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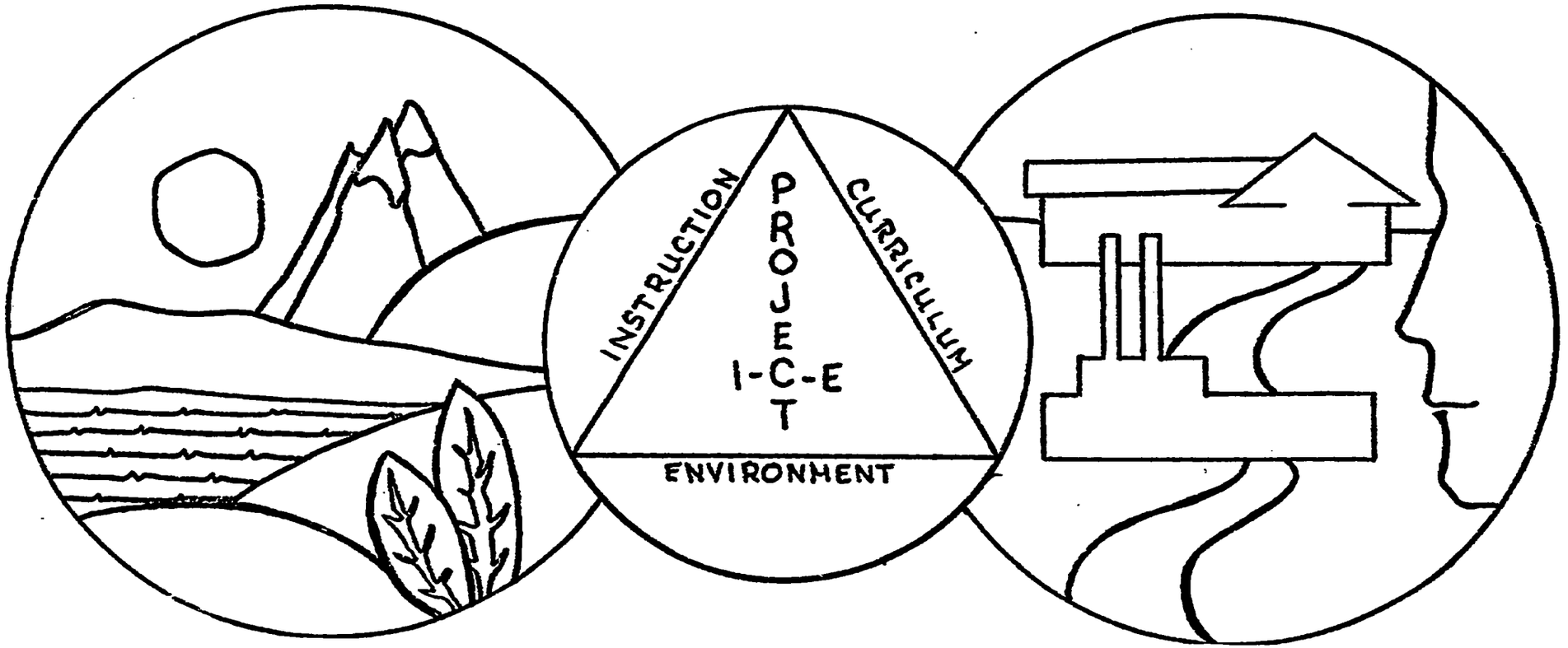
ABSTRACT

This mathematics guide, for use in grades 9-12, is one of a series of guides, K-12, that were developed by teachers to help introduce environmental education into the total curriculum. Since the nature of mathematics is abstract, students do not learn mathematics from ecology, nor ecology from mathematics. But, by observation and manipulation of environmental data, the students may inductively discover a principle in mathematics which can be reached deductively. The purpose of this booklet is to make an attempt to bridge mathematics and ecology. The guide is a supplementary handbook of ecologically-oriented mathematics exercises, designed to be self-contained and complete with answers. The exercises are built around 12 major environmental concepts that form a framework for each grade or subject area, as well as for the entire K-12 program. The problems and exercises are designed to be integrated into algebra, geometry, advanced algebra, probability, statistics, trigonometry, and analysis. Each lesson deals with a mathematical concept and its applications to an environmental problem. Further, each lesson offers subject area integration, subject area activities, interdisciplinary activities, cognitive and affective behavioral objectives, and suggested references and resource materials. (Author/TK)

ENVIRONMENTAL EDUCATION GUIDE



MATHEMATICS 9-12

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FORWARD TO PROJECT I-C-E ENVIRONMENTAL EDUCATION GUIDES

In 1969, the First Environmental Quality Education Act was proposed in the United States Congress. At the time of the introduction of that legislation, I stated:

"There is a dire need to improve the understanding by Americans of the ominous deterioration of the Nation's environment and the increasing threat of irreversible ecological catastrophe. We must all become stewards for the preservation of life on our resource-deficient planet."

In the three years since the Environmental Education Act was passed by the Congress, much has happened in the United States to reinforce the great need for effective environmental education for the Nation's young people. The intensive concern over adequate energy resources, the continuing degradation of our air and water, and the discussion over the economic costs of the war against pollution have all brought the question of the environmental quality of this nation to a concern not merely of aesthetics but of the survival of the human race.

The intense interest by the public in the quality of our lives as affected by the environment clearly indicates that we cannot just use incentives and prescriptions to industry and other sources of pollution. That is necessary, but not sufficient." The race between education and catastrophe can be won by education if we marshall our resources in a systematic manner and squarely confront the long-term approach to saving our environment through the process of education.

As the incessant conqueror of nature, we must reexamine our place and role. Our world is no longer an endless frontier. We constantly are feeling the backlash from many of our ill-conceived efforts to achieve progress.

Rachel Carson's theme of "reverence for life" is becoming less mystical and of more substance as our eyes are opened to much of the havoc we have wrought under the guise of progress. A strong commitment to an all-embracing program of environmental education will help us to find that new working definition of progress that is a pre-requisite to the continued presence of life on this planet.

- Senator Gaylord Nelson

MATHEMATICS PREFACE

This is a supplementary handbook of ecologically-oriented mathematics exercises, designed to be self-contained and complete with answers. They are indexed by mathematics area and major mathematical concept and cross-indexed by environmental concepts. Each lesson deals with a mathematical concept and its applications to an environmental problem. The material in this booklet has been written and revised by mathematics teachers for use by mathematics teachers. The problems and exercises in this handbook are designed to be integrated into Algebra, Geometry, Advanced Algebra, Probability, Statistics, Trigonometry and Analysis. These lessons are a beginning--perhaps you can contribute others.

Since the nature of mathematics is abstract, students do not learn mathematics from ecology, nor ecology from mathematics. But, by observation and manipulation of environmental data, the student may inductively discover a principle in math, which can be readied deductively. Also, by using environmental data, the student can exercise learned math skills.

