.

Conservation of natural resources and environmental awareness has been mandated by the State of Iowa to become a part of the quality education experienced by Iowa's future citizens in grades K-12. Energy is an integral part of our nation's natural resource base. The major emphasis of IDEAS is to provide uniquely designed K-12 classroom activities that are adaptable into various classroom situations, i.e., highly populated, urban schools to less populated rural facilities. The focal points of IDEAS are: energy concerns, impacts, choices, challenges, and conservation.

Revised IDEAS adopts a learning cycle strategy based upon the learning theory of Jean Piaget. The cycle has three phases: awareness, concept development and application. Activities are loosely structured to allow for student exploring, hypothesizing, and decision-making.

Awareness activities encourage students to experience a new idea, phenomenon or perception. A variety of experiences should stimulate the students' interest, appreciation, and initiate a positive attitude toward the concept to be formulated. Concept development involves the building of a concept of energy based upon the awareness phase. Concept development may include such activities as reading, performing experiments, solving problems, group interactions, games and role-playing in order to reinforce the developing concept. The application phase is designed to enable the student to apply the new concept to various situations or problems. Application activities may include the same types of activities plus a gamut of others, including debates, panels, simulations, surveys, designing, constructing and community or school projects.

This learning cycle approach integrates content with processes and encourages the development of higher level reasoning and thinking skills. The interdisciplinary importance of energy education is emphasized.

The activity format used in the revised edition of IDEAS includes a title, subject and grade level designation, a short description of the activity, learning objectives, materials needed, approximate time required, and descriptions of the three phases of the activity. A suggested evaluation section has been included, in most packets, to assist the instructor and/or learner in determining the extent to which each learner achieved each objective. Follow-up or background information and a detailed activity description complete the format.

Iowa is an excellent example of how energy is an interrelated and interdependent resource. Iowa imports 98% of the energy it uses and has a high potential for reducing its dependence on outside energy sources through conservation and alternative energy forms. Iowa's current energy dependence has a major impact on Iowa's economy and the ability of the state to compete in the industrial and agricultural community. All segments of Iowa's society involving service-related employment, agriculture, and industry, are impacted by energy costs and availability.

The most obvious means of energy reduction is energy conservation. More efficient use of energy resources available in Iowa (i.e. coal, wind, hydro, solar, gasohol, biomass) can have a significant impact on the cost of production/distribution factors as fossil fuels begin to diminish in the twenty-first century.

The revised IDEAS were developed by classroom teachers who realize the need to provide students with an enriched curriculum. Iowa's tradition of excellence in education has always pointed toward an improved future for our youth. IDEAS will provide the creative educator with a multitude of activities from which they can choose, adapt, and improve.

The professional educator who uses IDEAS may adapt the activities for any classroom setting. Students will be given the basis to form an energy attitude, ethic, and philosophy which will serve them and the citizens of Iowa throughout life.

Members of the IDEAS Revision Committee

Duane Toomsen, Environmental and Energy Consultant, Department of Education

Dr. Tony Heiting, Research/Education Director, Energy Division, Iowa Department of Natural Resources.

Dr. Bob Vanden Branden, University of Northern Iowa, editor.

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National Energy Foundation, 4980 West Amelia Earhart Drive
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Energy and Self-Reliance Center, 3500 Kingman Boulevard
Des Moines, Iowa 50311. 515/277-0253

National Energy Information Center, El-20, Energy Information
Administration, Forrestal Building, Room 1F-048
Washington, D.C. 20585. 202/252-8800

New York Energy Education Project and the
Solar Energy Project, SUNY at Albany, 1400 Washington Avenue
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Ministry of Energy, 56 Wellesley Street West,
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NATAS (National Appropriate Technology Assistance Service) 800-428-2525.

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MATHEMATICS

INTRODUCTION

The activities included in the mathmatics section have been designed for a variety of teaching situations with regard to the equipment and facilities usually available in a mathematics classroom. The creative educator will be able to incorporate selected activities that will blend with their current curriculum material to infuse energy education into the mathematics curriculum

The learning cycle methodology using awareness, concept development, and application has been used to guide the instructor in directing the activities. The learning cycle provides suggestions for implementation and serves as a guide for the instructor. It directs the students' use of computation skills to develop appreciation and understanding of contemporary energy problems.

Most of the activities are brief and should not require lengthy preparation or persentation time. The application part of the learning cycle can be expanded and is an important part of the energy education curriculum which allows students to acquire knowledge and make decisions based upon educated attitudes and values.

Educators who assisted in the formation of this section include the following:

Dwight Bakker	-Western Christian High School, Hull, Iowa
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WRAP YOUR HOUSE AND SAVE

SUBJECT Mathematics **LEVEL** 6 - 8

ACTIVITY IN BRIEF

Students will graph and interpret data concerning home heating costs and insulation.

OBJECTIVE

Students will recognize the value of insulation as an energy saver.

MATERIALS

worksheets

TIME

class period

LEARNING CYCLE

AWARENESS - Ask students how they would keep food hot or cold if they are packing a lunch to take somewhere. How are the containers they put such food in different? What is the value of insulation? Is it a way of saving energy, of saving money?

CONCEPT DEVELOPMENT - Have students complete worksheet.

APPLICATION - After checking the worksheet discuss why utility bills may fluctuate from month to month. Discuss why utility costs would not continue to decrease the following year. Why might the bills be higher the next year?

EVALUATION - Ask each student to list what factors cause utility bills to increase or decrease. Their list should include items discussed in the application phase.

FOLLOW-UP/BACKGROUND INFORMATION

Seasonal temperatures, traffic in and out of the house, closed off rooms, installation of storm doors, windows, insulation and use of a solar water heater may account for such fluctuations. Savings are realized at the time of installation. Rising cost of energy, changing weather, additions to family, added rooms, more electrical appliances and tools can all increase the cost of energy used in future years.

Information concerning the school heating and electric bills may be obtained from the superintendent's office for several years and graphed. If the school has recently been involved in energy saving projects such as insulation or rewiring, you should see some excellent examples of saving energy.

SOURCE OF ACTIVITY

Science Activities in Energy, U.S. Dept. of Energy; adapted by Dorothea Trost

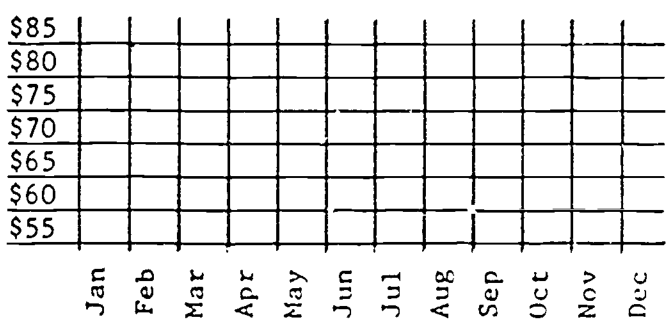
WRAP YOUR HOUSE AND SAVE

INSULATION-GRAPHS
How Much Can Be Saved?

Below are the Wilson's heating and air conditioning bills for 1979 and 1980. In 1979 their home had no insulation. They had insulation installed at the end of the year, so the cost for heating and air conditioning their home went down.

	1979	1980
January	$80	$70
February	$70	$65
March	$65	$65
April	$65	$60
May	$60	$55
June	$70	$60
July	$85	$70
August	$80	$65
September	$65	$60
October	$60	$60
November	$65	$60
December	$70	$65

On the graph below, place a dot for the cost of each month in 1979. Draw a line between the dots. Do the same thing for 1980 with a different color pencil.



1. How much did the Wilsons save in January 1980 as compared to January 1979?

____

2. How much did they save for the entire year?________________
3. During which month(s) were the utility costs highest? Why?

4. During which month(s) is there the greatest savings after insulation?

LEARN TO CARE

SUBJECT Mathematics LEVEL 6 - 8

ACTIVITY IN BRIEF

Students will construct a bar graph to represent the annual consumption of electricity in a home in the United States and in a less developed country.

OBJECTIVE

Each student will gain the ability to relate energy statistics to differences in life styles.

MATERIALS	TIME
worksheet	depends on preparation

LEARNING CYCLE

AWARENESS - Ask the students to share what new electrical appliances their families have purchased in the last couple of years. This should help them see that their consumption of energy is increasing.

CONCEPT DEVELOPMENT - Use the graphing exercise to illustrate how the consumption of electrical energy is increasing and how that consumption compares with a less developed country.

APPLICATION - Discuss with students what kinds of appliances they have that would not be found in homes in other countries such as Mexico. Are we using more electricity than is necessary to live comfortably? Is our consumption of energy for luxuries depriving people in other countries hardships?

EVALUATION - Ask students to list ways in which they can personally save energy.

FOLLOW-UP/BACKGROUND INFORMATION

Students may find help in visualizing other societies by reading the example of living conditions in Kenya given in "The Conserver Society" activity in the science activities packet of IDEAS.

SOURCE OF ACTIVITY

Adapted from EME/National Energy Foundation, by Dorothea Trost

In 1951, an average American family home consumed enough electricity to allow for the highest standard of living any people in the world had ever known. For example, by 1951, nearly 1/2 of the American homes had a TV set.

Let us refer to the total amount of electrical energy used by a home in 1951 as 1 CARE. CARE means: Consumption Annually of a Residence's Electricity.

The American electrical companies tell us that in 1961 each family in America used about 2 CAREs. As a matter of fact, these companies who provide the homes with electricity also give us the following information:

Year	Amount of CARE Used in a Home
1971	3 1/2
1981	4 1/2
1991	6

1. Using the information provided by the electrical companies, complete the graph, drawing taller houses to show the extra amount of electrical energy a home now uses or will probably be using in future years.

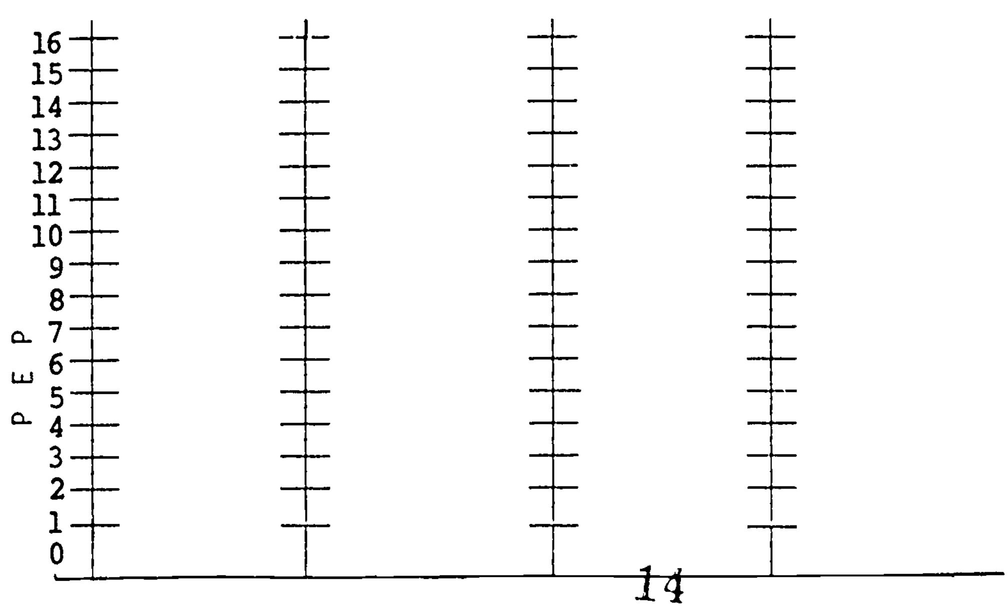
2. The electrical energy needed for 1 CARE will operate about 13 color TVs for a whole year. (a) How many color TVs would a home's energy consumption operate in 1971? (b) How many in 1991? (c) How old will you be in 1991?

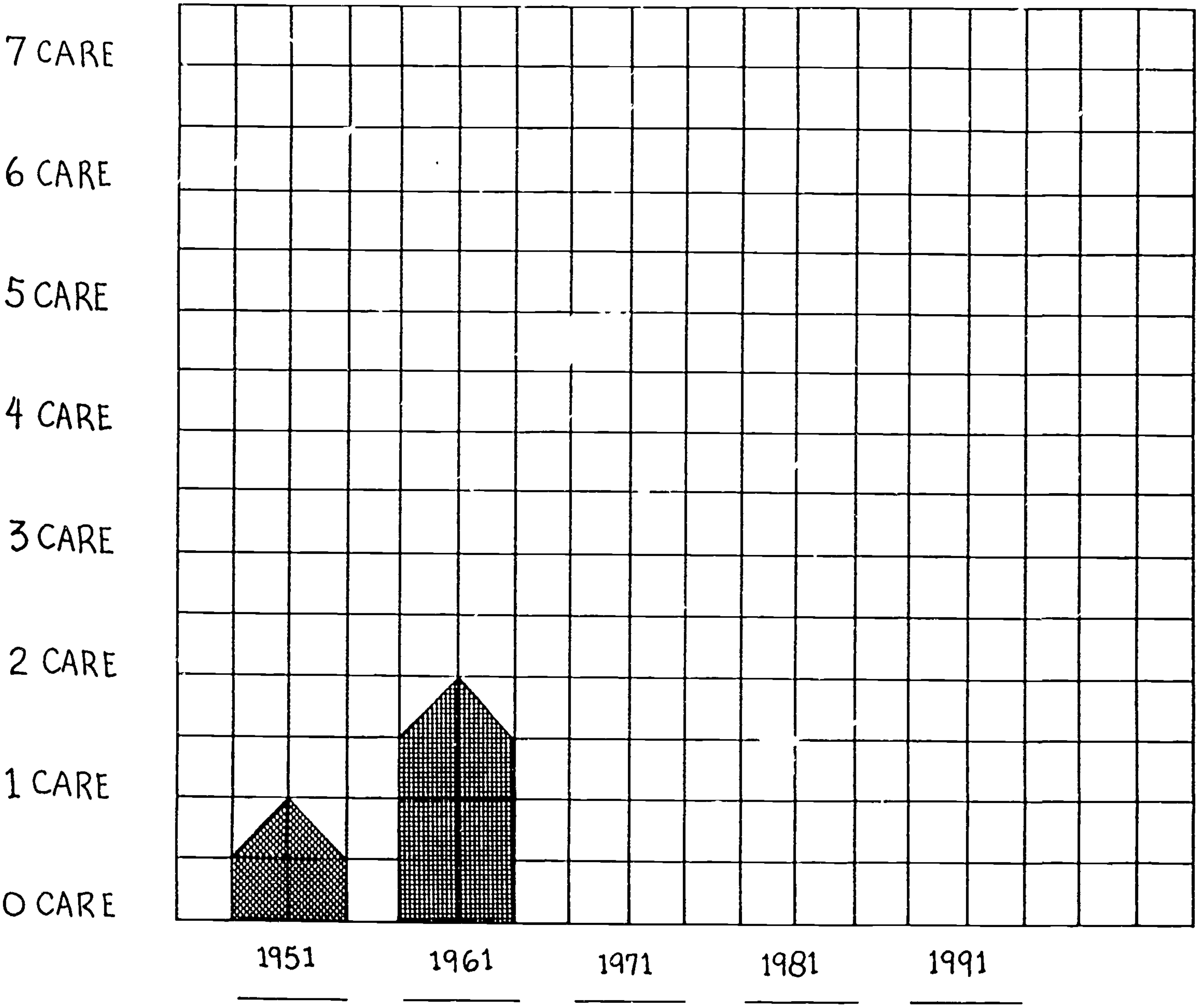
3. How many times greater will a home's electrical energy consumption be in 1991 than 1961?

4. Suppose our friend Pedro who lives in Mexico used 1 PEP of electricity. PEP means: Pedro's Electrical Power. When we use statistics collected in 1968, we find that each Jack and Jill in the United States used 15 PEPs. Using the following chart, finish the pictorial bar graph by drawing a stick-man of proper height.

Annual Electrical Power Use Per Each Citizen

Mexico	1 PEP
United States	15 PEP
Canada	16 PEP




7 CARE
6 CARE
5 CARE
4 CARE
3 CARE
2 CARE
1 CARE
0 CARE
1951
1961
1971
1981
1991

5. 1 PEP means about 470 KWH (Kilowatt-hours). Using the statistics provided in problem 4, find the number of KWH used by each person in the United States.