Thus, there is a need to bring ecology into math, and math into ecology. The purpose of this booklet is to make an attempt to bridge that gap for the high school math student. We hope you will find them useful and worthwhile in teaching some of the important ecological ideas to our young people. It is these young people, after all, who will pay a major role in the saving of our environment.

YOUR TASK AND RESPONSIBILITY IS TO USE THESE EXERCISES WHEREVER THEY MIGHT APPLY!

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DIRECTIONS FOR USING THIS GUIDE

This guide contains a series of episodes (mini-lesson plans), each containing a number of suggested in and out of class learning activities. The episodes are built around 12 major environmental concepts that form a framework for each grade or subject area, as well as for the entire K-12 program. Further, each episode offers subject area integration, multi-disciplinary activities, where applicable, both cognitive and affective behavioral objectives and suggested reference and resource materials useful to the teacher and students.

1. This I-C-E guide is supplementary in design--it is not a complete course of study, nor is its arrangement sequential. You can teach environmentally within the context of your course of study or units by integrating the many ideas and activities suggested.

2. The suggested learning activities are departures from regular text or curriculum programs, while providing for skill development.

3. You decide when any concepts, objectives, activities and resources can conveniently be included in your unit.

4. All episodes can be adapted, modified, or expanded thereby providing great flexibility for any teaching situation.

5. While each grade level or subject area has its own topic or unit emphasis, inter-grade coordination or subject area articulation to avoid duplication and overlap is highly recommended for any school or district seeking effective implementation.

This total K-12 environmental education series is the product of 235 classroom teachers from Northeastern Wisconsin. They created, used, revised and edited these guides over a period of four years. To this first step in the 1,000 mile journey of human survival, we invite you to take the second step--by using this guide and by adding your own inspirations along the way.

PROJECT I-C-E TWELVE MAJOR ENVIRONMENTAL CONCEPTS

1. The sun is the basic source of energy on earth. Transformation of sun energy to other energy forms (often begun by plant photosynthesis) provides food, fuel and power for life systems and machines.

2. All living organisms interact among themselves and their environment, forming an intricate unit called an ecosystem.

3. Environmental factors are limiting on the numbers of organisms living within their influence. Thus, each ecosystem has a carrying capacity.

4. An adequate supply of clean water is essential to life.

5. An adequate supply of clean air is essential for life.

6. The distribution of natural resources and the interaction of physical environmental factors greatly affect the quality of life.

7. Factors such as facilitating transportation, economic conditions, population growth and increased leisure time influence changes in land use and population densities.

8. Cultural, economic, social, and political factors determine man's values and attitudes toward his environment.

9. Man has the ability to manage, manipulate and change his environment.

10. Short-term economic gains may produce long-term environmental losses.

11. Individual acts, duplicated or compounded, produce significant environmental alterations over time.

12. Each person must exercise stewardship of the earth for the benefit of mankind.

A "Concept Rationale" booklet and a slide/tape program "Man Needs His Environment" are available from the I-C-E RMC to more fully explain these concepts.

CROSS REFERENCE OF MATH CONCEPTS TO ENVIRONMENTAL CONCEPTS

E. S. E. A. Title III – PROJECT I–C–E 59–70–0135–4

Environmental:

Integrated with:

CONCEPT NO. 8 - Values and Attitudes

SUBJECT Algebra

ORIENTATION Recycling

TOPIC/UNIT Coordinate Graphing - Alg. 1

BEHAVIORAL OBJECTIVES

Cognitive:

Determine points or positions in two dimensions using the principles of coordinate geometry.

Determine that locating positions can be conducted on a small scale, like locating a point or on a large scale like describing a position of a star.

Affective:

Use the principles of coordinate geometry to determine areas of land that could be used for other purposes if the the recyclable material had been recycled instead of placed in the landfill, for a given landfill area.

Skills Used:

1. Locating points on coordinate axes.
2. Using positive and negative numbers.

STUDENT–CENTERED LEARNING ACTIVITIES

In-Class:

A. Class review:
   1. Define a point and plane.
   2. On a plane, draw the horizontal line or x-axis and a vertical line which is the y-axis. Review the idea of positive and negative integers in reference to the two axes. Select two integers and plot this point to paper (graph paper preferred) in reference to the two axes.

   Note 1: The two axes intersect at a point called the origin.

   Note 2: The two numbers selected are called ordered pairs.

B. See Worksheet Alg. 1-B.

Outside or Community:

A. Take a field trip to the sanitary landfill in your community. Discuss the effect of recycling for the items observed in the landfill site. (The relationship of the idea with the student activity is that the answer for Part B is a can.)

B. The city's sanitation engineer can give a talk to the class on the landfill sites in the area, recycling in the community and other related topics.

SUGGESTED RESOURCES	CONTINUED OR ADDED LEARNING ACTIVITIES
Publications: Pollution: Problems, Projects, and Mathematical Exercise, Wisconsin Department of Public Instruction, ICE RMC, 110 Ka **Audio--Visual:** Films: Geometry in Action, BAVI What Are We Doing To Our World?, BAVI Garbage, King Screen Productions, ICE RMC, Film #260 **Community:** Sanitation engineer for your community Visit to community landfill site	

Worksheet Alg. 1-B

In the following problems, plot the pairs on graph paper and connect the points in order.

1)

1.	(-4, -5)	12.	(4, 0)	23.	(-4, 6)
2.	(-3.5, -5.5)	13.	(4, 6)	24.	(-3.5, 5.5)
3.	(-3, -5.8)	14.	(3.5, 6.5)	25.	(-3, 5.2)
4.	(-2.5, -5.9)	15.	(3, 6.8)	26.	(-2.5, 5.1)
5.	(-2, -6)	16.	(2.5, 6.9)	27.	(-2, 5)
6.	(0, -6)	17.	(2, 7)	28.	(2, 5)
7.	(2, -6)	18.	(0, 7)	29.	(2.5, 5.1)
8.	(2.5, -5.9)	19.	(-2, 7)	30.	(3, 5.2)
9.	(3, -5.8)	20.	(-2.5, 6.9)	31.	(4, 6)
10.	(3.5, -5.5)	21.	(-3, 6.8)	32.	(3.5, 5.5)
11.	(4, -5)	22.	(-3.5, 6.5)		

Connect (-4, 6) and (-4, -5).
What polluting article does this represent?

2)

1. (-5, -4)
2. (0, -4)
3. (3, -3)
4. (3, 1)
5. (1.7, 3)
6. (1.7, 4)
7. (-3.3, 4)
8. (-3.3, 3)
9. (-5, 0)
10. (0, 0)
11. (1.7, 3)
12. (-3.3, 3)

Connect (0, 0) and (3, 1)
Connect (0, 0) and (0, -4)
Connect (-5, 0) and (-5, -4)
Name the object.

Answers to Alg. 1-B

1. Right circular cylinder (can)

2. Milk carton

E. S. E. A. Title III – PROJECT I–C–E 59–70–0135–4

Environmental:

Integrated with:

CONCEPT NO. 1 - Energy

SUBJECT Algebra

ORIENTATION Energy

TOPIC/UNIT Problem Solving - Alg. 2

BEHAVIORAL OBJECTIVES

Cognitive:

Calculate the amount of energy required to raise the temperature of a given substance from one given temperature to another.

Evaluate several ways of storing the sun's energy.

Affective:

Discover the vital functions of the sun.

Use the results of his calculations of energy to support the fact that the sun is the most important source of energy.

Skills Used:

1. Problem solving.
2. Formula computation.

STUDENT–CENTERED LEARNING ACTIVITIES

In-Class:

A. Worksheet Alg. 2-A on problem solving--heat and energy.

B. List, discuss and evaluate the ways the sun's energy can be stored for later use. (i.e. fossil fuels)

C. Demonstrate how 23° tilt diminishes the sun's effect on the environment, causing seasons. (See Problem 1 on worksheet.)

Outside or Community:

A. Do you know where the sun rises and sets? Do Project I-5, pages 17 and 18 of Measure and Find Out, Book 3. (available at ICE RMC.) You may then be the only person in your neighborhood who knows where the sun rises and sets!

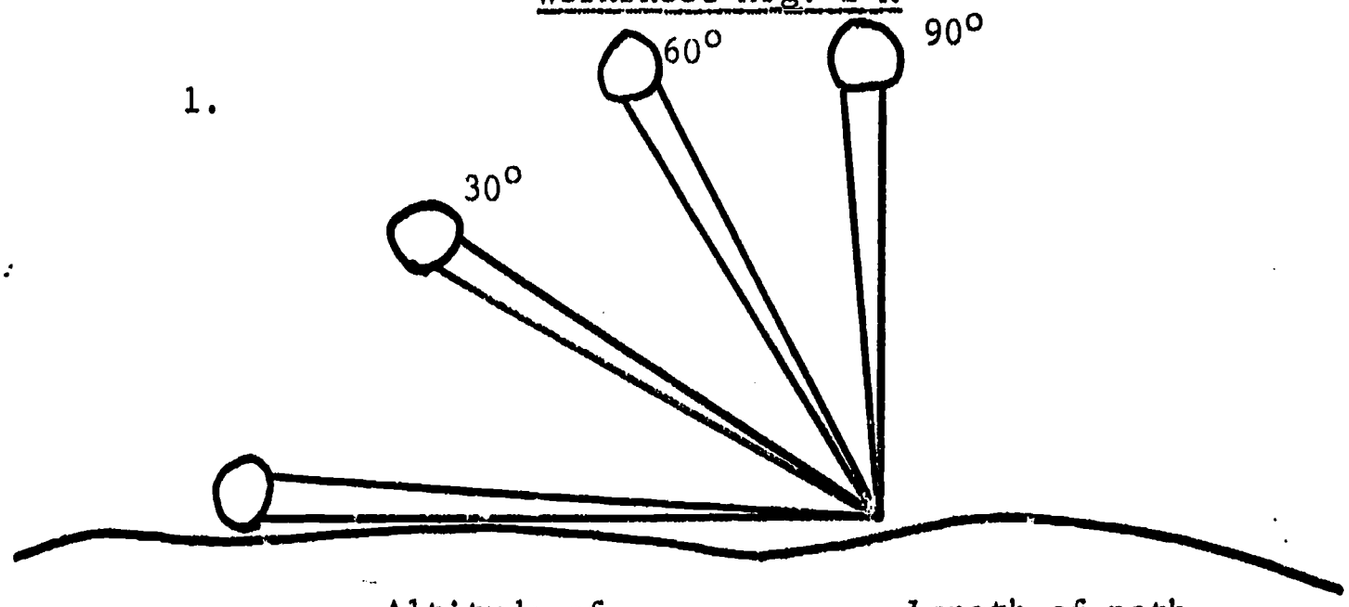
B. Visit the U.S. Weather Bureau. Have a meteorologist explain the sun's influence on weather patterns.

C. Visit the telephone company for an explanation of the operation and use of photoelectric cells.

SUGGESTED RESOURCES	CONTINUED OR ADDED LEARNING ACTIVITIES
Publications: Measure and Find Out, Book 3, Swertz and Gallant, ICE RMC Population, Resources, Environment, Ehrlich & Ehrlich, W. H. Freeman & Co., ICE RMC, 165 Eh The World of Life, Branley, Pella, and Urban, Ginn & Co., 1968 Physical Science, A Modern Approach, Bickel, Eigenfeld and Hogg, American Book Co., 1970 **Audio-Visual:** Films: Sun's Energy, BAVI Sun: Friend or Foe?, BAVI **Community:** Meteorologist	

Worksheet Alg. 2-A

1.



Altitude of sun in degrees	Length of path of sun's rays
90°	1.00
60°	1.15
30°	2.00
10°	5.70
0°	44.70

The path of sunlight through the atmosphere is almost forty-five times as long when the sun is on the horizon as when it is directly overhead. The above table shows the length of the path changes with latitude.

A. What is the highest elevation of the sun at 44 1/2° latitude? Follow these directions: Subtract your latitude from 90° (this is your colatitude). Now add 23 1/2 to the colatitude. This is the highest elevation the sun will attain where you are.

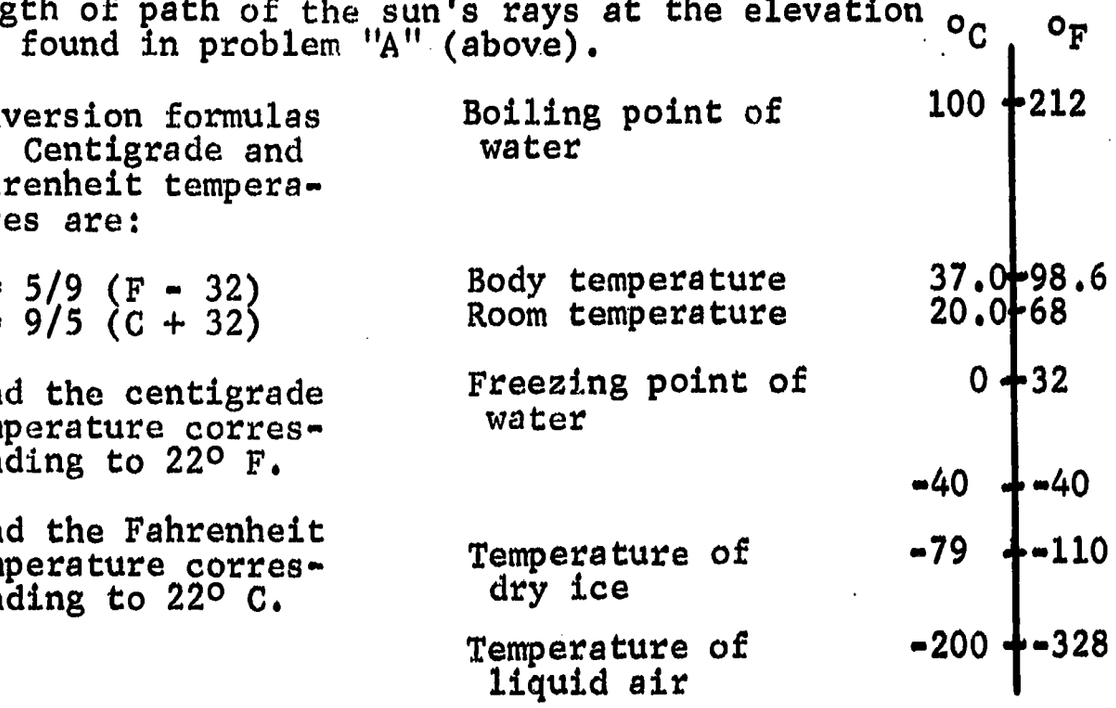
B. Use interpolation on the above table to find the length of path of the sun's rays at the elevation you found in problem "A" (above).