6. Use 1 PEP for a citizen in Mexico and 15 PEPs for a citizen in the United States. A Mexican citizen uses 1/15 the electrical energy that an American citizen uses. What percent is this?

CONTROLLING CONSUMPTION

SUBJECT Mathematics LEVEL 6 - 8

ACTIVITY IN BRIEF

By eating cookies students will generate consumption information which can be graphed and discussed in terms of conservation and preservation.

OBJECTIVE

Students will be able to state the effects of conservation as compared to unlimited consumption and be able to distinguish between the terms "conservation" and "preservation".

MATERIALS

two chocolate chip cookies per child
napkins
clock
time graphs

TIME

30 minutes

LEARNING CYCLE

AWARENESS - Use steps 1-6 to develop the graphical information to be discussed.

CONCEPT DEVELOPMENT - Use steps 7-8 to develop an understanding of the terms conservation and preservation.

APPLICATION - Use the questions in step 9 to relate what has been learned and apply it to our natural energy resources.

EVALUATION - Have students state the reasons for conserving a resource. Have students explain the differences in the graphs constructed and explain how slope is related to the rate of consumption.

FOLLOW-UP/BACKGROUND INFORMATION

Have students graph the data on page M- . This is an example of exponential growth. Compare this to the graph of the cookie consumption. The exponential graph represents our use of natural energy resources.

Resource Availability
Coal - 500 years
Natural Gas - 40 years
Oil - 35 years
Uranium - 50 years

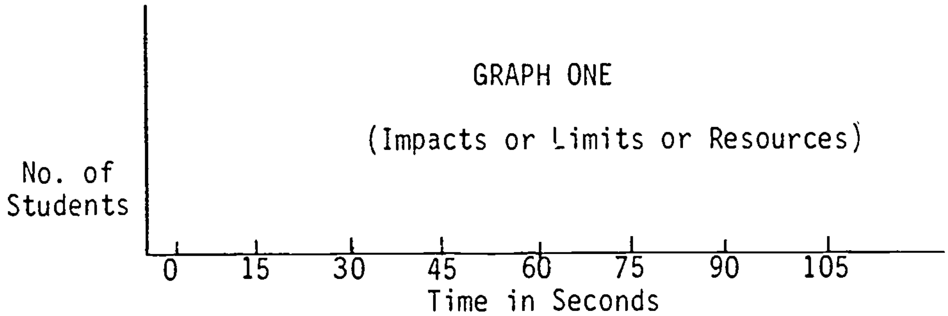
SOURCE OF ACTIVITY

Adapted from E.M.E./National Energy Foundation by Sylvia Sather

ACTIVITY: Controlling Rate of Consumption

IMPLEMENTATION: (Note: the chocolate chips represent coal)

1. Each child is given a cookie and napkin.
2. When a signal is given have children begin eating their cookie. They MUST raise their hand when they finish. You count hands that are raised every 15 seconds until all cookies are consumed. At your last count, all hands should be raised. Once a child raises his hand, he must keep it up.



3. Create graph - talk about its (analyze) interpretations.
   a. after 15 seconds how many coal deposits were consumed?
   b. after 30 seconds how many coal deposits were consumed?
   c. after 45? after 60? after 75? etc.
4. Distribute the second cookie. Children can only take a bite when you say "take a bite" (every 15 seconds). The system is the same - students raise their hand when finished and you tally every 15 seconds.
5. Again construct the graph.
6. Analyze the data again. How long did it take for all resources to be eliminated?
7. Compare the two graphs. Graph One represents unlimited consumption while Graph Two represents limited consumption rate. Is Graph Two like Graph One? How are they different?
8. Discuss the terms "conservation" and "preservation". In the second exercise, conservation was practiced. Does conservation result in preservation? Why not? What good does it do to conserve?
9. Divergent Questioning Techniques:
   a. Tell why you think coal was consumed at different rates?
   b. How did we control the rate of consumption on our second graph?
   c. Does this have any implications for us as we use coal, electricity, and natural gas?
   d. Can we help control how rapidly we use resources?
   e. Give your own ideas as to how we can do this.
10. This lesson can be enhanced by expanding it as a result of student and teacher brainstorming.

FUEL MIX

SUBJECT Mathematics LEVEL 6 - 8

ACTIVITY IN BRIEF

Using a metric scale, the students will produce a graph representing the fuel mix used to fill the energy needs of our country.

OBJECTIVE

The student will be able to:

- list the energy sources used in the fuel mix of the U.S.
- list the fuels by the percentage used
- generalize that the fuel mix does or does not represent wise use of our energy resources.

MATERIALS

meter sticks
register tape
crayons
activity sheet, "Fuel Mix"

TIME

30 minutes

LEARNING CYCLE

AWARENESS - Construct the graph representing the fuel mix used in the United States.

CONCEPT DEVELOPMENT - Interpret the graph that has been constructed by using the questions listed 1-6.

APPLICATION - Discuss with students whether this fuel mix represents wise use of our resources in view of the years of availability of them. Availability of resources are listed on page M- .

EVALUATION - Have students list the energy resources in order of percentage of the fuel mix. Have them make a second list of the fuels in the order of how they should be used in the fuel mix based on availability.

FOLLOW-UP/BACKGROUND INFORMATION

See Activity - 'Controlling Rate of Consumption" for information on resource availability. A follow-up activity would be "Sources of Electrical Energy: Two ways of Looking at Them".

SOURCE OF ACTIVITY

Adapted from Science Activities in Energy, U.S. Dept. of Energy by Dorothea Trost.

MATH

FUEL MIXES

Strategies:

1. Provide meter sticks, register tape (or other paper cut into long narrow strips), and crayons for each student or groups of students.

2. Tell students they are to represent the U.S. fuel mix on the 100 cm. paper strip. Each centimeter of the graph is equal to 1% of the energy sources used in the fuel mix. Explain that the United States uses a variety of fuel for energy. The percentage of various fuels that make up the total fuel consumption is called the fuel mix. Students must divide the strip into fuel source lengths according to the chart below, which can be copied on the chalkboard.

Oil	47%
Gas	26%
Coal	19%
Nuclear	4%
Hydro	4%
Other	.1%

Strips should look like this:

OIL GAS COAL

3. Students should color each section in solid colors.

4. Students should individually complete the following worksheet.

FUEL MIX

1. The strip of paper you measured was 1 meter long. Name something else that is about 1 meter long.

2. a. How many centimeters are there in one meter?

   b. Name some words that have the prefix "centi."

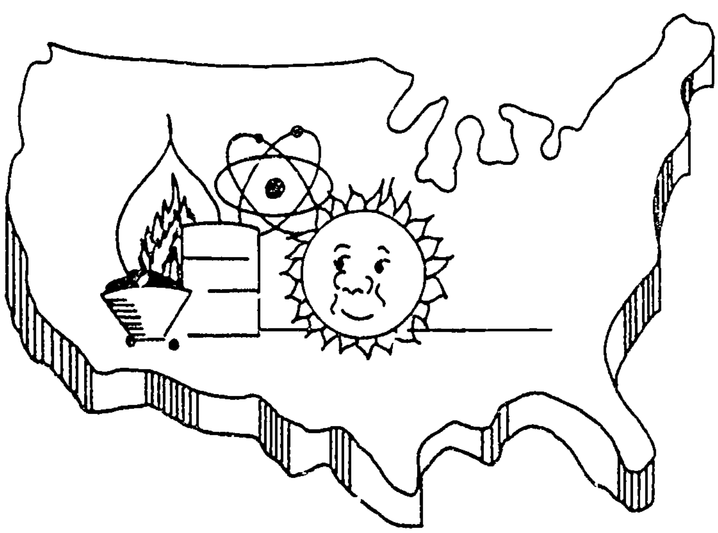
   c. What does centi mean?

3. How are percents and centimeters alike:

4. Which fuel does the United States use the most?

5. Which fuel does the United States use the second most?

6. Which fuel does the United States use the third most?



SOURCES OF ELECTRICAL ENERGY

SUBJECT Mathematics LEVEL 6-8

ACTIVITY IN BRIEF

Students will interpret graphic information about resource use in producing electricity.

OBJECTIVE

Students will be able to list the resources used in the production of electricity and propose reasons for changes in the fuel mix for future production and justify them.

MATERIALS	TIME
activity sheet	20 minutes

LEARNING CYCLE

AWARENESS - Discuss with students what energy resource is used to produce the electricity they use and why is it used.

CONCEPT DEVELOPMENT - Have students complete the activity sheet.

APPLICATION - Discuss with students why the fuel mi'. is as it currently is, and why it will be undergoing the predicted change.

EVALUATION - Have students list the resources used in producing electricity. Have students explain why there will be a need for a change in the fuel mix in the future.

FOLLOW-UP/BACKGROUND INFORMATION

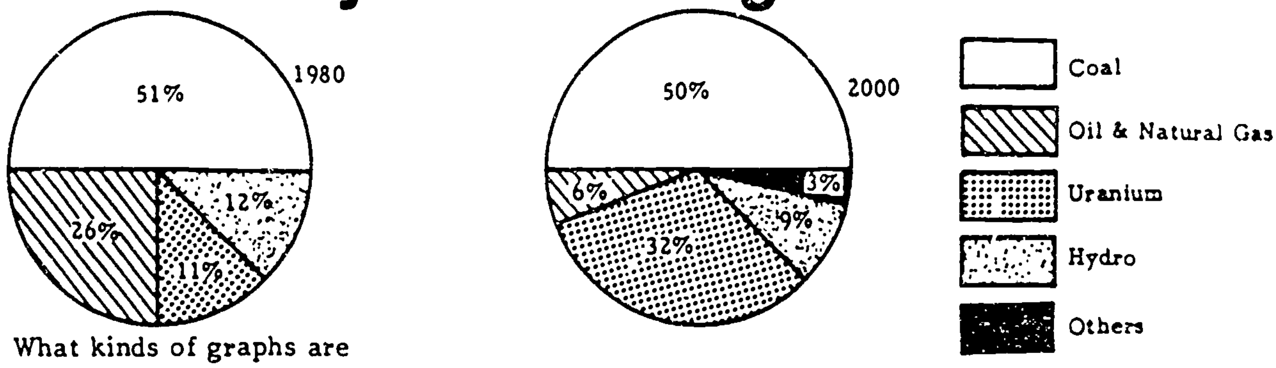
Follow up activities might include:

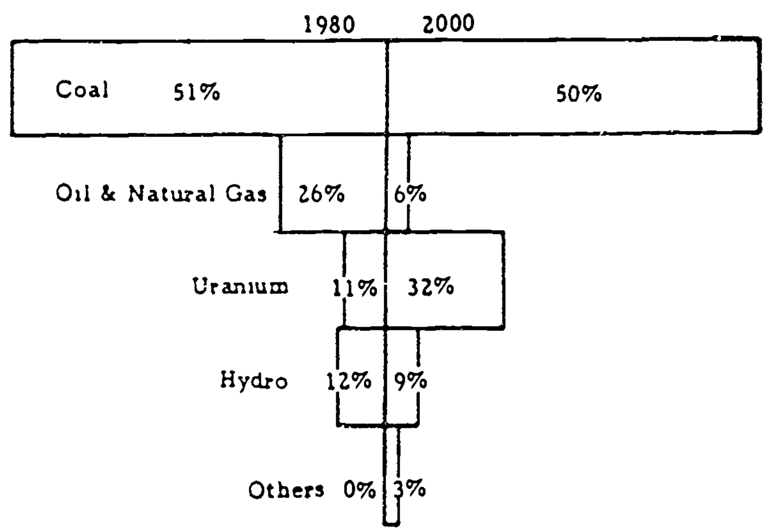
"Controlling Consumption"
"Fuel Mix"

SOURCE OF ACTIVITY

U.S. Department of Energy, Science Activities in Energy; Adopted by Dorothea Trost.

Sources of Electrical Energy: Two Ways of Looking at Them





1. What kinds of graphs are shown?

____

2. Add the percentages for the year 1980.

____

3. The percentages for the year 2000 total 100%. What does this mean?

____

____

4. The use of which fuel will probably decrease the most by the year 2000?

____

5. Which fuel is predicted to show the greatest increase in use by the year 2000?

____

6. Which fuel should maintain about the same percentage of use?

____

7. Which two categories provided approximately 75% of our electricity in 1980?

____

8. What change is anticipated in the percentage of power provided by hydroelectric plants in the year 2000 as compared to 1980?

____

9. What percent of the electricity will coal and uranium produce in the year 2000?

____

10. Why does this information lend itself to a circle graph?

____

Bonus: What possible sources could make up the remaining 3% in the year 2000?

HEIR CONDITIONING

SUBJECT Mathematics LEVEL 6 - 12

ACTIVITY IN BRIEF

Students use percentage to calculate a needed reduction of future energy use and develop a plan for such a future reduction for their family.

OBJECTIVE

Each student will be able to devise a method of reducing energy use in their homes and state the impact of such reductions on their life style.

MATERIALS

charts and questions provided

TIME

class period

LEARNING CYCLE

AWARENESS - Use the information on the circle graph and the questions to help students see how energy is used in their home.

CONCEPT DEVELOPMENT - Acquaint students with the information about increased consumption of energy contained in the activity "Learn to CARE". Stress to them the need for us to reduce our use of energy in the future so that there can be more equitable sharing of the earth's resources among all people when shortages begin to occur.

APPLICATION - Using the information on Chart I, have the students devise a plan for reduction of home energy consumption by 50%.

EVALUATION - Have students submit their plans and evaluate them according to feasibility and how close they were to the 50% reduction. Ask them to state the major impacts this plan will have on their family.

FOLLOW-UP/BACKGROUND INFORMATION

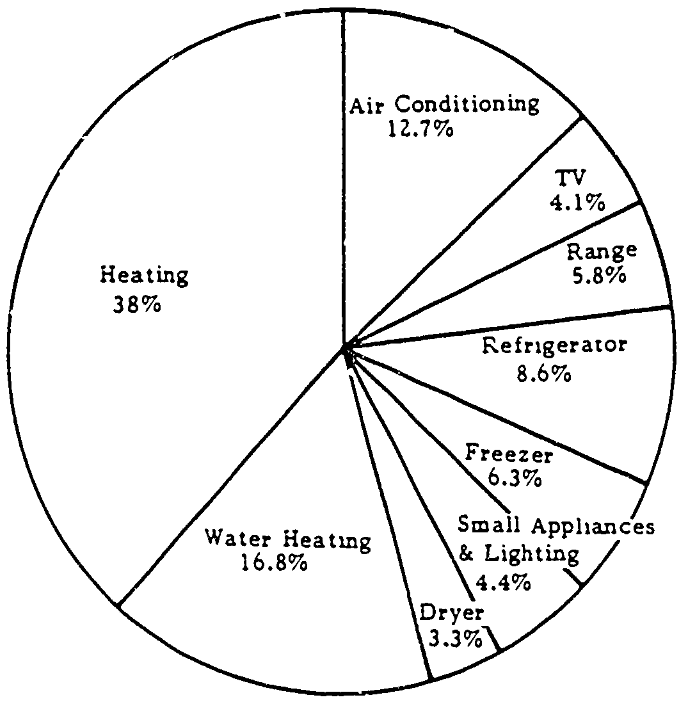
Have students write a short essay which would describe the effect their reduction of energy use would probably have on the way their family would live. Consider the daily routine and also special times such as holidays, cold winter nights, and hot summer days.

SOURCE OF ACTIVITY

E.M.E./National Energy Foundation and,
Science Activities in Energy, U.S. Dept of Energy.
Adapted by Dorothea Trost

HEIR CONDITIONING

Use the information in the circle graph and a calculator to answer the questions.



Where the energy dollar goes during the year in an all electric home.