2. Conversion formulas for Centigrade and Fahrenheit temperatures are:

$C = 5/9\ (F - 32)$
$F = 9/5\ (C + 32)$

A. Find the centigrade temperature corresponding to 22° F.

B. Find the Fahrenheit temperature corresponding to 22° C.



Worksheet Alg. 2-A (Continued)

3. The amount of heat needed to raise the temperature of a given amount of water can be computed by multiplying the mass by the rise in temperature. In formula form:
Heat in BTU's = (Mass of water in pounds) x (Temp. change in F)

   A. How much heat is needed to raise the temperature of 12 pounds of water from 60^{o} to 212^{o} F?

   B. Compute the initial temperature of 200 pounds of water raised to a temperature of 100^{o} F if 2,000 BTU's of heat are put into it.

4. The specific heat of a substance is the number of calories required to raise one gram of the substance through one C^{o}, on the number of BTU's to raise one pound of the substance through one F^{o}.

   The specific heats of some common substances are listed in the following table:

Water	1.00
Alcohol	0.55
Ice	0.50
Aluminum	0.22
Iron	0.11
Lead	0.031

   Heat put into a body equals mass of body x specific heat x rise in temperature. Or in symbols, $H = m \times s \times (t_2 - t_1)$

   Compute the heat needed to raise the temperature of 0.31 gm. of aluminum wire from $20^{o}C$ to $300^{o}C$.

Answers to Alg. 2-A

1. A. 69°
   B. 1.105
2. A. -5.6°C
   B. 72°F
3. A. 1800 BTU's
   B. 90°F
4. 19.1 calories

E. S. E. A. Title III – PROJECT I–C–E 59–70–0135–4

Environmental:

Integrated with:

CONCEPT NO. 7 - Land Use

SUBJECT Geometry

ORIENTATION Land Use

TOPIC/UNIT Measurement - Area & Perimeter - Geom. 1

BEHAVIORAL OBJECTIVES

Cognitive:

Measure the length of given objects or land area.

Calculate the perimeter; area of a given land area.

Make estimations of distances and areas based on observations of the land or object.

Affective:

Generalize the types and percentages of physical uses of space in his environment.

Skills Used:

1. Measurement.
2. Computations involving perimeters and areas.

STUDENT–CENTERED LEARNING ACTIVITIES

In-Class:

A. Complete indoor and outdoor activities to Worksheet Geom 1-A.

B. Complete calculations to data gathered from community activity B - Geom 1-B Worksheet.

Outside or Community:

A. Complete outdoor activities to Worksheet Geom 1-A.

B. Worksheet Geom 1-B, if not used in class.

SUGGESTED RESOURCES	CONTINUED OR ADDED LEARNING ACTIVITIES
Publications: Discovering Your Environment, Jones and Swan Audio-Visual: Films: The Green City, ICE RMC, Film #440 Harmony, ICE RMC, Film #340 Community:	

Worksheet Geom. 1-A

DISCOVERING YOUR ENVIRONMENT

Area, Perimeter, and Shape

Objects and areas found in the classroom and outdoors can be used to apply some of the mathematical knowledge and skills you have developed. You should remember that perimeter is the distance around an object, area refers to the size of the surface and shape is defined as a square, circle, rectangle, etc.

Observations and Problems

INDOORS

1. Estimate in feet the perimeter of the classroom. _____ Use a yardstick to measure the perimeter_____Compare the results. Which was larger?

   _____

   Using the information acquired in measuring the classroom, what is the area of the classroom? _____
2. Locate the north and east walls in the classroom. Which of the walls do you think has the greater area? _____
   Use a yardstick to measure both walls and compare your finding with your estimate.
3. Outside the classroom door is a hallway. Estimate in feet the length and width of the hallway. Length_____ Width_____
   Use a yardstick to measure in feet the length and width of the hallway. Length_____
   Width _____
   Compare your estimation and your actual measurement. What is the percentage of error between your estimated length of the hallway and the measured length of the hallway?_____ (To find percentage of error, divide your error by the measured distance and multiply by 100.)

OUTDOORS

1. If you could look at your school building from an airplane, what shape do you think it would be?

   _____
2. Estimate in feet the perimeter of the school building_____
   Measure the perimeter of the school building using feet as the standard unit of measure _____What is the difference between your estimation and the actual measurement? _____
   What is the percentage of error? _____
3. What is the shape of the school ground?_____What is the area contained in the school ground?

   _____
4. Locate the west wall of the school building. Estimate the length and height of the wall and compute the area contained in the wall_____
5. An acre is a measure of land and contains 43,560 square feet. (A parcel of land 208.75 feet on each side is an acre.)
   Using the above information, what would you estimate to be the number of acres in the school ground?_____Note: Ask your principal to check the school architect's building plans so you can compare your answer with the actual size of the school ground.

Going the Next Step

1. Volume refers to the capacity of a given object or area, or to the space occupied by it. The mathematical formula for finding volume is length x width x height. Using this formula and the data you secured in working the above problems, compute the volume of the classroom, hallway, and school building.
2. Using your home as the object to measure, try these same exercises.

Worksheet Geom. 1-B

DISCOVERING YOUR ENVIRONMENT

School Parking Lot

Because few people walk from home to their place of work, there is an increasing need for automobile parking space. Providing ample parking space for everyone is expensive to the employer. But he must do this if he is to keep his employees. Schools must also set aside areas on the school ground to be used for parking. This limits the space available for play and for educational purposes.