1. Which 2 items make up about 50% of the cost? ____________

2. Which 3 items make up 14% of the cost? ____________

3. What is the difference in the percent of heating and cooling? ____________

4. The range, refrigerator and freezer equal what percent? ____________

5. How would you explain the difference in cost between the dryer and heating? ____________

6. Why is the section of the graph for TV smaller than the one for heating? ____________

7. Suppose the heating portion was 20% and the air conditioning 35%. What would you conclude about the climate? ____________

8. By setting the thermostat at 68 in winter they could have saved 20% on heating costs.

   a. If they paid $342, how much savings would that be? ____________

   b. What would the heating cost be then? ____________

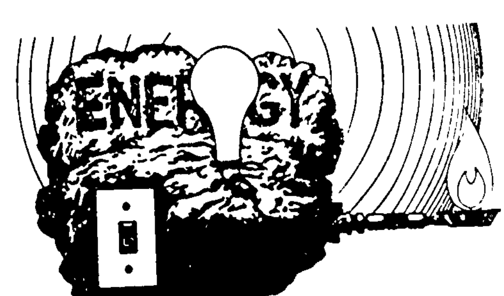


CHART I

APPLIANCE	KWH
Air conditioner (used only on hot days)	935
Cooking appliances (average for all cooking)	1750
Dishwasher (once a day)	430
Food freezer	1760
Lighting (5 hours per day)	1500
Refrigerator	1850
Television (color - 4 hours per day)	525
Television (black & white - 4 hours per day)	360
Electric blanket	150
Can opener (3 uses per day)	0.3
Clock	17
Clothes dryer (6 loads per week)	1200
Coffee maker (once per day)	100
Fan (stove exhaust - 1 hour per day)	30
Food mixer (1 hour per week)	10
Food waste disposer	30
Frying pan (1 use per day)	240
Hair dryer (1 use per week)	15
Iron (hand) (3 uses per week)	150
Radio (solid state - 2 hours per day)	20
Radio Phonograph (solid state - 2 hours per day)	40
Sewing machine (3 hours per week)	10
Shaver	0.6
Toaster (6 minutes per day)	40
Vacuum cleaner (4 times a week)	45
Washer (automatic - 6 loads per week) (does not include hot water)	100
TOTAL	11,307.9

CHART II

MY PROPOSED 50% REDUCTION IN HOME ELECTRICAL ENERGY USE

Appliance	KWH	NUMBER	TOTAL KWH
Lighting	1500	1*	1500*
Air conditioner	935		
Cooking appliances	1750		
Dishwasher	430		
Food freezer	1760		
Refrigerator	1850		
Television (color)	535		
Television (black & white)	360		
Electric blanket	150		
Can opener	0.3		
Clock	17		
Clothes dryer	1200		
Coffee maker	100		
Fan (stove exhaust)	30		
Food Mixer	10		
Food Waste Disposer	30		
Frying pan	240		
Hair dryer	15		
Iron (hand)	150		
Radio (solid state)	20		
Radio Phonogragh (solid st)	40		
Sewing machine	10		
Shaver	0.6		
Toaster	40		
Vacuum cleaner	45		
Washer (automatic)	100		
	Grand Total		

*We are suggesting 1500; you may want to use less.

SQUARING "ON THE DOUBLE"

SUBJECT Mathematics LEVEL 6 - 12

ACTIVITY IN BRIEF

Students will color in squares on graph paper to simulate exponential growth.

OBJECTIVE

Each student will be able to synthesize a model of exponential growth or "doubling time".

MATERIALS	TIME
sheets of graph paper with 1/4" or 5-6mm. squares colored pencils, crayons or colored pens (3 colors) watch with second hand or minute timer	20 minutes

LEARNING CYCLE

AWARENESS - Use one of the stories about exponential growth to stimulate interest, i.e., algae growth on a pond, or the servant who requested payment of grain exponentially.

CONCEPT DEVELOPMENT - Use the coloring exercise to teach students the concept of exponential growth.

APPLICATION - Discuss the exponential use of resources, the doubling time of energy consumption, population growth, human expectations or material goods.

EVALUATION - Give students a starting population and a doubling time and have them predict the population at various time intervals.

FOLLOW-UP/BACKGROUND INFORMATION

Energy use grows exponentially at a rate of about 7% per year. The doubling time at this rate is every 10 years. If half of the world's reserves of oil were left, how long would they last? Would there be concern at that point of running out? The concept of exponential consumption is an important one to understand in explaining the current energy dilemma.

SOURCE OF ACTIVITY

I.D.E.A.S. Adapted by Dorothea Trost

PROCEDURE

Tell the students that you will give them one minute to color a square on their graph paper. They don't need that much time, but give them a full minute anyway.

Then ask them to use another color on two squares during the next minute. Ask for a third color and four squares during the third minute. Keep a steady pace with no waiting time between minutes. Ask for eight squares during the fourth minute, etc., until there is no more room on the paper.

TABLE A

Minute	Number of squares to color		Total Colored
1	1	2^0	1
2	2	2^1	3
3	4	2^2	7
4	8	2^3	15
5	16	2^4	31
6	32	2^5	63
7	64	2^6	127
8	128	2^7	255
9	256	2^8	511
10	512	2^9	1023

EXPECTED RESULTS

Depending on size of the squares on the original graph paper, students may be able to color in eight or nine doublings before running out of space. Note to students how easy (plenty of time) it was to color in the first six minutes worth of squares, but how hurried they were during the last minutes of coloring.

QUESTIONS

Ask what one would do in order to double the squares one more time. Get another sheet of paper. Put Table A on the chalk board. Ask students to label their various colored areas with the exponent (power of 2) it represents. Draw attention to the fact that each successive doubling colors an area bigger than all the previous ones put together.

Now ask, "If we had continued to color only one square per minute instead of doubling everytime, how much longer would the graph paper have lasted?"

The answer will be on the order of 1,200 - 1,500 minutes vs. the 8 to 10 minutes for the doubling pace.

The following stories give some more examples of the fantastic increases resulting from exponential growing.

Manhattan Island. In the year 1626, Peter Minuit purchased Manhattan Island for the equivalent of $24. In 1972 (346 years later), the total assessed valuation of New York City was $\$3.8 \times 10^{10}$. If Peter had put his $24 in a bank paying 6.1% per year compounded continuously, his account would have had in it a sum equal to the assessed valuation of all of New York City and its billions of dollars of buildings and improvements. No wonder most states have banking laws that prevent inactive accounts from growing indefinitely.

National Inheritance Proposal. Realizing the results of compounding interest (another way of saying "exponential growth"), David H. Fisher* has proposed that giving each American a capital "nest egg" at birth would be much less drain on the national budget than providing income at the end of life. The gift inheritance would have very restricted use, being unavailable for spending, lending, borrowing, or attachment in any way. Invested at the average rate for the last 300 years of fiscal history (6% annually, with interest earning interest in successive years), a birthday gift of $4,400 would be worth $200,000 at age 65. This sum would generate $12,000 income per year per person at a flat 6% rate, much more than Social Security provides today.

The King and the Mathematician. Supposedly a court mathematician pleased his patron the king by inventing the game of chess. The king invited him to name his own reward. The clever one's response was, "Give me one grain of wheat for the first square of the chessboard, two grains for the second square, four grains for the third square, eight grains for the fourth square, etc., doubling the number of grains for each succeeding square until all the squares have been compensated for."

The king was surprised, at first, that his mathematician asked for so small a reward. But he changed his mind when he started counting out the grains of wheat. Table 2 shows the number of grains requred for each square, ending with 2^{63} grains for the 64th square alone:

Table 2: Wheat for the Chessboard (8 x 8 squares)

No. of Square	Grains of Wheat per Square	Total Grains of Wheat Due
1	$1 = 2^0$	$1 = 2^1 - 1$
2	$2 = 2^1$	$3 = 2^2 - 1$
3	$4 = 2^2$	$7 = 2^3 - 1$
4	$8 = 2^3$	$15 = 2^4 - 1$
5	$16 = 2^4$	$31 = 2^5 - 1$
6	$32 = 2^5$	$63 = 2^6 - 1$
n	2^{n-1}	$2^n - 1$
64	2^{63}	$2^{64} - 1$

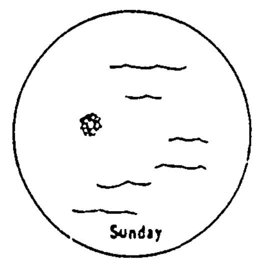
*History professor at Brandeis University and author of Growing Old in America, Oxford University Press.

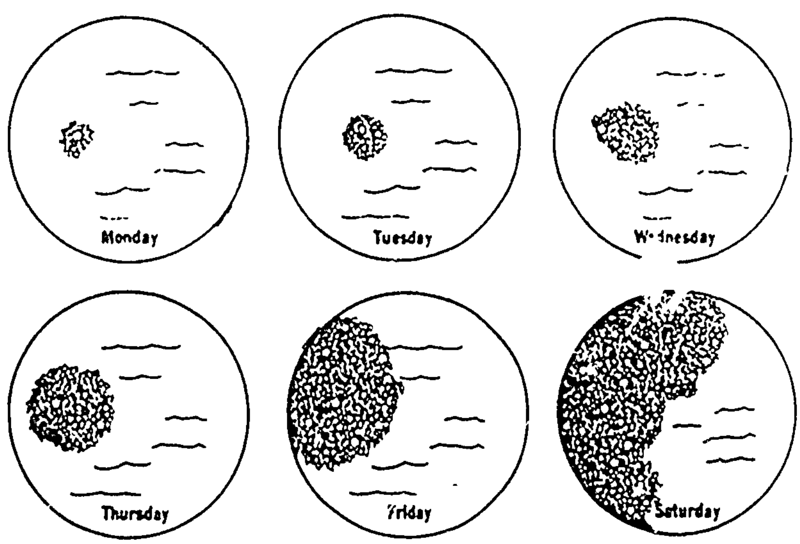
If the king could provide all the wheat due, he would be stacking up $2^{64} - 1$ grains or 18.45×10^{18} or <u>18 billion billions</u> of grains of wheat. Based on an average mass of 3.4 g per hundred, the total weight of this grain pile would be 6.27×10^{14} kg, approximately 500 times the current annual world-wide harvest of wheat! (Thanks to Dr. A. A. Barlett of the University of Colorado for these figures.)

<u>Farm Pond</u>. Imagine that a few water hyacinths get started in a farm pond and then double their growth daily. The farmer notices, on Sunday, that less than 1% of the surface area (or 1/128) is covered by the green invaders. That amount doesn't concern him, and he doesn't come back until later in the week to look at the pond again.

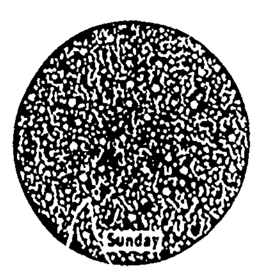
Meanwhile, the hyacinths double daily. They expand to cover 1/64 of the pond's surface on Monday; 1/32 on Tuesday; 1/16 on Wednesday; 1/8 on Thursday; 1/4 on Friday. By Saturday, when the farmer notices that a week's growth has blanked half of his pond with hyacinth leaves, he may decide to go get a manatee or a herbicide. But when he returns the very next day, the pond is already completely suffocated with vegetation. See the illustration included with this activity.

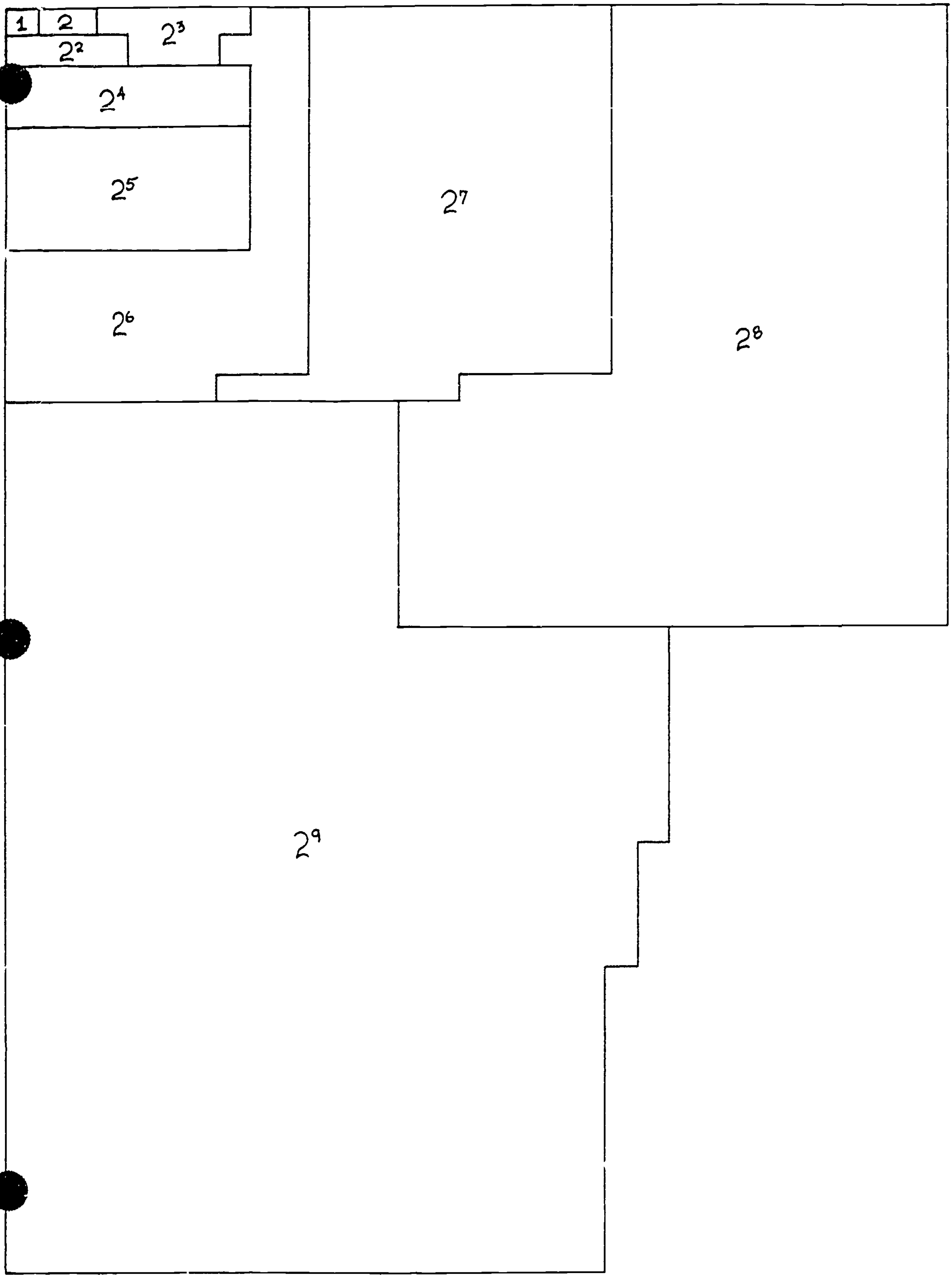
<u>Farm Pond</u> example of exponential growth. One Sunday the farmer notices that water hyacinths have started to grow in the pond. They cover about 1/128 or less than 1% of the surface. But they double their growth . . .





It took a week's rapid growth to blanket half the pond. The surprised farmer may decide to intervene during the following week. BUT the very next day ---




1
2
2²
2³
2⁴
2⁵
2⁶
2⁷
2⁸
2⁹

SECRET MESSAGE

SUBJECT Mathematics LEVEL 6 - 8

ACTIVITY IN BRIEF

Students locate graph coordinates to solve a puzzle.

OBJECTIVE

Identify coordinates of points and identify an important energy concept; conservation.

MATERIALS TIME 15 minutes

secret message activity sheet

LEARNING CYCLE

AWARENESS - Supply each student with a copy of "Secret Message" worksheet. Have students solve the message.

CONCEPT DEVELOPMENT - Discuss what it means to conserve energy.

APPLICATION - List ways students or their families can conserve energy everyday at school or at home.