Observations and Problems

1. Describe the composition of the materials used in the parking lot_____
2. Is the parking lot level?____ What evidence can you find to support your answer?_____
3. What kinds of plant or animal life do you find in the parking lot?_____
4. Is the parking lot affected by weathering?_____ If yes, describe the evidence you find to support your answer._____
5. In addition to providing space for parking cars, is the parking lot area used for other purposes?_____If yes, how is it used? _____
6. Estimate in feet the length and width of the parking lot. Width_____ Length_____
7. Use yardsticks or measuring tapes to measure the length and width of the parking lot. Length_____ Width_____ Width:_____Compare the results with your estimations.
8. What is the number of square feet contained in the parking lot? (Multiply length x width). _____
9. How many linear feet are contained in the perimeter of the parking lot?_____
10. If the average-size parking space is 9 feet wide and 24 feet long (this provides enough space for the cars to back up and drive out), what is the maximum numbers of cars that can park in the parking lot?_____
11. Materials used in parking lots are usually purchased in quantities of cubic yards. A cubic yard of material will cover an area that is 9 feet wide, 9 feet long, and 4 inches deep. Using this information, find the answers to the following questions: If blacktopping costs $9.75 per cubic yard, how much would the school have paid for the materials in the parking lot?_____ If concrete costs $15.50 per cubic yard, how much would the school have paid for the materials in the parking lot?_____

Going the Next Step

1. If you had planned the school site, would you have located the parking lot in the same spot on the school ground? If not, where would you have placed it? Give reasons for your decision.
2. Should the school provide free parking space, or should each person be expected to pay a parking fee to be used in providing and maintaining parking facilities?
3. Explain the ways in which insufficient parking space tends to affect the behavior of people.

E. S. E. A. Title III – PROJECT I-C-E 59-70-0135-4

Environmental: **Integrated with:**

CONCEPT NO. 12 - Stewardship SUBJECT Geometry

ORIENTATION Land Use TOPIC/UNIT Area - Volume - Geom. 2

BEHAVIORAL OBJECTIVES

Cognitive:

Compute areas and volumes of given land or water areas.

Compare several areas of land, land-water, etc. within the community.

Affective:

Decide that land use affects all of mankind, and not just the owner, based on observations of the community.

Skills Used:

1. Area.
2. Volume.
3. Percents.

STUDENT-CENTERED LEARNING ACTIVITIES

In-Class:

A. Worksheet Geom. 2-A.
B. View film: Cry of the Marsh, ICE RMC, Film #390.
C. Discuss the meaning of the movie to the various members of the class. (This could be given as a written assignment, if preferred.)
Sample questions:
1. How can we protect our wetlands?
2. Who is responsible for seeing to the preserving of adequate wetlands?
3. What can you, as an individual, do about this problem?

Outside or Community:

A. Interview property owners on their views as to their rights on their land. (Ask) can we pollute the land we live on? Streams? Take pictures of pollution in the community and make a bulletin board collage.
B. Take a field trip to farm area and measure off areas.
C. Map out areas along roadways to compare for amount of pollution.

SUGGESTED RESOURCES	CONTINUED OR ADDED LEARNING ACTIVITIES
Publications: Wisconsin Conservation Bulletin published by Department of Natural Resources	
Audio-Visual: Films: Seeds of Destruction, BAVI Cry of the Marsh, ICE RMC, Film #390 Kit: Investigations in Ecology, ICE RMC, KT #43 Game: New Town, ICE RMC, SG 8	
Community: Use community streets Use farm area School grounds	

Worksheet Geom. 2-A

1. A marsh, which is the natural habitat of much animal life, is 30 miles long and 10 miles wide. A major highway is to cut lengthwise through the marsh, using a strip 1/2 of a mile wide.

   a. What is the area of the original marsh?

   b. What is the area of the highway?

   c. If three square mile supported 1% of the natural animal life in the marsh, what percent of the animal life has now been replaced by the highway?

2. Lake Pothole is 600' long, 400' wide, with an average depth of 20'. The Allbad Industry has been polluting the lake by pumping its sewage into it, at the rate of 14,960 gallons per day.

   a. At the equivalence of 7.48 gallons of sewage per cubic foot, how many cubic feet of sewage is being pumped into the lake daily?

   b. How many cubic feet would this amount to in one year (365 days)?

   c. What is the percent of increase (to the nearest %) in the volume of the lake due to the pollution?

Answers to Geom. 2-A

1. a. 300 square miles

   b. 15 square miles

   c. 5%

2. a. 2000 cubic feet

   b. 730,000 cubic feet

   c. 1.3%

E. S. E. A. Title III – PROJECT I–C–E 59–70–0135–4

Environmental:

Integrated with:

CONCEPT NO. 1 - Energy

SUBJECT Geometry (Cross Ref. - Biology)

ORIENTATION Environmental Design

TOPIC/UNIT Symmetry - Geom. 3

BEHAVIORAL OBJECTIVES

Cognitive:

Identify point and line symmetry in natural features.

Affective:

Record identified examples of symmetry in nature.

Skills Used:

1. Symmetry:
   a. Point.
   b. Line.
2. Geometric shapes.

STUDENT–CENTERED LEARNING ACTIVITIES

In-Class:

A. This lesson could be used as an introduction to symmetry or as a review. A starting point would be using the film, Symmetry, or posters on Perception and Space. (See AV materials.)

B. Have students work on Worksheet Geom. 3-B on symmetry.

C. Have the students bring some small natural objects like a blade of grass, leaves of different trees, flowers, stones and twigs to class to recognize lines of symmetry, if these objects possess any.

Outside or Community:

A. A field trip through your community, especially to a city park.
   1. Observe large natural things like trees and clouds. Sketch these observations.
   2. Select several buildings and look at them from different points of view. Sketch silhouettes of the buildings.

B. Compare the natural and man-made forms.

C. Repeat these observations at different times of the year and sketch your observations. Compare your results to various seasons of the year.

SUGGESTED RESOURCES	CONTINUED OR ADDED LEARNING ACTIVITIES
Publications: Geometry text The Community School Site - A Laboratory for Learning, ICE RMC **Audio-Visual:** Kit: Investigations in Ecology, ICE RMC, KT #43 Film: Symmetry, BAVI Posters: Reinhold Visuals, Perception, ICE RMC, KT #29 Reinhold Visuals, Space, ICE RMC, KT #29 **Community:** City park	

Worksheet Geom. 3-B

1. Draw the following geometric figures:
   Square, Rectangle, Circle, Ellipse, Hyperbola, Parabola, Regular Octagon, Regular Hexagon, Equilateral Triangle.

2. For each of the above figures, seek to find symmetry to a point, and then symmetry to a line. Give yes or no answers. If your answer is yes, construct the point, or line, to which your figure is symmetric.

3. Does a sphere have symmetry with respect to:
   a. A plane thru the center?
   b. The point at the center?
   c. A point on the sphere?
   d. A line thru the center?