FOLLOW-UP/BACKGROUND

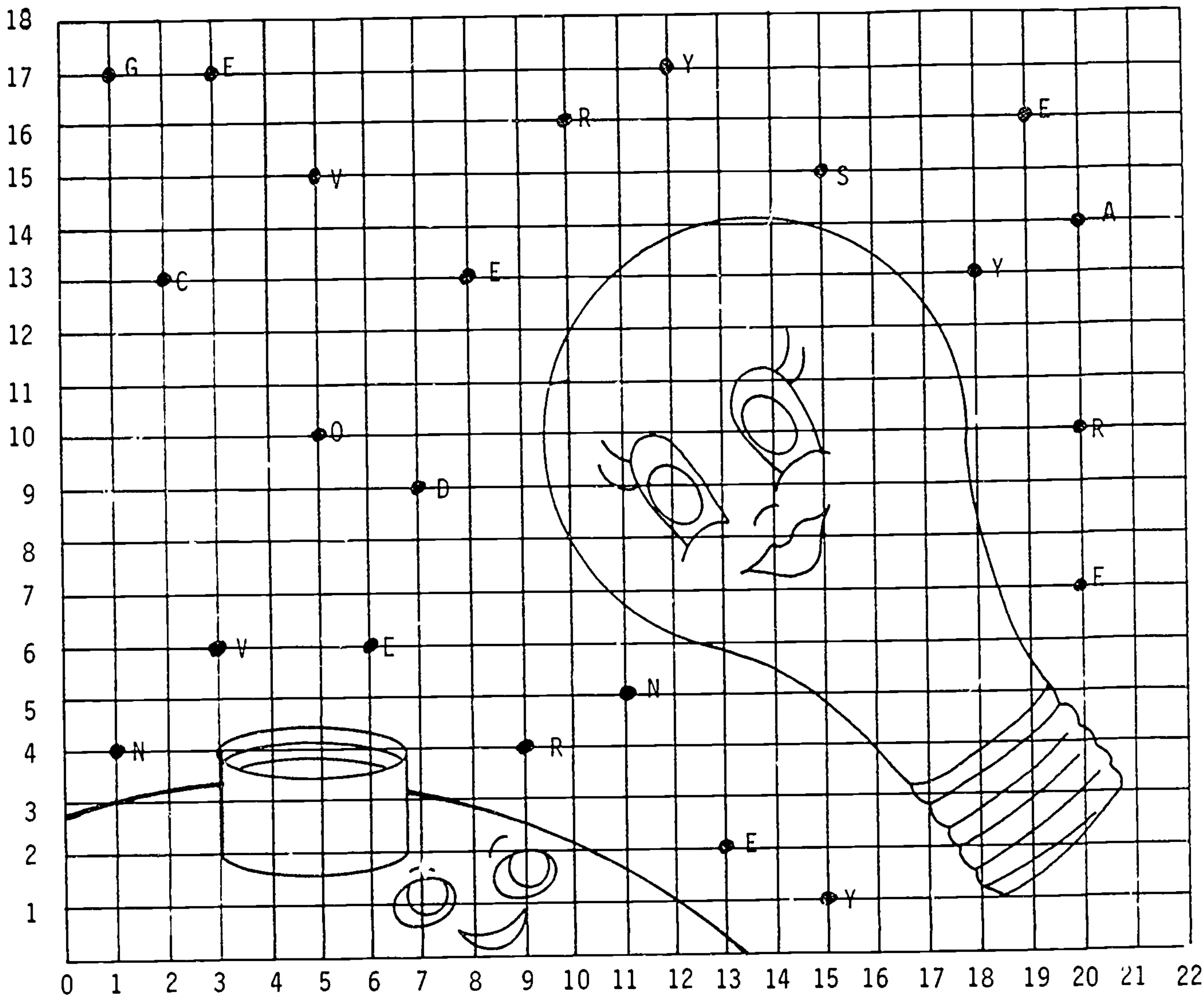
Conserving energy is something that takes the effort of everyone everyday. It is an idea that needs to be internalized and acted out in small ways, (turning off unnecessary lights) as well as in major decisions (buying a more efficient furnace).

SOURCE OF ACTIVITY

Science Activities in Energy, U.S. Dept. of Energy; adapted by Dorothea Trost

SECRET MESSAGE

Directions: Using the coordinates given below, fill in the blanks with letters from the graph to decode the message.



____ (2,13) ____ (5,10) ____ (11,5) ____ (15,15) ____ (13,2) ____ (20,10) ____ (3,6) ____ (20,7)

____ (19,16) ____ (1,4) ____ (6,6) ____ (9,4) ____ (1,17) ____ (18,13)

____ (3,17) ____ (5,15) ____ (8,13) ____ (10,16) ____ (15,1)   ____ (7,9) ____ (20,14) ____ (12,17)

PARABOLIC CURVES SHINE BRIGHT

SUBJECT Mathematics **LEVEL** 9 - 12

ACTIVITY IN BRIEF

Using simple algebra, graph paper, cardboard and aluminum foil, the student will: 1. Design and construct a parabolic reflector. 2. Test the design outside on a sunny day.

OBJECTIVE

Each student will be able to construct a parabolic curve and manipulate materials to construct a solar collecting device.

MATERIALS

handout on Parabolic Curves
large pieces of cardboard
tagboard
aluminum foil
glue
squeegee
graph paper
thermometer
container to hold water to be heated

TIME

2-3 hours

LEARNING CYCLE

AWARENESS - Draw 3 parabolic curves using the equation $y=nx^2$. Let n=-10, 1, 1/2. Calculate x and y (x,y) for at least 6 data points. Discuss what happens to the focal length F as the curve flattens out (n approaches zero). Discuss the uses of parabolas in collecting light (this information is on the student handout).

CONCEPT DEVELOPMENT - Design a parabola of reasonable size (no larger than you can build or carry) using the equations $y=n \cdot x^2$ and $F=x^2/4y$. Build the reflector and test it.

APPLICATION - Heat some water using the reflector and discuss the usage of solar energy.

EVALUATION - Have each student demonstrate that she/he can use his/her constructed device to heat water.

FOLLOW-UP/BACKGROUND INFORMATION

1. Check with power companies about the possibility of them financing solar systems for homes and businesses instead of more power plants.
2. Check the practicality of using solar energy (active/passive).
3. Check the heat available on cloudy days.
4. Check with contractors to see if they are using solar systems.
5. Resources:
   - Chemistry Textbooks
   - New Shelter Magazine
   - Mother Earth News Magazines
   - Sellers of Solar Collectors (no caps on solar collectors)
   - Book, Entrophy by Jeremy Rifkin

SOURCE OF ACTIVITY

E.M.E./National Energy Foundation, adapted by Dwight Bakker

ACTIVITY

1. Design a parabola of reasonable size (no larger then you can build or carry).

2. Graph the parabola on regular paper until you are sure of your design.

3. Transfer the design onto a large piece of sturdy corrugated cardboard. Cut out the parabola.

4. To make the reflector, glue aluminum foil to flexible tagboard and smooth it with a squeegee until it is mirror-like.

5. Attach the reflector to the cardboard parabola securely.

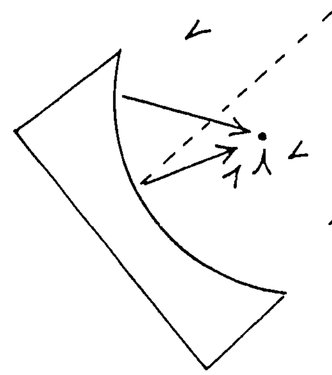
6. Test the parabolic reflector in the sun. Locate the focal point with your hand. BE CAREFUL NOT TO GET BURNED! DO NOT LOOK AT THE SUN!

7. Measure the focal length and see if it agrees with your calculations.

PARABOLIC CURVES SHINE BRIGHT

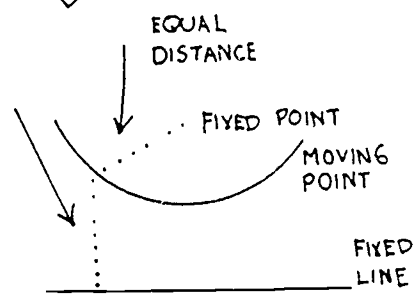
PARABOLIC CURVES

Parabolic reflectors can be used to concentrate sunlight to create high temperatures. They also are typically found in lighting devices, such as, flashlights, automobile headlamps, and searchlights.



In this lesson you will learn to draw a parabola, design and build one to any size. Upon completion you can test your design in the sunlight.

DEFINITION: Parabola - A curve generated by a point moving so that its distance from a fixed point is equal to its distance from a fixed line.

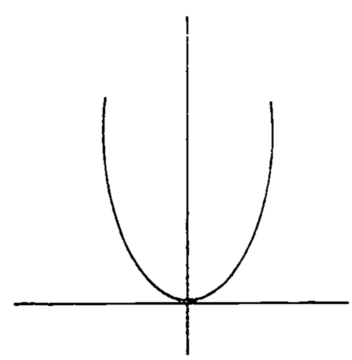


The general equation used for graphing parabolas is:

$$y = n \cdot x^2$$ Where n can be any number.

For example: If n = 1

x	y
0	0
1	1
2	4
3	9
4	16
.	.
.	.
.	.



As the value for n approaches zero the curve flattens.

All parabolas have a focal length, or focal point (F). The focal point is the area in which the reflected light reaches maximum concentration.

The focal length can be calculated using the following equation:

$$F = x^2/4y$$

PARABOLIC CURVES SHINE BRIGHT

PARABOLIC CURVES
(continued)

In the previous example, n = 1, the focal length is:

$$F = (2)^2/4x4 = 1/4 = .25 \text{ meters}$$

(You can use any units of measurement as long as you are consistent.)

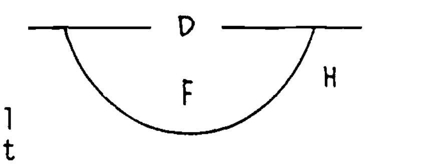
Notice that once you have determined n, any pair of numbers (x,y) will give you the same focal length. Why?

For existing parabolas, such as flashlight or automobile headlamp reflectors, the focal point can be calculated using the following equation:

$$F = D^2/16H$$

where D = diameter of the reflector rim.
H = height of the reflector from bottom to top rim.
F = focal length

To Focal Point

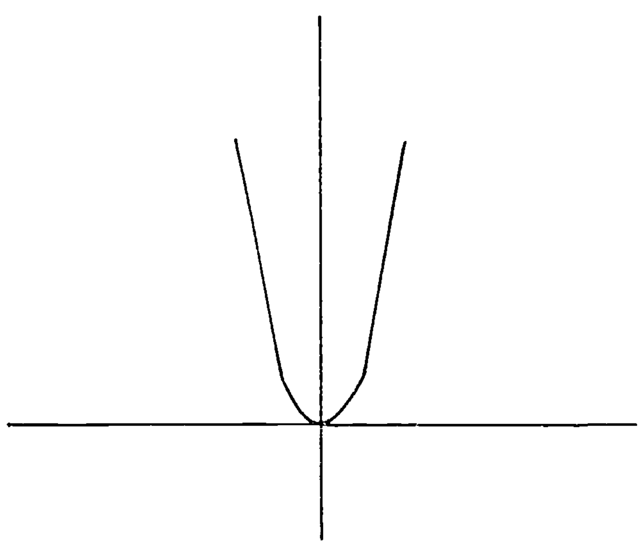


To design a parabola choose n , then calculate for a number of different points (-5 to 5).

x	y

Graph this set of points. As in the example described before, n = 1, $y = n \cdot x^2$ and F = .25 meters.

x	y
-5	25
-4	16
-3	9
-2	4
-1	1
0	0
1	1
2	2
3	9
4	16
5	25



NUMBER SCAVENGER HUNT

SUBJECT Mathematics LEVEL 6 - 8

ACTIVITY IN BRIEF

Students are involved in a scavenger hunt to collect data pertaining to energy use.

OBJECTIVE

Each student will be able to describe some ways to decrease energy consumption.

MATERIALS	TIME
scavenger list	Several days for the scavenger hunt (out of class). Data analysis time will vary.

LEARNING CYCLE

AWARENESS - The scavenger activity should enable students to become more aware of the various ways they use energy and amounts of energy they consume. As students collect their data they will relate numbers to energy related topics which directly affect them.

CONCEPT DEVELOPMENT - Since this data is collected by the students they will have some interest in it.
1. Have the class list the various forms of energy they collected data about.
2. Have the class list different kinds of work done with the energy they used.
3. Have students determine the difference in their answers to question 1 and 2 of the list. Students can then determine the greatest and least amounts consumed, and the average consumption for their entire class. (Do this for some of the other energy forms used also, i.e. gasoline.)

APPLICATION - Have students discuss why some families consumption of the various energy forms were higher or lower than others. How could they decrease their families energy consumption?

EVALUATION - Have students describe ways energy consumption may be reduced.

FOLLOW-UP/BACKGROUND INFORMATION

The data collected can be examined in many ways through comparison. See how many ways you can increase the students awareness of its value and the need for wise use of energy.

SOURCE OF ACTIVITY

Adapted from Science Activities in Energy, U.S. Dept. of Energy - by Dorothea Trost.

Name ____________________

Date ____________________

Number Scavenger Hunt

Directions: This scavenger hunt will take several days to complete. Write your answers in the space at the end of each task. Read all the tasks before you begin!

TASK	ANSWER
1. Reading on your electric meter today. Give date.	1. ________ ________
2. Reading on your electric meter three days from today. Give date.	2. ____________
3. Temperature at which your home hot water heater is set.	3. ____________
4. Capacity of your home refrigerator in cubic feet.	4. ____________
5. Size of light bulb (in watts) in your bedroom light.	5 ____________
6. Octane level in super unleaded gasoline at the nearest gasoline service station.	6. ____________
7. Average fuel consumption (miles per gallon of gasoline), of your family car.	7. ____________
8. Capacity of fuel tank in your family car.	8. ____________
9. Size in gallons of the hot water heater in your home.	9. ____________
10. Size of the school's lunch room hot water heater. (In gallons)	10. ____________
11. Number of gallons of gasoline needed to completely fill a school bus gasoline tank.	11. ____________
12. Storage capacity of gasoline at the nearest oil dealer.	12. ____________
13. Number of watts in a 3-way light bulb.	13. ____________
14. Amount of electricity (number of kilowatt hours) used in your home last month.	14. ____________

15. Size (in gallons) of an aquarium in your school. (Location of aquarium)	15.	________
16. Number of cylinders in your family car.	16.	________
17. Number of electrical appliances in your home.	17.	________
18. Number of electrical appliances you used today.	18.	________
19. Cost per gallon of regular gasoline at the nearest service station.	19.	________
20. Number of electrical outlets in your classroom.	20.	________
21. Cost per kilowatt-hour of your home's electricity.	21.	________
22. High temperature predicted for the next 3 days (In degrees fahrenheit)	22.	________
23. Number of fireplaces in your home.	23.	________
24. Number of homes in your neighborhood or community with solar panels.	24.	________
25. Time of today's sunset. (Give date)	25.	________
26. How many liters of soft drinks does your family drink in a week?	26.	________
27. Hours per day the lights are on in your classroom.	27.	________
28. Number of electric lamps in your home.	28.	________
29. Distance the sun is from the earth.	29.	________
30. Number of minutes you spent working on this scavenger hunt.	30.	________

WHAT'S THE BEST INSULATION

SUBJECT Mathematics LEVEL 9 - 12

ACTIVITY IN BRIEF

Students will collect data to determine the difference in heat transfer through different materials and see how R-values are reciprocals of U-values.

OBJECTIVE

Each student will be able to distinguish between the differences in heat transfer of different materials and relate the information to U-values and R-values of insulating materials.

MATERIALS

100 watt bulb in ceramic socket
a variety of insulating and noninsulating materials - wood, aluminum foil, fiberglass, (7.5 cm-10cm thick), glass, metal, newspaper, heavy cloth
4 thermometers
cardboard
watch
masking tape
knife

TIME

class period

LEARNING CYCLE

AWARENESS - Have students construct the device for gathering the data and gather the data.

CONCEPT DEVELOPMENT - Explore which materials are the best insulators. Why is full insulation now required in new houses? Why is this a new requirement?

APPLICATION - Look up the R-values for the insulating materials you used. Convert these to U-values and compare them to the temperature information collected. (R-values are reciprocals of U-values.)

EVALUATION - List several U or R values of materials and have students compute the reciprocals and rank them according to which represent the best insulators.

FOLLOW-UP/BACKGROUND INFORMATION

A U-value is a coefficient of heat transfer which represents BTU's per hour which pass through a unit area of surface (sq. ft) for every degree (Fahrenheit) of temperature difference from one side to the other.

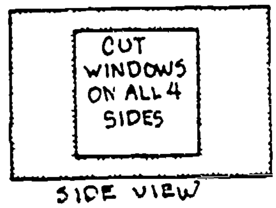
SOURCE OF ACTIVITY

Adapted from, Science Activities in Energy, U.S. Dept. of Energy by Myrna Moore

ACTIVITY: What's the Best Insulator?