4. Points A and A' have symmetry with respect to the x-axis. Find A' when A is:
   a. (3, -1)
   b. (-2, 0)
   c. (0, 4)

5. Points C and C' have symmetry with respect to a line parallel to and 4 units to the left of the y-axis. Find C' when C is:
   a. (-2, 4)
   b. (3, -2)
   c. (-4, 0)

6. Points E and E' have symmetry with respect to the origin. Find E' when E is:
   a. (4, -3)
   b. (2, 0)
   c. (0, -5)

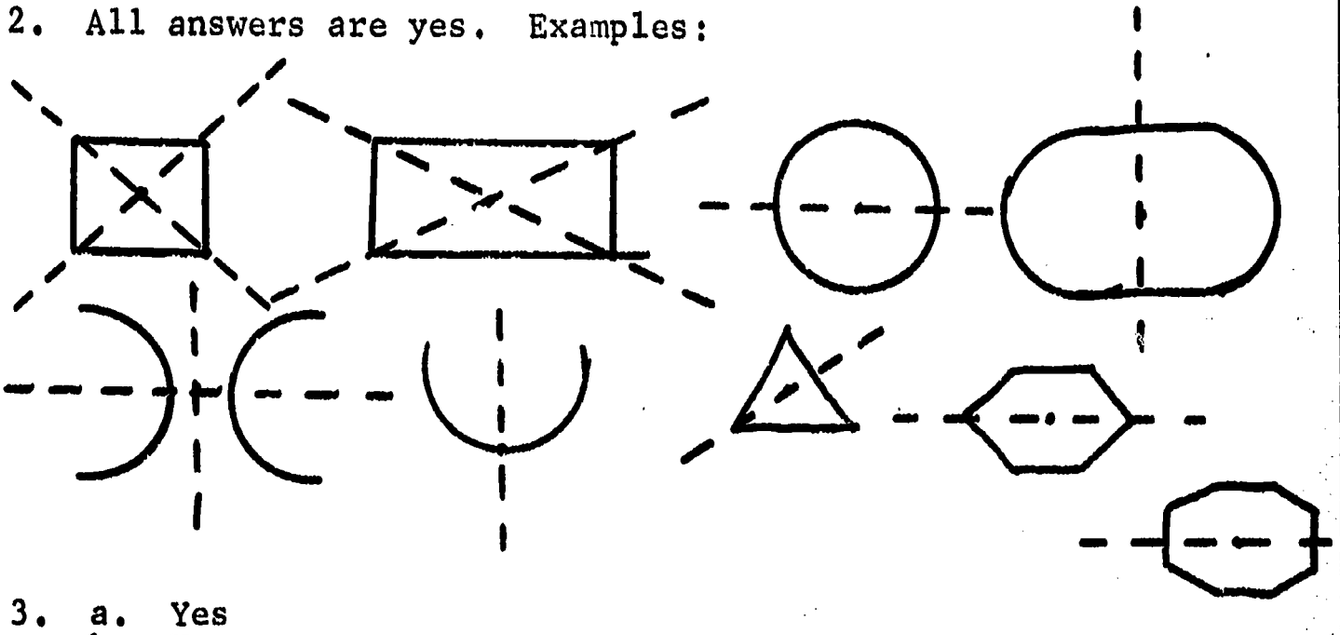
7. Points G and G' have symmetry with respect to point (3, -2). Find G' when G is:
   a. (4, 7)
   b. (3, 3)
   c. (0, 0)

8. Points J and J' have symmetry with respect to a Point S. Find S when J, J' are:
   a. (4, 2) and (-4, 2)
   b. (2, 3) and (4, 7)
   c. (-6, 1) and (-2, 3)

Answers to Geom. 3-B

1. Draw figures.

2. All answers are yes. Examples:



3. a. Yes
   b. Yes
   c. No
   d. Yes

4. a. (3, 1)
   b. (-2, 0)
   c. (0, -4)

5. a. (-6, 4)
   b. (-11, 2)
   c. (-4, 0)

6. a. (-4, 3)
   b. (-2, 0)
   c. (0, 5)

7. a. (2, -11)
   b. (3, -7)
   c. (6, -4)

8. a. (0, 0)
   b. (3, 5)
   c. (-4, 1)

E. S. E. A. Title III – PROJECT I–C–E 59–70–0135–4

Environmental:

Integrated with:

CONCEPT NO. 6 - Resources

SUBJECT Geometry

ORIENTATION Dams and Ecology

TOPIC/UNIT Applications of Geometry to Construction - Geom. 4

BEHAVIORAL OBJECTIVES

Cognitive:

Identify geometric designs used in the construction of dams, given a diagram.

Evaluate the feasibility of constructing a given type of dam for a given set of conditions, using the principles of geometry and its effect on the environment.

Affective:

Demonstrate appreciation of the amount of study and research that goes into building a dam by citing examples. Accepts that fact that the ecology can be changed by construction of a dam.

Weighs alternatives to the construction of a dam as a way of bettering the environment.

Skills Used:

1. Practical use for geometric constructions.
2. Understanding of how geometry is used in construction.

STUDENT–CENTERED LEARNING ACTIVITIES

In-Class:

A. Worksheet Ceom. 4A.

B. cf. Design of Small Dams. Students will study different types of dams and their uses.
   1. Masonry dams.
      a. Hollow dams.
      b. Buttress dams.
      c. Multiple-arch dams.
   2. Embankment dams.
      a. Earth fill.
      b. Semi-hydraulic fill and hydraulic fill.
      c. Rock fill.
   3. Timber dams.
   4. Gravity dams.
   5. Overflow dams.

C. Students work in small groups and first draw the plans, then construct models of various types of dams. (This could be given as an "A" contract.) If everyone did not participate, a special class could be devoted to explanations of the various drawings or models. The instructor should point out

(Continued)

Outside or Community:

A. Visit a dam in the vicinity. Find:
   1. Cost of construction.
   2. How did it change the environment?
      a. Economically.
      b. Aesthetically.
   3. Was it necessary to relocate?
      a. Homes.
      b. Highways.
      c. Utilities.
   4. What were the advantages to the area?
   5. What were the disadvantages?

B. When traveling or visiting other areas, the large dams are always a feature of extreme interest. Students should be interested in finding out the reasons for the particular dam.
   1. Stop flow of water in river or stream.
   2. Raise the water level.
   3. Stored water produces hydro-electric power.

(Continued)

SUGGESTED RESOURCES

Publications:

Encyclopedias
Brochures from any of the large dams by writing to the authorized places
Design of Small Dams, U.S. Department of Interior, 1960 (available thru UW-GB library)

Audio–Visual:

Films:
Dams, BAVI
Rivers, BAVI

Community:

Visit to a local dam.