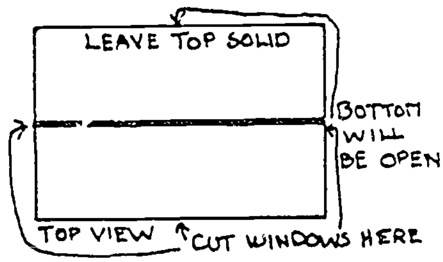
Set up the box like this:

Tape four insulating materials over the windows on the inside of the box.



Tape a thermometer to the outside of each insulating material.

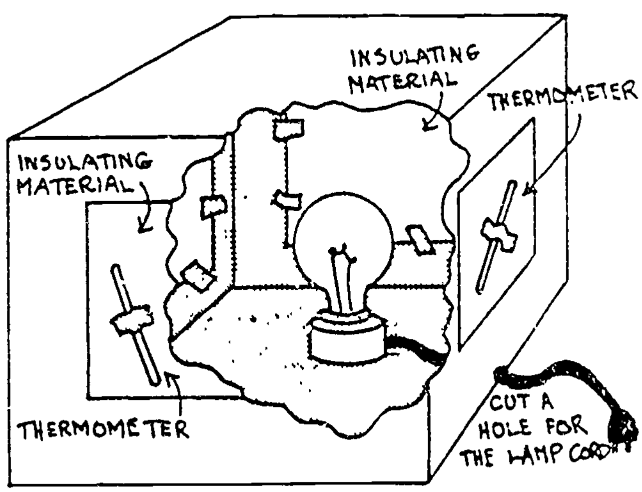
Record the starting temperatures.



Place the light in the center of the box.

Turn the lamp on for 5 minutes.

Record the rise in temperature for each material. How much better is the best insulator compared to the worst?



Why is full insulation now required in new houses?

Why is this a new requirement?

TURN, TURN, TURN

SUBJECT Mathematics LEVEL 6 - 8

ACTIVITY IN BRIEF

Students will practice reading an electric meter

OBJECTIVE

Each student will be able to measure electrical energy used in a household and relate the meter reading to the use of energy by the household.

MATERIALS

activity sheet

TIME

Activity runs 1 1/2 weeks, but classtime is 30 minutes

LEARNING CYCLE

AWARENESS - Bring to class an electric meter or take your class to look at the school's electric meter.

CONCEPT DEVELOPMENT - Teach the students how to read the meter through the exercises given on the worksheet.

APPLICATION - Hav[illegible]ents determine the daily usage of electricity at home or for the school. [illegible] them determine energy savings or wasting of some devices.

EVALUATION - Test each student's ability to correctly read a meter by having them read an actual meter or a simulation of one. Have them show what the reading would be after the use of a specific appliance for a given period of time.

FOLLOW-UP/BACKGROUND INFORMATION

Some ways of extending this activity include:

1. Have students produce a model of the dials on the meter on cardboard and have a pointer on each capable of turning. Use this to teach others how to read the meter.
2. Read your meter each day for one week. Calculate the average kilowatt hours used per day and the kilowatt hours per person used each day. Compare the last figure with others in your group and develop a class or group average.

3. Invite the custodian or superintendent to give the class an overview of the use of electrical energy in the school. Where do they think electrical energy could be conserved in the school? Are steps already being taken to conserve?

SOURCE OF ACTIVITY

Adapted from EME/National Energy Foundation by Dorothea Trost

ACTIVITY: Turn, Turn, Turn

The power that is developed and distributed to houses by the utility company enters the house and is used to perform a multitude of tasks.

Energy costs money, and in order to monitor its use, the utility provides a meter when the service is installed. The meter is read regularly and is the basis for determining electric bills.

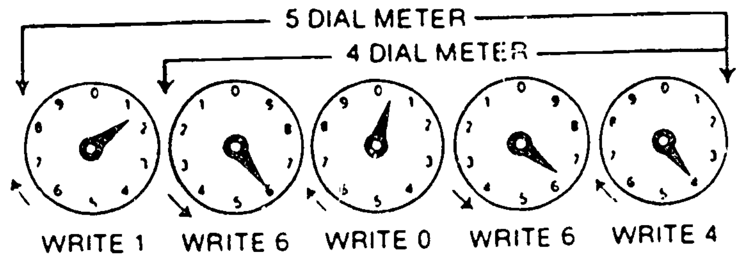
1. Do the exercises on the worksheet

2. Read your electric meter at the same time each day for one week. By subtraction, find the number of kilowatt hours used each day and plot a bar graph. Explain the changes in daily consumption.

3. Before going to school one day, read your meter and record your reading. Then (something you shouldn't usually do!) leave on electricity consuming things that are usually turned off, such as extra lights, the TV, the radio, and so on. Let this continue to the evening (not overnight). Next morning read the meter and record the reading. That day, conserve electricity by turning on only those items that are necessary. On the morning of the third day, read the meter again. Compare the number of kilowatt hours used the first day (reading #2-reading #1) to that of the second day (reading #3-reading #2). What was the difference in kilowatt hours used between the two days? Calculate what percentage the savings was of the total used the first day.

HOW TO READ YOUR ELECTRIC METER

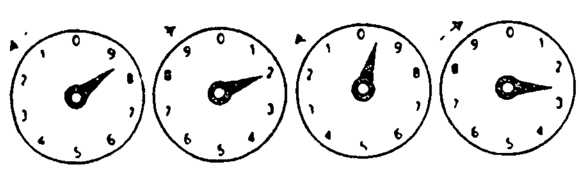
The dials are like watch faces lined in a row (every other dial moves counterclockwise). The reading for a five dial meter would be 16,064. The reading for a four dial meter would be 6,064.



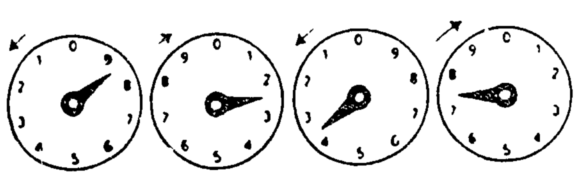
Notice that when the pointer is between two numbers, you should record the lower of the two numbers.

When the pointer seems to be directly on a number, look at the dial to the right; if the pointer on the right side dial has passed "O", then write down the number the pointer seems to be on, if the pointer on the right side dial has not passed "O", then write down the previous lower number on the dial you are recording.

METER NO 1

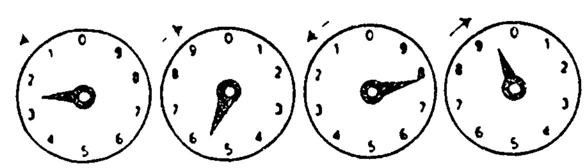


A ______________________________

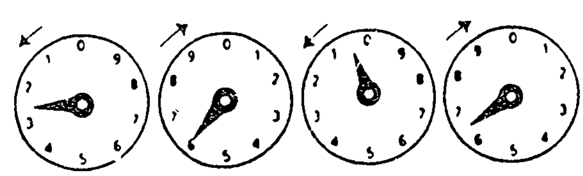


B ______________________________

METER NO.2



A ______________________________



B ______________________________

Subtract the number of line A from the number on line B to find the number of KWH of electricity used

Line B ______________________ Line B ______________________

Line A ______________________ Line A ______________________

KWH used ______________________ KWH used ______________________

NAME ______________________________

BLOWING IN THE WIND

SUBJECT Mathematics **LEVEL** 6 - 8

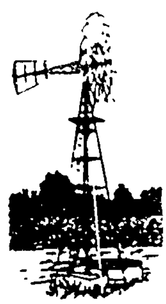
ACTIVITY IN BRIEF

Students will construct a device to measure wind speed. Students will then record the wind speed at various locations and keep a daily record to determine if wind power generation is practical in their location.

OBJECTIVE

Each student will identify an alternative energy source and describe its usefulness.

MATERIALS



1 ping pong ball
1 bubble level
1 piece fishline
glue
needle
protractor
red magic marker
1 strip balsa, about 1/2cm sq. x 18cm long x 1/4 in. thick

TIME

1 class period

LEARNING CYCLE

AWARENESS - Build the device and demonstrate how it can be used for measuring wind velocity.

CONCEPT DEVELOPMENT - Discuss how wind is a form of energy. How does it do work? Can this be an alternative energy resource. Do the activities.

APPLICATION - Evaluate the data that has been collected and discuss whether using wind energy is a viable alternative for their area.

EVALUATION - Have students describe how wind energy could be used in place of some current non-renewable resource.

SOURCE OF ACTIVITY

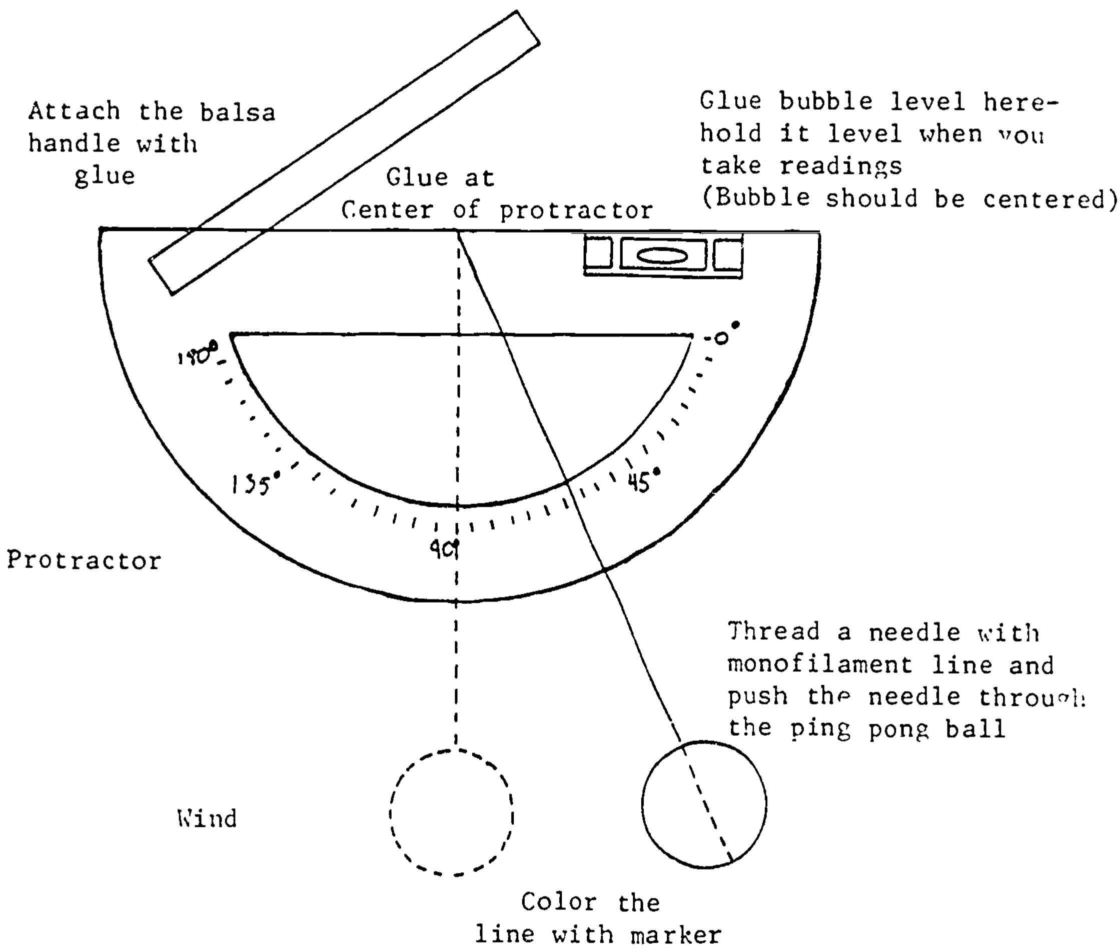
Adapted from Science Activities in Energy, U.S. Dept. of Energy. By Dorothea Trost.

BLOWING IN THE WIND

Calibrate the wind speed like this:

Angle	mph
90	0
85	5.8
80	8.2
75	10.1
70	11.8
65	13.4
60	14.9
55	16.4
50	18.0
45	19.6
40	21.4
35	23.4
30	25.8
25	28.7
20	32.5

Build a Device to Measure the Wind:



1. Test the wind at various places on your school ground. Keep a chart of the results.

2. What is the difference in wind speed at ground level and at higher elevations? Are the winds stronger in the valleys or in the hills where you live?

3. Are the winds in your area steady or gusty?

4. Any wind over 8 mph can be used to generate electricity. At what time of day is there enough wind to make electricity?

5. At what time of day do the fastest winds usually occur?

6. How many hours during the day could a wind generator make electricity?

CABIN FEVER / SURFACE AREA

SUBJECT Mathematics **LEVEL** 9 - 12

ACTIVITY IN BRIEF

To determine the best building design for efficient heating. Floor area, volumes, surface areas and volume/surface area ratios are calculated for various home designs.

OBJECTIVE

Each student will be able to determine the best building design for efficient heating by selecting the best design for slowing heat transfer.

MATERIALS

worksheet

TIME

30 - 60 minutes

LEARNING CYCLE

AWARENESS - Set out two ice cubes that are equal in volume but with different surface areas. Observe the rate at which they melt. Help students to develop the idea that heat transfer depends on the volume to surface area ratio.

CONCEPT DEVELOPMENT - Determine the floor area, volume, surface, and volume/surface area ratio for seven home designs.

APPLICATION - Determine by discussion of the questions which is the best energy conserving home design.

EVALUATION - State the criteria for the "best" design and assign each student to devise the best design for the dwelling.

FOLLOW-UP/BACKGROUND INFORMATION

See the first page under "Activity"

SOURCE OF ACTIVITY

Adapted from .D.E.A.S. by Dorothea Trost

ACTIVITY: Cabin Fever/Surface Area

(Background Information)
Heat naturally travels from a warmer place to a cooler one. How quickly that transfer happens depends on many factors. In the case of buildings that need heating or cooling, some of the considerations are:

How much surface area is conducting heat?
How well insulated is it?
How tightly sealed is it?
What does the site and its plantings contribute to the energy flow?
What are the activities of its occupants?

In general, the larger the volume of inside air to the outer surface areas of floor, walls and roof, the slower the rate of total heat exchange between the inside and the outside.

Because interior air has been deliberately heated or cooled at some energy cost, slowing its exchange is desirable. Designs that provide a higher volume to surface area ratio require less energy for space heating and air conditioning assuming that the buildings being compared are alike in materials, construction, window area, and other factors listed previously.

Compare the heat retaining advantages of various shapes of homes. Using the dimensions given on the following chart, do the calculations necessary to complete it.

After completing the chart, answer the following questions:

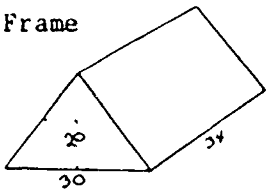
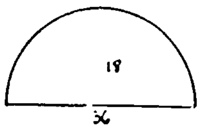
1. How similar are these houses/apartments in functional living area:
   a. What is the average floor area of each living unit. Assume that the two story square is a duplex. Make the same type of calculation for the four-unit apartments.
   b. Which house plan shows the largest difference (plus or minus) from the average floor area?
   c. Using your calculations in 1.b. determine the largest percentage of difference from the average floor area.

$$\frac{\text{Largest Difference in Floor Area}}{\text{Average Floor Area}} \times 100\%$$

2. Which design has the best potential for slowing down heat losses?
3. Which design would be easiest to insulate?
4. Can you suggest another design that would be better in slowing heat transfer?