CONTINUED OR ADDED LEARNING ACTIVITIES

CLASSROOM (Continued)

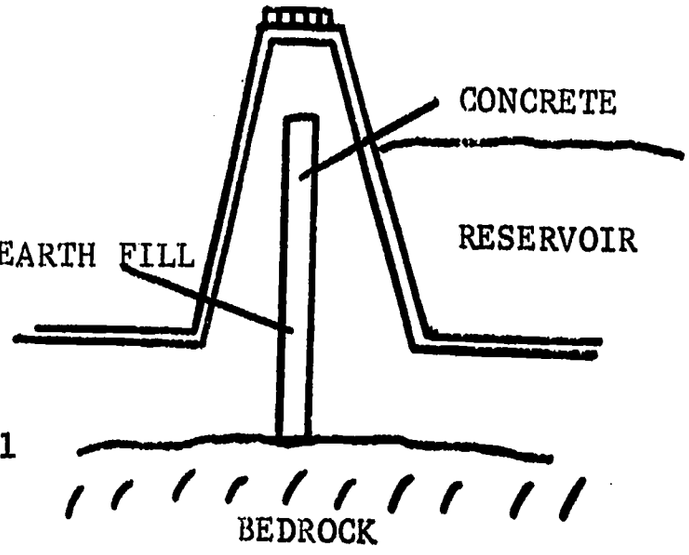
various types of geometric constructions used in making dams.

OUTSIDE ACTIVITIES (Continued)

4. Release at a certain time to assure water at all times in certain rivers which may dry up. The wildlife, fish, etc. can thus be saved.
5. Irrigation to change worthless land into productive land, etc.

Worksheet Geom. 4-A

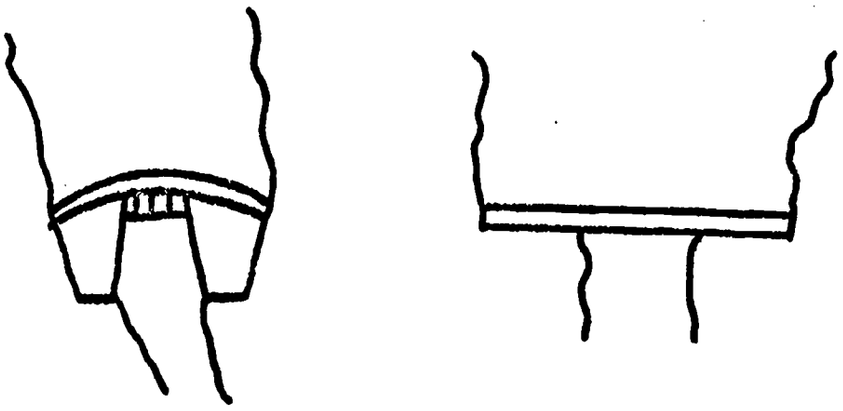
1. A cross-section diagram of an earth dam.



   a. Why is the dam thicker at the bottom?

   b. What geometric patterns can you find in the structure of an earth dam?

2. Aeriel view of a straight wall dam and of an arched dam.



   a. Which dam is stronger? Why?

   b. Conduct an experiment, using a piece of flexible cardboard.

      1) Place it over an open space between two desks. How much weight will it hold before bending down?
      2) Now curve the surface up and brace it over the space. How much more weight will it hold?
      3) Based on this experiment, which type of dam is stronger?

   c. Why does the arch point upstream?

   d. Can you think of any other applications of an arch in construction?

Environmental:

Integrated with:

CONCEPT NO. 7 - Land Use

SUBJECT Geometry

ORIENTATION Land Uses

TOPIC/UNIT Basic Angles and Construction - Geom. 5

E. S. E. A. Title III – PROJECT I–C–E 59–70–0135–4

BEHAVIORAL OBJECTIVES

Cognitive:

Construct a map drawn to scale of an area to illustrate what objects are found in that particular area. The maps will be constructed by a method called triangulation.

Affective:

Investigate the value of maps as an aid to an ecologist in identifying land uses.

Skills Used:

1. Angles and measurement.
2. Use of protractor.
3. Scale drawing.

STUDENT–CENTERED LEARNING ACTIVITIES

In-Class:

A. Review in class:
   1. Define what an angle is.
   2. Different kinds of angles, like acute, obtuse, etc.
   3. A protractor, the scale on a protractor and how to read this scale.
   4. Review scale drawings and how they are used on different maps, the globe, pictures in books.

B. Description of the procedure used in map-making by triangulation. See Worksheet Geom. 5A.

Outside or Community:

A. Construct the experiment which was described in class activity, part B.
   1. Students can do this in their own yard. Allow the students a week to complete their map.
   2. The same experiment can be conducted in the city park, rural areas, etc.
   3. Can also be conducted in school yard under the supervision of the teacher.

SUGGESTED RESOURCES	CONTINUED OR ADDED LEARNING ACTIVITIES

Publications:

Introducing Measurement, Unit 5 Minnesota Math & Science Teaching Project, ICE RMC, 110 Un

Map Reading, FM 21-26, Department of the Army Field Manual.

Audio--Visual:

Films:

Don't Crowd Me, BAVI

Litter Monster, BAVI

Man Uses and Changes the Land, BAVI

Kit:

Investigations in Ecology, ICE RMC, KT #43

Community:

Visit to a city park

Worksheet Geom. 5-A

1. Mark a "base line" with 2 stakes and a string on one side of your area. The distance between the 2 stakes is selected by the individual and it is suggested that the distance represents a length which can easily be converted to scale drawing. Label one stake "A" and the other "B". Attach a protractor at stake "A", select an object in the area and measure the angle of the object to the "base line" (string). Record this angle measure.

   Go to stake "B" and record the angle from the same object and the "base line".

   Follow the same procedure with other objects in the area that you want to map. Be sure to record the angle measurements of objects at the two stakes.

   A scale drawing of the area can be constructed by using the selected scale and the angle readings which you obtained.

   Note: A sextant could be used in place of a protractor in this episode.

E. S. E. A. Title III – PROJECT I–C–E 59–70–0135–4

Environmental: **Integrated with:**

CONCEPT NO. 11 - Individual Acts **SUBJECT** Geometry

ORIENTATION Environmental Design **TOPIC/UNIT** Constructions - Geom. 6

BEHAVIORAL OBJECTIVES

Cognitive:

Identify various geometric designs (circle, square, triangle and rectangle) and "environmental designs" (a house, room, city, etc.) are very useful to man.

Affective:

Consider different geometric shapes, as well as textures and colors when producing paintings, drawings and sculpture.

Skills Used:

1. Construction.
2. Measurement.
3. Pattern arrangement.

STUDENT–CENTERED LEARNING ACTIVITIES

In-Class:

A. Each student will construct two squares with two-inch sides, one circle with a two-inch diameter, one circle with a three-inch diameter, an equilateral triangle with two inches by four inches from different color construction paper.
   1. Use these geometric figures to form an interesting design and sketch this on a sheet of paper.
   2. Make another design and sketch this on another sheet of paper.

B. Take each shape and label the squares as chairs, the small circle as a lamp, the large circle as a table, the triangle as a television and the rectangle as a sofa.
   1. Arrange these "items of furniture" as is acceptable to you.

(Continued)

Outside or Community:

A. Obtain an art book from the library to observe geometric and "environmental" designs such as a plan of a cathedral, the design of a city...
B. Obtain a book on architecture.
C. Take a field trip thru the school to identify various environmental designs found in the building like the color of brick, stone or wood, the patterns of windows and doors, etc.
D. On the way home, observe the different patterns of buildings, how they are grouped and how their design tells us about their use.
E. Have the industrial arts instructor come to class and give a talk on the use of geometric designs in construction.