Name ____________________

Student Worksheet

House Shape	Exterior Dimensions (ft.)	a. Floor Area (ft.^{2})	b. Volume (ft.^{3}) (to heat & cool)	c. Surface Area (ft.^{2})	d. Ratio Volume/ Surface Area
"A" Frame 	30 x 34 x 20 ft. peak				
Dome 	36 ft. = diameter, 18 ft. = radius				

1. a. ____________________

   b. ____________________

   c. ____________________

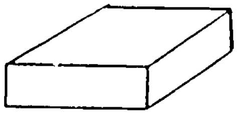
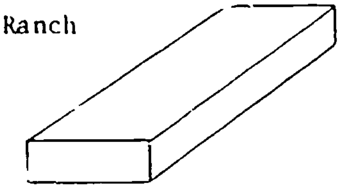
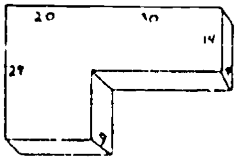
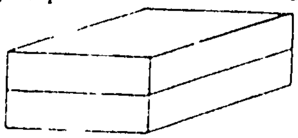
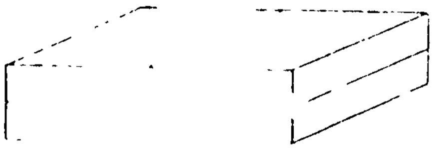
2. ____________________

3. ____________________

4. ____________________

Name ______________________________

Student Worksheet

House Shape	Exterior Dimensions (ft.)	a. Floor Area (ft.^{2})	b. Volume (ft.^{3}) (to heat & cool)	c. Surface Area (ft.^{2})	d. Ratio Volume/ Surface Area
Square 	32 x 32 x 8				
Ranch 	24 x 43 x 8				
Small "L" 	20 x 28 x 8 and 30 x 14 x 8				
2-Story Square 	32 x 32 x 16				
4-Unit Apartments 	64 x 32 x 16				

Teacher's Answer Sheet

House Shape	Exterior Dimensions (ft.)	a. Floor Area (ft.^{2})	b. Volume (ft.^{3}) (to heat & cool)	c. Surface Area (ft.^{2})	d. Ratio Volume/ Surface Area
Square	32 x 32 x 8	1,024	8,192	3,072	2.67
Ranch	24 x 43 x 8	1,032	8,256	3,136	2.63
Small "L"	20 x 28 x 8 and 30 x 14 x 8	980	7,840	3,208	2.44
2-Story Square	32 x 32 x 16	2,048	16,384	4,096	4.0
4-Unit Apartments	64 x 32 x 16	4,096	32,768	7,168*	4.57

Teacher's Answer Sheet

House Shape	Exterior Dimensions (ft.)	a. Floor Area (ft.^{2})	b. Volume (ft.^{3}) (to heat & cool)	c. Surface Area (ft.^{2})	d. Ratio Volume/ Surface Area
"A" Frame	30 x 34 x 20 ft. peak	1,020 + loft	10,200	3,320	3.07
Dome	36 ft. = diameter 18 ft. = radius	1,017.4 + loft possible	12,208.3	2,034.7	6.00

1. a. Average floor area/living unit + 1,017.3 ft.^{2}

   b. Small "L" house shape

   c. 3.6%

2. In terms of potential, the dome is best due to less escape routes for heat transfer.

3. There is no one right answer. Ease of insulation depends upon local limitations on construction, materials, installation expertise, costs, and time.

4. A number of valid suggestions may be proposed including berming, double wall or envelope construction, underground homes, row housing with shared walls, windowless north walls, etc.

WINDOW WASTE

SUBJECT Mathematics **LEVEL** 6 - 8

ACTIVITY IN BRIEF

Students will determine the window area and floor area of the classroom to determine if the building is an energy waster.

OBJECTIVE

Each student will be able to discuss critically the importance of proper building design to conserve energy.

MATERIALS	TIME
2 thermometers measuring tape	30 min.

LEARNING CYCLE

AWARENESS - Ask the students if some classrooms are warmer than others. Can they give some explanations if all the thermometers are set the same? Does the amount of window area affect how warm or cold it is?

CONCEPT DEVELOPMENT - Have students make the measurements for the activity.

APPLICATION - Discuss with students other energy wasting concepts used in architecture.

EVALUATION - Have students write a brief paper discussing the design of their school building for energy efficiency.

FOLLOW-UP/BACKGROUND INFORMATION

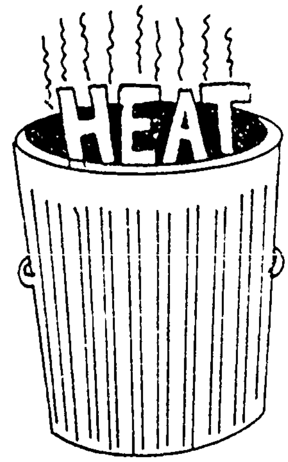
Do activity "Cabin Fever" to examine another example of architectural design affecting energy effeciency.
Discuss how the school is situated with regard to the sun. Make a draftometer and use it to help explain your results.

SOURCE OF ACTIVITY

Science Activities in Energy, U.S. Dept. of Energy; adapted by Dorothea Trost

M-52

IS YOUR SCHOOL WASTING HEAT

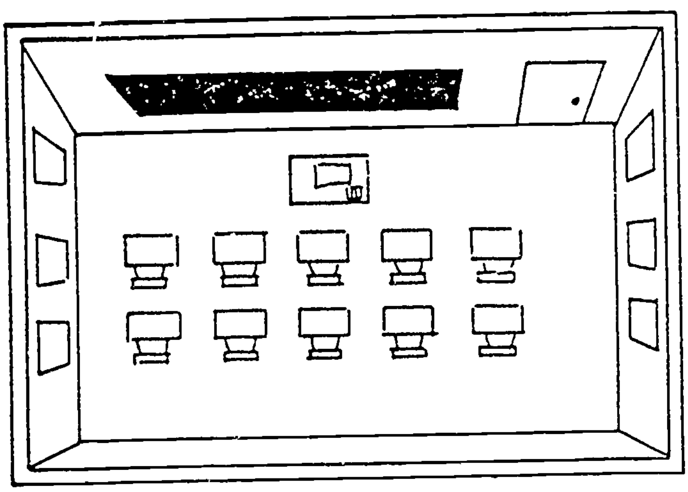


MATERIALS:

2 thermometers
measuring tape

Measure and record the window wall temperatures in your classroom.

Record your thermostat setting. How do the temperatures compare?



Measure the total areas of the windows. Measure the total area of the floor.

Window/Floor Ratio		
area of windows	area of floor	window/floor ratio

Temperature comparison		
window temperature	wall temperature	thermostat setting

Divide the floor measurement into the window measurement to get the window to floor ratio. A ratio greater than 10% is an energy waster.

Summary question:

WOULD YOU SAVE ENERGY IF YOU HAD FEWER WINDOWS?

ENERGY - NO CREATION OR DESTRUCTION

SUBJECT Mathematics LEVEL 6 - 8

ACTIVITY IN BRIEF

Students will calculate percentages to solve a puzzle.

OBJECTIVE

The student will be able to:
- calculate percentages
- state a basic law of energy. (Energy can neither be created nor destroyed, only changed in form)

MATERIALS

activity sheet - "Percent Riddle"

TIME

15 minutes

LEARNING CYCLE

AWARENESS - Supply each student with a copy of "Percent Riddle" worksheet. Have student complete the worksheet. (Answer is E N E R G Y)

CONCEPT DEVELOPMENT - Explain that energy exists in many forms. The basic fact to remember about energy is that it changes form with every use. Even though it changes form, it cannot be created or destroyed.

APPLICATION - Use examples of energy converters and name the forms of energy desired from that conversion and those forms of waste energy that are given off.

EVALUATION - Have students do percentage calculations. Have students state the energy transformations in various common appliances.

FOLLOW-UP/BACKGROUND INFORMATION

Examples for Application:

Electric light bulb (Electricity) ——>	Waste sound energy	1%	+ Light 2%
	Waste heat	97%	
Oil fired furnace (Chemical potential) ——>	Waste sound energy	3%	
	Waste heat energy	30%	+ Heat Energy 66%
	Waste light	1%	

Jet plane system ----------> Waste heat energy 70% + Mechanical Energy 25%
(Chemical potential) Waste sound energy 3%
Waste light energy 2%

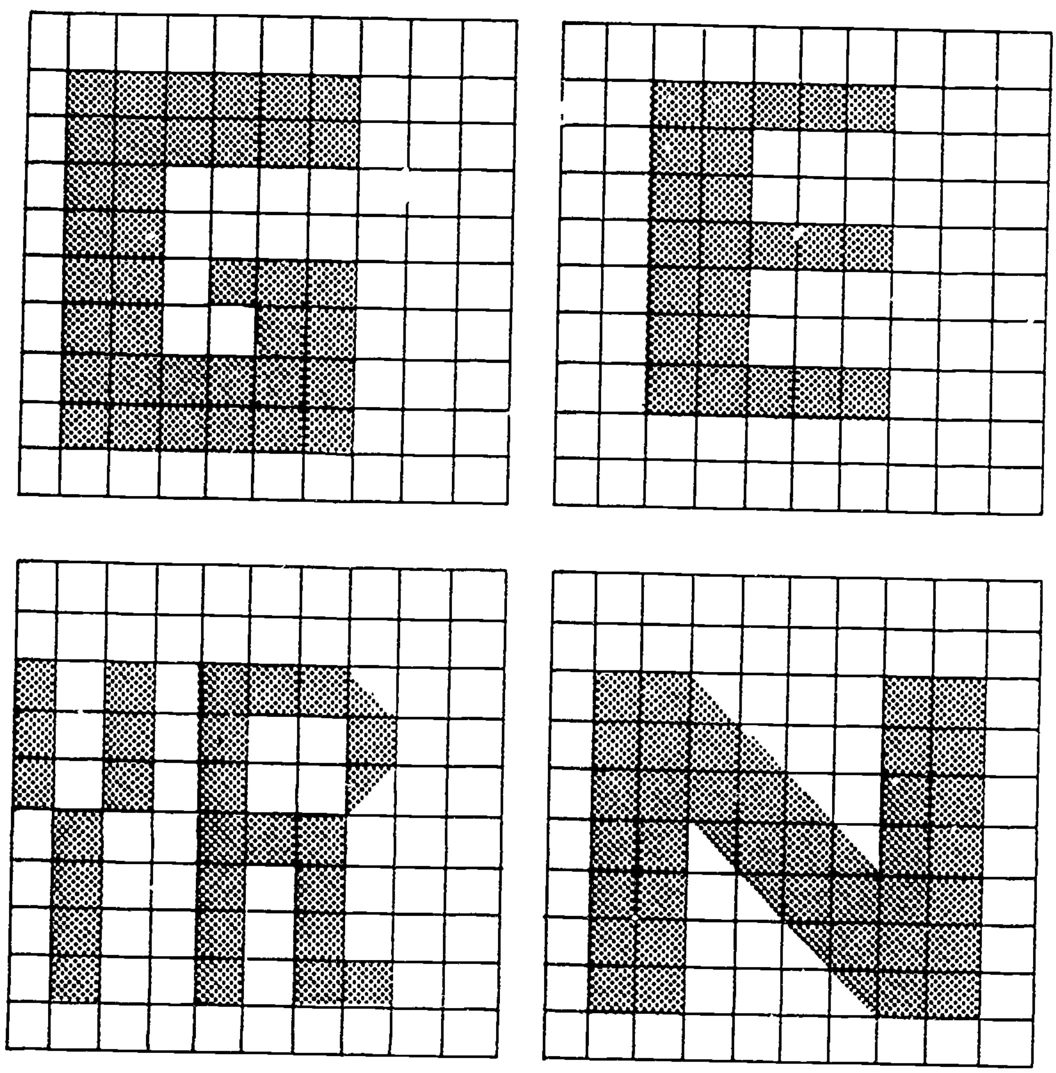
SOURCE OF ACTIVITY

Science Activities in Energy, U.S. Dept. of Energy. Adapted by Dorothea Trost

PERCENT RIDDLE

What changes but always stays the same?

To answer the riddle, find what percent of the square is used to make each letter. Then match the letter to its percent at the bottom of the page.



Answer: ____ 23% ____ 40% ____ 23% ____ 17% ____ 37% ____ 10%

INSULATION PERCENTAGES

SUBJECT Mathematics LEVEL 6 - 12

ACTIVITY IN BRIEF

Students are asked to do word problems involving percentages to calculated heat loss as a result of inadequate insulation.

OBJECTIVES

Each student will be able to:
- define BTU
- calculate the amount of BTU's lost because of heat passing into or out of a house
- state the relationship between insulation and conservation of energy in heating and cooling the home.

MATERIALS	TIME
balloons match activity sheet "Insulation Calculations"	class period

LEARNING CYCLE

AWARENESS - Ask students: "When you are cold and you put a blanket around you, what happens? Do you feel air from outside? Do you feel warmer?" The blanket <u>insulates</u> your body by keeping your body heat trapped between your body and the blanket. Define the word <u>insulate</u>. Strike a wooden match and let it burn completely out. It generates 1 BTU of heat. It would take 40,000,000 BTU's to heat a house for a year. (40,000,000 matches)

CONCEPT DEVELOPMENT - Insufficient insulation causes heating and cooling systems to work harder. Take a balloon that you have placed several pin holes in; begin blowing it up. (have students do this) Have them develop a relationship between the holes in the balloon and quality of the insulation in a home, and with a balloon with no holes and a well insulated home. How hard does the heating or cooling system have to work in a poorly insulated home?

APPLICATION - Direct students to complete the worksheet "Insulating Calculations".

EVALUATION - Each student should demonstrate his/her ability to do the calculations, define BTU, and explain how insulation conserves energy.

FOLLOW-UP/BACKGROUND INFORMATION

In poorly insulated homes, space heating and cooling accounts for 65% of energy consumption. Heating and cooling provides one of the greatest opportunities to save energy.

Insulation is the most effective way to reduce heat loss or gain. Inadequate insulation causes the cooling and heating systems to work harder. The circle graph shows how heat normally passes into or out of a house. The greatest loss is through the ceiling and roof, which, fortunately, is the most accessible area to install insulation.

SOURCE OF ACTIVITY

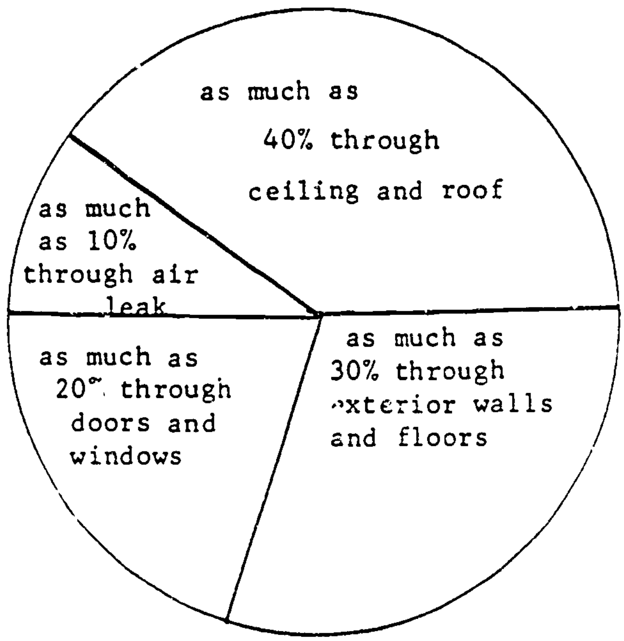
Science Activities in Energy, U.S. Dept. of Energy; adapted by Dorothea Trost

INSULATION PERCENTAGES

INSULATION CALCULATIONS

Using the circle graph below, answer the following questions.

DIVISION OF HEAT TRANSFER



1. a. During the winter, the Johnsons used 40,000,000 BTUs of heat in their home. 16,000,000 BTUs of this heat was lost through the ceiling, walls, floors, windows, door, and air leakage. How much of this lost heat was through the ceiling and roof?

   Ans: ____________________

   b. The Johnsons decided to install insulation in the attic which would cut the loss through the ceiling to 25%. How many BTUs would then be lost through the ceiling and roof?

   Ans: ____________________

   c. How many BTUs would then be saved by installing insulation in the ceiling and roof?

   Ans: ____________________

2. a. Last year the Martins used 38,000,000 BTUs to heat their home. 15,200,000 BTUs of this heat was lost through the ceiling, walls, floors, windows, doors, and air leakage. How much of this lost heat was through exterior walls and floors?

   Ans: ____________________

INSULATION CALCULATIONS (continued)

b. After installing insulation in the walls, the heat loss was reduced to 23%. How many BTUs would then be lost through the walls and floors?

Ans: ____________________

c. How many BTUs would be saved by installing this insulation in the walls and floors?

Ans: ____________________

3. a. During the winter, the Holts used 41,000,000 BTUs of heat in their home. 16,400,000 BTUs of the heat passed out of the house. How much of this lost heat was through the doors and windows?

Ans: ____________________

b. The Holts decided to install storm windows and doors. This insulation reduced heat loss to 14%. How many BTUs would then be lost through the walls and floors?

Ans: ____________________

c. How many BTUs would be saved by installing this insulation on the windows and doors?

Ans: ____________________

4. a. 39,000,000 BTUs of heat were used to heat the Brown's home last year. 15,600,000 BTUs passed outside the house. How much of this lost heat was through air leakage?

Ans: ____________________

b. The Browns decided to caulk between window frames and siding, outside water faucets, and between porches and the main body of the house. This insulation would reduce heat loss to 7%. How many BTUs would then be lost through air leakage?

Ans: ____________________

c. How many BTUs would be saved by caulking these air passages?

Ans: ____________________

TO POOL OR NOT TO POOL

SUBJECT Mathematics **LEVEL** 9 - 12

ACTIVITY IN BRIEF

Students investigate the costs of operating a car and the savings possible by carpooling.

OBJECTIVES

Each student will be able to compute transportation cost and identify carpooling as a means of conserving energy.

MATERIALS

'Cost per mile' chart
'Carpooling Cost Estimates' worksheet

TIME

2 class periods

LEARNING CYCLE

AWARENESS - Students will list pros and cons of carpooling--monetary, environmental, social.

CONCEPT DEVELOPMENT - Go through an example of calculating savings by carpooling.

APPLICATION - Students calculate personal commuting costs, and potential savings. Interview carpoolers vs. non-carpoolers. Research environmental impact.

EVALUATION - Have each student demonstrate his/her ability to compute transportation costs and list means of transportation which conserve energy.

FOLLOW-UP/BACKGROUND INFORMATION

1. Free class copies of current gas mileage guides from U.S. Department of Energy, Fuel Economy Distribution, Office of Administrative Services, Washington, D.C. 20585.

2. Federal Highway Department Statistics from U.S. Department of Transportation, 400 Seventh Street, S.W., Washington, D.C. 20590.

SOURCE OF ACTIVITY

Adapted from I.D.E.A.S. by Sue Marzinske

ACTIVITY

1. As a group, have students list pros and cons to carpooling to school, including monetary, environmental, and social aspects.
2. Distribute 'costs per mile' chart.
3. Using the 'Carpooling Cost Estimates' worksheet, work an example of calculating carpooling savings.
4. Each student will calculate his/her own savings, those of a parent, or those of a typical worker at a local industry.
5. Additional activities could include interviews with carpoolers vs. non-carpoolers regarding their attitudes toward the ride to school or work—any general trends?
   Research the amounts of pollutants emitted by each car per year. Could a small individual reduction in driving time result in a significant reduction of pollution nationwide?

COSTS PER MILE

Car Type	Depreciation (cents)	Parts & Tires (cents)	Gas & Oil (cents)	Insurance (cents)	Taxes (cents)	Total Cost (cents)
Standard	12	5	7.5	2.1	1.7	28.3
Mid-Size	11	5	5.5	2.0	1.6	25.1
Compact	9	4	4.5	2.0	1.3	20.3
Sub Compact	7	4	4.0	2.0	1.0	18.0

Example:

To figure commuting cost, multiply number of miles (say 20) times cost for a mid-size car (Chevy Malibu)—

1. 20 x $.251 = $5.02

2. Add daily parking fee + $.50

3. Total daily cost $5.52

4. Multiply daily cost x number of school days per month (21) for total cost per month to drive alone ($115.92).

5. Divide this by the number of people in the carpool (say 4—). $115.92 divided by 4 = $28.98, cost per passenger in car pool.

6. Monthly savings, per person, is the difference in cost between driving individually and using the carpool. $115.92 - $28.98 = $86.94.

Note that more than money is saved. Energy use is reduced, and environmental damage is also less. Parking areas do not have to be so large and the atmosphere does not have to absorb so much heat and exhaust fumes.

Now have each student compute his own commuting costs, those of a parent, or those of the "typical worker" at a nearby industry. An answer sheet is provided.

STUDENT WORKSHEET NAME______________________________

Carpooling Cost Estimates

1. Multiply cost per mile x miles per day:

   __________x___________ = $____________

2. Add daily parking cost +____________

   Daily cost TOTAL:

3. Multiply daily cost
   by number of school (working)
   days per month x____________
   Lone driver's monthly cost TOTAL:

4. Divide monthly cost of driving
   alone by number of people
   in carpool ____________

5. New cost per person by
   carpooling =____________

6. Monthly carpool savings, #3 - #5

   $_________-$_________=$__________

7. What other differences (besides personal savings) might carpooling make in your life?

UP WITH PEOPLE POWER

SUBJECT Mathematics **LEVEL** 6 - 12

ACTIVITY IN BRIEF

Students will make the necessary measurements and calculations to determine the work and power expended in climbing stairs.

OBJECTIVE

Each student will be able to define personal energy expenditures to concepts of work and power.

MATERIALS

meter sticks
bathroom scales (metric preferred)
stopwatch, digital watch, or watch with second hand

TIME

class period

LEARNING CYCLE

AWARENESS - Ask students to name powerful machines, and machines which do large amounts of work. Define these terms. Discuss how both units are derived.

CONCEPT DEVELOPMENT - Use the exercise to make a calculation of both of these quantities.

APPLICATION - Discuss what advantages and disadvantages there are in using powerful machines. Are they efficient energy users?

EVALUATION - Have students define, work, power, joule and watt.

FOLLOW-UP/BACKGROUND INFORMATION

As students develop more power they will also produce more heat (wasted energy) which decreases the efficiency. This also happens in machinery, with an accompanying efficiency decrease.

Efficiencies	Car battery	73%
	Diesel engine	36%
	Car engine	26%
	Airplane	25%
	Steam locomotive	9%

Power decreases the amount of time for the task to be done, but the work accomplished is the same. The energy wasted in inefficiency is a factor that needs to be considered in doing some jobs.

SOURCE OF ACTIVITY

Adapted from I.D.E.A.S. by Dorothea Trost

ACTIVITY: Up With People Power

PROCEDURE:

1. Locate a stairway in your school or neighborhood where it is possible to climb two consecutive flights or one long flight without interruptions.
2. Taking turns with another student, climb these stairs slowly and steadily while your partner records stopping and starting times.
3. Calculate the total distance climbed by multiplying the height of the step (in centimeters or meters) by the total number of steps. Record this on the chart provided.
4. Measure or calculate each student's weight in newtons (9.8N = 2.2 lbs. 1 pound = 4.5N). Record this on your chart.
5. Climb the stairs again, as fast as possible this time. Have your partner record the time. Then do the same for your partner. (If either of you has a health problem, one can do the leg work for both of you.)
6. The same amount of work was done each time you climbed the stairs, because the amount of material (yourself) and the distance it moved were the same. But the <u>power</u> required was different; power has a time factor in it.

Calculate the power required each time you climbed the stairs.

$$\text{Power} = \frac{\text{wt. (N)} \times \text{distance (m)}}{\text{time (sec.)}}$$

Example: $\frac{637 \text{ N} \times 6 \text{ m}}{10 \text{ sec.}} = \frac{3822 \text{ N.m}}{10 \text{ sec.}} = 382.2$ N.m/sec. or 382.2 J/sec or 382.2 watts (unit of power)

Use your figures now:

1. Climbing stairs slowly......
2. Climbing stairs rapidly.....

Student Worksheet

Name ______________________

UP WITH PEOPLE POWER

Measurements & Calculations		Climbing Stairs: slowly	Climbing Stairs: rapidly
3. a.	height of one step (m)		
b.	number of steps climbed		
c.	total distance climbed (m)		
4.	weight of student (N)		
2.&5.	time required (sec.)		
6.	power required		

Use the back of this sheet for calculations if necessary. Put answers on the chart.

Compare the results (numbers) on the chart for climbing rapidly vs. climbing slowly. What do they tell you about energy, work and power?

Did you see or feel any difference between climbing slowly and climbing rapidly that does not show up on your chart?

SUM SUPER SLEUTH

SUBJECT Mathematics LEVEL 6 - 8

ACTIVITY IN BRIEF

Students will solve addition and missing addend to decode energy words relating to electricity.

OBJECTIVE

Students will be able to define terms associated with electrical energy.

MATERIALS	TIME
activity sheets	15 minutes

LEARNING CYCLE

AWARENESS - Students will do the puzzle

CONCEPT DEVELOPMENT - Have students find where these words are use, (i.e., on appliances, electric bills, news articles)

APPLICATION - Discuss with students how these words are used in determining electrical energy consumption or its cost to them as consumers.

EVALUATION - Have each student write the definitions of the terms in the exercise.

FOLLOW-UP/BACKGROUND INFORMATION

Follow this activity with an activity on calculating the cost of electrical energy.
i.e. "Cutting the Kilowatt"
"Chart Reading"
"Heir Conditioning"

SOURCE OF ACTIVITY

Adapted from U.S. Department of Energy, Science Activities in Energy by Dorothea Trost.

Sum Super Sleuth!

Each of the following 6 problems contains an energy word whose letters represent numerals. Each problem has a different number code. Find values for the letters and then determine the sum of those digits. Match that sum to find the correct definition below. Write each energy word next to its definition. Study examples #1 and #7.

1.
```
   7,298
  +VOLT
  16,234
```
8+9+3+6 = 24
VOLT

2.
```
   25,658
 +440,538
  BOILER
```
_____ = ___
BOILER

3.
```
   9,678,555
  +CURRENT
  14,600,723
```
_____ = ___
CURRENT

4.
```
  KILOWATT
  31,157,890
 109,522,045
```
_____ = ___
KILOWATT

5.
```
  93,482,046
  +RESERVE
  99,663,717
```
_____ = ___
RESERVE

6.
```
  4,126,689,075
  +SUBSTATION
  6,539,052,870
```
_____ = ___
SUBSTATION

7. VOLT (24) Units need to measure electromotive force.

8. ____ (39) 1000 watts; a measure of the rate of electricity usage.

9. ____ (28) a large vessel that contains many tubes in which water is heated to steam to drive a turbine.

10. ____ (30) an excess of capacity beyond actual load.

11. ____ (42) a facility which helps to transfer electricity from generator to consumer.

12. ____ (32) the flow of charged particles through a conductive material.

CHART READING

SUBJECT Mathematics LEVEL 9-12

ACTIVITY IN BRIEF

Students will learn to use the information found on appliances to compute the cost of operation.

OBJECTIVE

After analyzing the cost involved in appliance operation, each student will be able to state what is the best appliance buy for energy conservation and explain why it is.

MATERIALS	TIME
worksheet appliance catalog	60 minutes

LEARNING CYCLE

AWARENESS - Use the worksheet to familiarize students with the energy cost to operate various home appliances.

CONCEPT DEVELOPMENT - Use the appliance catalogs and have students look up the wattage rating for various brands of appliances.

APPLICATION - Using the average hours used per year, have students make a cost comparison of various brand appliances taking into consideration the purchase price, life expectancy and yearly operational cost. Have them determine the best appliance buy.

EVALUATION - Ask each student to state the best appliance buy and explain why.

FOLLOW-UP/BACKGROUND INFORMATION

Follow up activities: "Heir Conditioning"

SOURCE OF ACTIVITY

Science Activities in Energy, U.S. Dept of Energy; adapted by Dorothea Trost

Chart Reading

When you buy an appliance, the manufacturer has indicated the wattage needed to run this appliance. The utility company has estimated the average number of hours this appliance is used in one year by a customer. This information is needed to determine the number of kilowatt-hours an appliance is used. The formula for this is: $kwh = \frac{\text{watts x time (hours)}}{1000}$

To find the yearly cost of using an appliance: multiply kilowatt-hours x $.07.

For example: Clock

wattage = 2
average hours used per yr. = 8,760
$kwh = \frac{2 \times 8760}{1000} = \frac{17520}{1000} = 17$

Appliance	Average Wattage	Average Hours Used Per Year	Average kwh Used Per Year	Estimated Yearly Cost
Clock	2	8,760	17	$ 1.19
Clothes Dryer	4,856	204	991	$69.37
Iron	1,008	143	144	$10.08
Radio	71	1,211	86	$ 6.02
Window Air Conditioner	1,566	750	1,175	$82.25
Blender	386	39	15	$ 1.05
Coffee Maker	894	119	106	$ 7.42
Attic Fan	370	786	291	$ 20.37

Using the chart, answer the following:

1. Which of the appliances has the lowest (least) average wattage?
2. Find the appliance with the greatest yearly cost.
3. What appliance is used on the average of 119 hours per year?
4. One of the appliances uses 991 kilowatt-hours per year. Name this appliance.
5. Name the appliance that has an average wattage of 370.
6. Which appliance cost $10.08 to use for 1 year?
7. A toaster is used on the average 34 hours per year. Which appliance is used 5 more hours than the toaster?
8. Which appliance has an average wattage of 1,008?
9. Which appliance cost approximately $1.00 to use for 1 year?
10. Which appliance is used the most in 1 year?

Objective: Reading a chart.

IS FASTER BETTER?

SUBJECT Mathematics LEVEL 9 - 12

ACTIVITY IN BRIEF

Calculations are made to determine which is the best financial investment for a farmer; a 37.3 diesel tractor with a three blade plow share (50 hp) or a team of horses and single furrow mouldboard.

OBJECTIVE

Each student will be able to discuss critically the relative value of simpler vs. faster and larger systems.

MATERIALS

worksheet

TIME

50 minutes

LEARNING CYCLE

AWARENESS - Given the task of traveling from home to school, ask students to list all of their options. Which requires the least capital investment? Which takes longest? Which requires the least amount of energy expenditure?

CONCEPT DEVELOPMENT - Determine the operational costs of the two different systems; horse vs. tractor.

APPLICATION - Discuss what implications this cost comparison has economically for a farmer who is still getting the same price for his product as he was before farming became highly mechanized. What factors contribute to the loss of profit? Do these factors represent an energy problem? Does our modern system of tillage represent good energy economics?

EVALUATION - Ask each student to write a paper ciritically discussing each system.

FOLLOW-UP/BACKGROUND INFORMATION

Although the metric unit, the hectare, (ha.) is not in wide usage in the agricultural field, it is introduced here as a sciencific unit. The equipment used is of a smaller scale than most farming operations use today. Ask the students which expenses will increase and which will decrease. In light of those, is larger machinery better?

SOURCE OF ACTIVITY

Energy in Society, Ministry of Education, Ontario, Canada; adapted by Dorothea Trost

During the era of subsistence farming, the mouldboard single-furrow plow was usually pulled by a team of horses with a combined mass of 1500 kg and a man to direct the plow. Feed for the team of horses per day was 1 kg of oats and a similar amount of hay for each 100 kg of the horses mass. This consumption of energy allowed the farmer to plow a .3m furrow to a depth of .18m at a walking pace of 2.5 km/hr. Assume that the oats cost $100/t (ton) and that the hay cost $60/t.

In contrast, a 37.3 kw tractor with a three blade plowshare will cut a width of 1m to an .18m depth at a speed of 5km/hr. The fuel consumption varies with soil conditions. The suggested amount to use is 150L/ha of diesel fuel at a cost of 25 cents/L.

1. If each operator plows for 10 hours, find the cost per hectare for each type of operation.

2. Which is the cheaper method of tillage? Which method permits greater farmland productivity? Give your reasons.

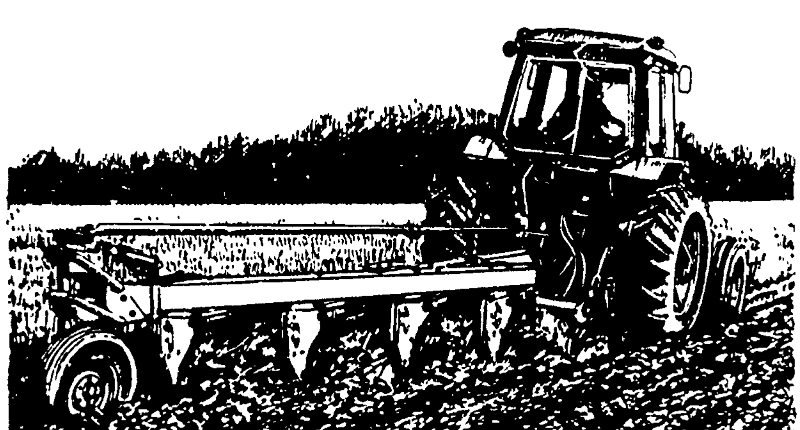
3. Which method of operation requires more energy per hectare? For energy conversion, use the following values:

   diesel fuel = 38.4 MJ/L (magajoule per liter)
   oats = 3 MJ/kg
   hay = 1.5 MJ/kg

4. When the horses are not working, they require only half the amount of oats and hay The capital investment of the two horses and plow is $800 for the team and $150 for the plow, plus the feed and care by the farmer. Assuming that the horses are not used for work during 6 months of the year, what is the total investment of the farmer using horses? Compare this to a farmer who has a capital investment of $10,000 in his diesel tractor and plow.

5. If each farmer pays a preferred rate of interest of 10% on a government loan for the capital investment and is permitted to depreciate the capital investment to zero at the rate of 20% a year, which farmer is better off financially?

NOTE: Livestock cannot be depreciated; when sold, they may be claimed as a capital investment and are not taxable.



ENERGY IN, ENERGY OUT

SUBJECT Mathematics **LEVEL** 9 - 12

ACTIVITY IN BRIEF

A cost of operation comparison is done for various types of farming operations performed in producing grain.

OBJECTIVE

Each student will be able to identify what the energy consuming operations are in growing crops and compare energy costs for alternative farming methods and devise a method of production which would be more economical and better ecologically.

MATERIALS

Fuel Required for Field Operations
(Information from Iowa State University Cooperative Extension Service.)

TIME

class period

LEARNING CYCLE

AWARENESS - Students are asked to compile a list of energy consuming operations in grain farming. They will develop an operating plan and compute their costs for a particular crop.

CONCEPT DEVELOPMENT - Present the students with information concerning alternative farming methods.

APPLICATION - Ask students to develop a second method of production which would be more economical and better ecologically.

EVALUATION - Ask each student to submit a production plan, identify its energy costs and explain its economical and ecological advantages.

SOURCE OF ACTIVITY

Developed by Dorothea Trost.

IMPLEMENTING THE ACTIVITY

1. Have students compile a list of the energy costs in a grain farming operation.

2. Have students outline the steps in planting, cultivation and harvesting a particular crop. If their family farms, have them use their current method of operation, otherwise have them outline a conventional method. Have them compute the amount of fuel that is consumed to carry out their proposed plan.

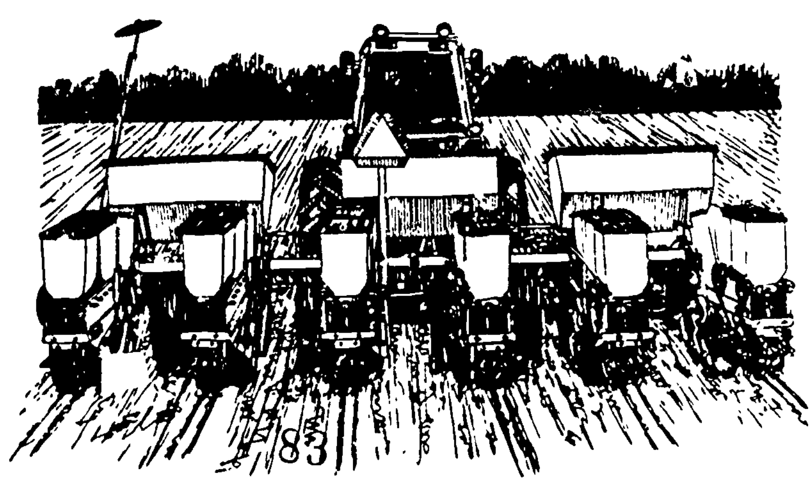
3. Present students with the following information concerning alternative tillage practices.

   The moldboard plow, which has been used over the centuries to break, aerate, and prepare the seed bed for planting, also made the soil more permeable for water absorption and reduced the competition by weeds for soil nutrients. Farmers have come to recognize this "conventional" method of plowing, discing and harrowing as the best way of preparing the seed bed.

   Recently, this method of tillage has been questioned by agrologists. With the advent of selective herbicides, it is no longer necessary to destroy weeds by the conventional methods. Agricultural research is experimenting with a "no tillage", "spray plant" system. It is an energy-saver in labor, time, fuel and the cost of machinery. Smaller machinery with a low power demand that may use from one-half to two-thirds less diesel fuel is designed to break the soil with a coulter disc; this followed by two other discs which break the soil, incorporate fertilizer and seed all in one operation. The only additional operation needed is herbicide treatment for weed control.

   The spray plant system has several advantages in addition to the already mentioned economic ones. Farmers can plant their seed at the optimum time with respect to soil and climatic conditions. The existing porosity of the soil, which is brought about by previous plant roots and earth worm activity, is not destroyed. The plant residue of the previous crop acts as a surface mulch to prevent erosion and aids in water retention. Crop productivity can equal crops produced by using conventional tillage methods.

4. Have students develop an alternative method of production which would be more economical and better ecologically. Compute the cost of production using the alternative plan.



Machinery Management Series

FUEL REQUIRED FOR FIELD OPERATIONS

The table below contains estimates of the **average** quantity of gasoline or diesel fuel required for field operations. The estimates include only the fuel required for actual field work. No allowance is included for machine preparation or travel to and from the field. Because fuel consumption values for any particular operation vary between tractors, soil type, etc., actual fuel requirements may be as much as 35 percent higher or lower than the values listed in the table.

Fuel requirements for tillage machines were calculated for a central Iowa loam soil. If your soil is heavier, the values in the table should be increased slightly. Values were calculated for a 7-inch plowing depth and 4 to 5-inch operating depth for other tillage machines. Field speeds were assumed to be 4 to 5 mph for all tillage operations, 5 mph for planting and spraying, 4 to 5 mph for forage harvesting machines, and 2.5 mph for corn and soybean harvesting.

The values for row-crop operations were calculated for 30-inch rows. They should be adjusted for other row widths. All values were calculated assuming efficient materials handling in the field, proper tractor ballasting to keep wheel slippage below 15 percent, properly tuned and adjusted tractor engines, and part-load tractor operation efficiency by shifting up a gear and throttling the engine back.

Approximate Fuel Required for Field Operations, in Gallons Per Acre.

Field Operation	Fuel Type	
	Gasoline	**Diesel**
FERTILIZATION		
Spreading dry fertilizer, bulk cart	0.20	0.15
Anhydrous ammonia (30-inch spacing)	0.80	0.60
TILLAGE		
Shredding cornstalks	0.70	0.50
Moldboard plow	2.70	1.90
Chisel plow	1.70	1.20
Offset disk	1.35	0.95
Powered rotary tiller	2.30	1.60
Tandem disk, plowed field	1.00	0.70
Tandem disk, tilled field	0.85	0.60
Tandem disk, cornstalks	0.70	0.50
Field cultivate, plowed field	1.15	0.80
Field cultivate, tilled field	1.00	0.70
Spring-tooth harrow, plowed field	1.00	0.70
Spring-tooth harrow, tilled field	0.85	0.60
Peg-tooth harrow, tilled field	0.45	0.30
PLANTING (30-inch rows)		
Planter, seed only, tilled seedbed	0.65	0.45
Planter with fertilizer and pesticide attachments, tilled seedbed	0.85	0.60
Till-planter (sweep)	0.85	0.60
No-till planter (fluted coulter)	0.70	0.50
Harrow-plant combination	1.30	0.90
Rotary strip till-plant	1.50	1.05
Grain drill	0.50	0.35
Broadcast seeder	0.20	0.15

(Table continued on back)

Prepared by George E. Ayres, extension agricultural engineer

Cooperative Extension Service
IOWA STATE UNIVERSITY
Ames, Iowa 50011

Pm-709
November 1976

Approximate fuel required for field operations, in gallons per acre (continued)

Field Operation	Fuel Type Gasoline	Fuel Type Diesel
WEED CONTROL (30-inch rows)		
Sprayer, trailer type	0 15	0 10
Rotary hoe	0 30	0 20
Sweep cultivator	0 65	0 45
Rolling cultivator	0 60	0 40
Cultivator with disk hillers	0.65	0.45
Powered rotary cultivator	1.00	0 70
HARVESTING		
Cutterbar mower	0 55	0 35
Mower-conditioner, PTO	0 85	0 60
Self-propelled windrower	0 70	0 50
Rake	0 35	0.25
Baler	0 65	0 45
Stack-forming wagon	0.70	0.50
Forage harvester		
Green forage	1.35	0.95
Haylage	1 80	1.25
Corn Silage	5 20	3 60
High-moisture ground ear corn	2.75	1.90
Forage blower		
Green forage	0 50	0 35
Haylage	0 35	0 25
Corn silage	2 00	1 40
High-moisture ground ear corn	0 65	0 45
Combine, soybeans	1 70	1 10
Combine, corn	2 35	1 60
Corn picker	1 75	1 15
Grain drying, corn	10 90	7 50
Hauling, field plus ½ mile on graveled road		
Green forage	0 55	0 35
Haylage	0 30	0 20
Corn silage	2 00	1 40
Corn grain	0 30	0 20
Soybeans	0 12	0 08
Hauling, add following values to those above for each additional mile on gravel		
Green forage	0 20	0 14
Haylage	0 30	0.20
Corn silage	1 30	0 90
Corn grain	0 20	0 15
Soybeans	0 07	0 05

File: Engineering 3-2

Cooperative Extension Service Iowa State University of Science and Technology and the United States Department of Agriculture cooperating Charles E Donhowe director Ames Iowa Distributed in furtherance of the Acts of Congress of May 8 and June 30 1914

CUTTING THE KILOWATT

SUBJECT Mathematics LEVEL 6 - 12

ACTIVITY IN BRIEF

Students investigate home electrical consumption and costs.

OBJECTIVE

Each student will be able to:

- Calculate costs of operating various appliances per specified time period.
- List appliances which can be operated on a fixed "electrical budget".

MATERIALS

local electrical bills
copies of "Energy Consumption In The Home"

TIME

2 class periods

LEARNING CYCLE

AWARENESS - 1. Students bring home electric bills. 2. Students estimate consumption of household appliances.

CONCEPT DEVELOPMENT - 1. Define KWH 2. Calculate actual consumption of household appliances.

APPLICATION - Students construct a list of appliances which will be affordable on a fixed energy budget.

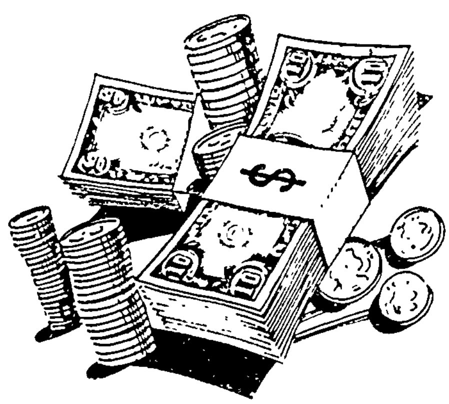
EVALUATION - Have each student demonstrate their ability to calculate the operating cost of an appliance, and list appliances which could be used with a specified energy budget.

SOURCE OF ACTIVITY

E.M.E./National Energy Foundation; adapted by Sue Marzinske

ACTIVITY

1. Students will bring in examples of home electrical bills.
2. After examining the bills, have the students list home appliances which use electricity.
3. Rank the appliances listed according to the student's estimate of amount of electrical consumption. (Or estimate the percent of total bill for each appliance.)
4. Define KWH.
5. Distribute "energy consumption" charts.
6. Work several examples of calculating appliance costs per month and per year.
7. Have students calculate the costs of several major appliances and compare the costs with their estimates in step #3.
8. Students will construct a list of desired appliances they can "afford" to use if given an electrical energy budget of $_____ per month.



ENERGY CONSUMPTION IN THE HOME

	Annual Energy Consumption (KWH)
AIR CONDITIONER	860
CAN OPENER	0.3
CLOCK	17
CLOTHES DRYER	993
COFFEE MAKER	140
DISHWASHER	363
ELECTRIC BLANKET	147
FAN (VENTILATION)	291
FAN (FURNACE)	650
FLUORESCENT LIGHT (THREE FIXTURES)	260
FOOD FREEZER, AUTOMATIC DEFROST, 16.5 CUBIC FEET	1,820
FOOD FREEZER, MANUAL DEFROST, 16 CUBIC FEET	1,190
FOOD MIXER	2
FOOD WASTE DISPOSER	7
FRYING PAN	100
HAIR DRYER	25
HOT PLATE (TWO BURNER)	90
IRON	60
LIGHT BULBS	1,870
RADIO	86
RADIO/PHONOGRAPH	109
RANGE WITH OVEN	700
REFRIGERATOR (FROST FREE, 17.5 CUBIC FEET)	2,250
SEWING MACHINE	11
SHAVER	0.5

TELEVISION (BLACK AND WHITE)	100
TELEVISION (COLOR)	320
TOASTER	39
VACUUM CLEANER	46
WASHER (AUTOMATIC)	103

Multiply the annual energy consumption (KWH) by the cost per KWH in your area to determine the annual cost of energy consumed.

ENERGY FIGURES

SUBJECT Mathematics LEVEL 6 - 12

ACTIVITY IN BRIEF

Students will do problems involving percentages.

OBJECTIVE

Each student will be able to list three major forms of energy they use, describe the work done with it and predict ways the amount consumed can be reduced.

MATERIALS

worksheets

TIME

class period

LEARNING CYCLE

AWARENESS - Discuss with students the use of percentages in everyday experiences.

CONCEPT DEVELOPMENT - Use the problems as drill work in solving problems involving percentages.

APPLICATION - Discuss with students the various forms of energy used, what work was accomplished and the various ways the energy used could be reduced.

EVALUATION - Have each student list three major forms of energy, describe work which can be done with each form, and list ways of conserving each form.

FOLLOW-UP/BACKGROUND INFORMATION

SOURCE OF ACTIVITY

Adapted from Science Activities in Energy, U.S. Dept. of Energy by Dorothea Trost

TITLE: Energy Figures

1. Mrs. Grey drives her car an average of 200 miles per week and uses 20 gallons of gasoline. She wants an auto that will travel the same distance but use 20% less fuel. How much fuel will she then use per week?

2. A car uses 100% more gasoline than a motorcycle. If the motorcycle travels 100 miles and uses two gallons. of gasoline, how much would the car use to travel the same distance? (Hint: 2 gallons represents 100% for the motorcycle.)

3. After having a motor tune up on her car, Mrs. Hatch's mpg (miles per gallon) increased from 15 to 18. What was the percent of the increase?

4. Miss Redlin drives her car 20 miles per day to work. In the winter, because of the ice and snow, her mpg decreases from 18 to 14. What is the percent of decrease?

5. During the year Mr. & Mrs. James' light and gas bill increased 15%. If the average cost prior to the increase was $60 per month, how much do they pay after the increase?

6. The cost of a barrel of imported crude oil in 1974 was 300% of the cost of a barrel of imported crude oil in 1973. If a barrel of imported crude oil cost $12.52 in 1974, what was the cost of a barrel of oil in 1973? (Hint: 1973 cost = 100%)

7. Emission control standards for cars manufactured since 1970 require that carbon monoxide (CO) in exhaust fumes should not exceed 4%. A recent test of a 1974 car indicated that 150,000 cubic centimeters (cm^3) of an exhaust sample contained 7,000 cubic centimeters of CO.

    a. Determine how many cubic centimeters of CO equals 4%.

    b. Determine how many cubic centimeters the CO must be reduced to meet the 4% requirement.

8. A drop in speed from 70 mph to 50 mph increases the gasoline mileage by 20%. If your car can average 25 mpg at 70 mph, what mileage will your car get if you drive at 50 mph?

9. To conserve energy, Mr. Beamer has decided to install a solar heating system in his home. The cost, excluding taxes and finance charge, is $5000. This installation will reduce his utility bill 60%. Presently his utility bill averages $700 per year.

    a. How much money will be saved yearly after the installation?

    b. If the federal government provides a tax credit of 40% on the first $1000 and 25% on the principal balance, what is the total tax credit provided by the government on the $5000 system?

    c. How long will it take the savings in the utility bill to pay for Mr. Beamer's reduced cost of $3600? (Assume the average utility bill will remain constant.)