SUGGESTED RESOURCES

Publications:

Curriculum Working Paper, Art Life and the Environment, E. Corso, University of Wisconsin, 1969

Architecture, Drafting and Design, D. Hepler and P. Wallach, McGraw-Hill, 1965

Mathematics in Everyday Things, Vergara, Signet, Science Library Book, 1959, pages 258-63.

Audio—Visual:

Films:

Ark, BAVI

Green Box, BAVI

Junkdump, ICE RMC, Film #310

Man's Impact on His Environment, BAVI

Noisy Landscape, ICE RMC, Film #170

Community:

City library
Architect
Building contractor

CONTINUED OR ADDED LEARNING ACTIVITIES

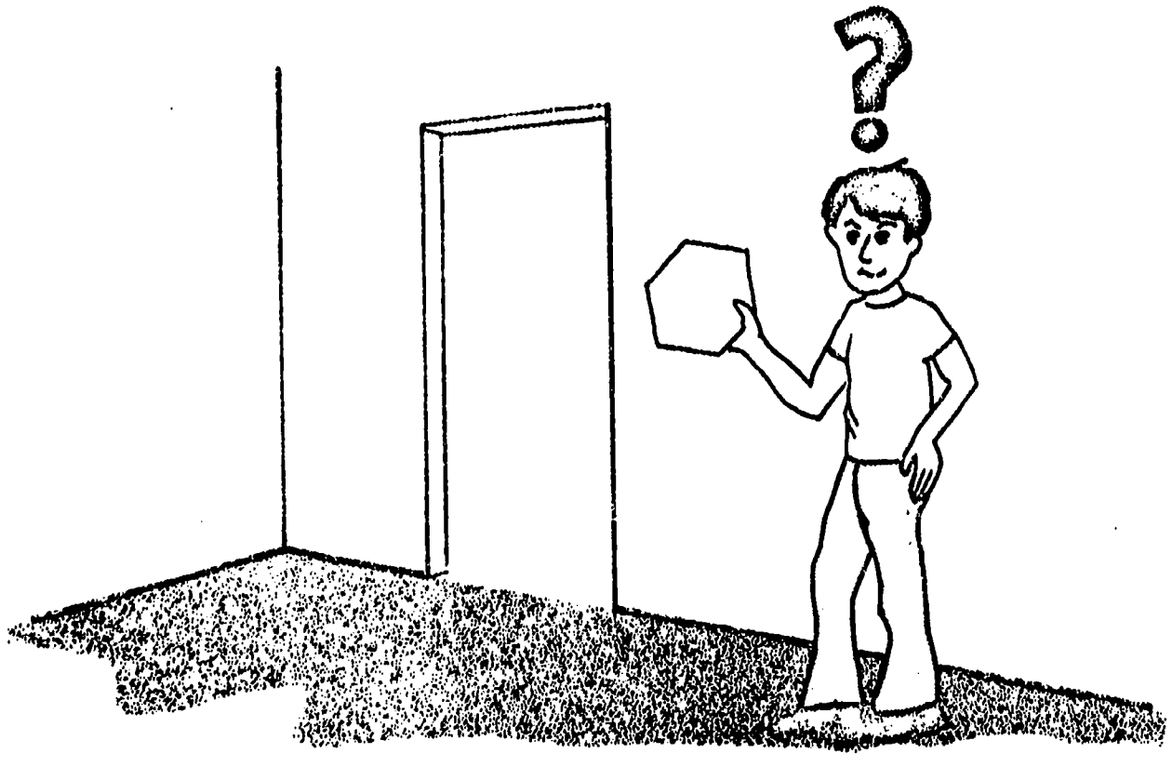
CLASSROOM (Continued)

2. Sketch on a piece of paper.
3. Rearrange the items of furniture and sketch this design on another piece of paper.

C. Compare the geometric design and "environmental" design on the four sheets of paper. Think about why you placed the shapes where you did in each case. The "why" is the real difference between the two kinds of designs.

D. Worksheet Geom. 6-D on pattern arrangements, using regular polygons.

FLOOR TILES: Sheet 1 NAME _____



A. Jeff wanted to finish his clubroom floor using tiles in the shape of regular polygons. All sides of regular polygons have the same length and all angles have the same measure.

Which regular polygons can be used to completely cover the floor? To find out, we will perform an experiment using the regular polygons on sheet 3.

Directions:

1. Carefully cut out the figures on sheet 3.
2. Group all the regular polygons having the same shape.
3. Use the set of triangles. Place a vertex of one of the triangles on point **P**. Continue placing triangles to fill up the region around point **P**. Remember there should be no overlapping.
4. Record your data in the Table on sheet 2
5. Continue this process until you have tested each group.

FLOOR TILES: Sheet 2 NAME _____

Name of Polygon	Measure of each interior angle	Number of angles meeting at point P	Total number of degrees	Can the regular polygon be used as a tile?
Triangle				
Square				
Pentagon				
Hexagon				

6. Use the Table to complete this statement:

If the sum of the measures of the interior angles at the point is____°

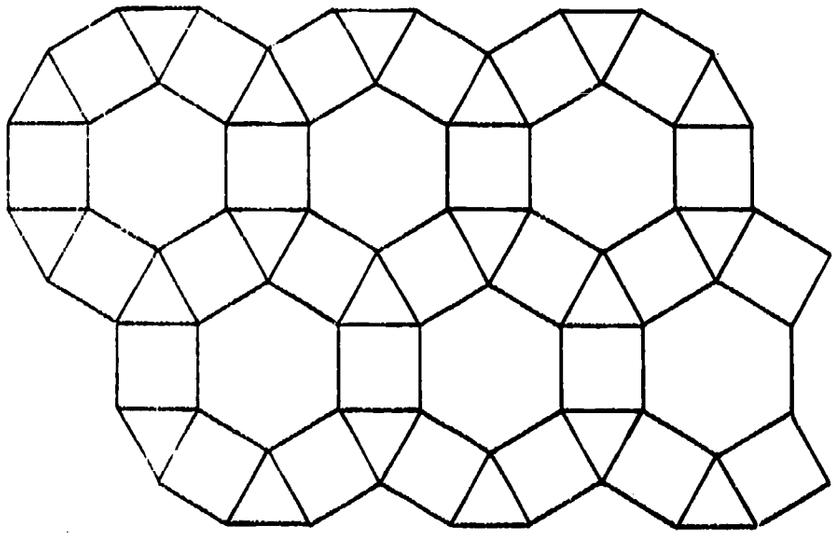
the regular polygon can be used as a tile.

B. Some tile designs can be made using different combinations of regular polygons.

Follow the steps below:

Place a regular polygon on the paper. → Mark a point at each vertex → Connect the points with a straightedge → Continue process using different figures to completely cover the region.

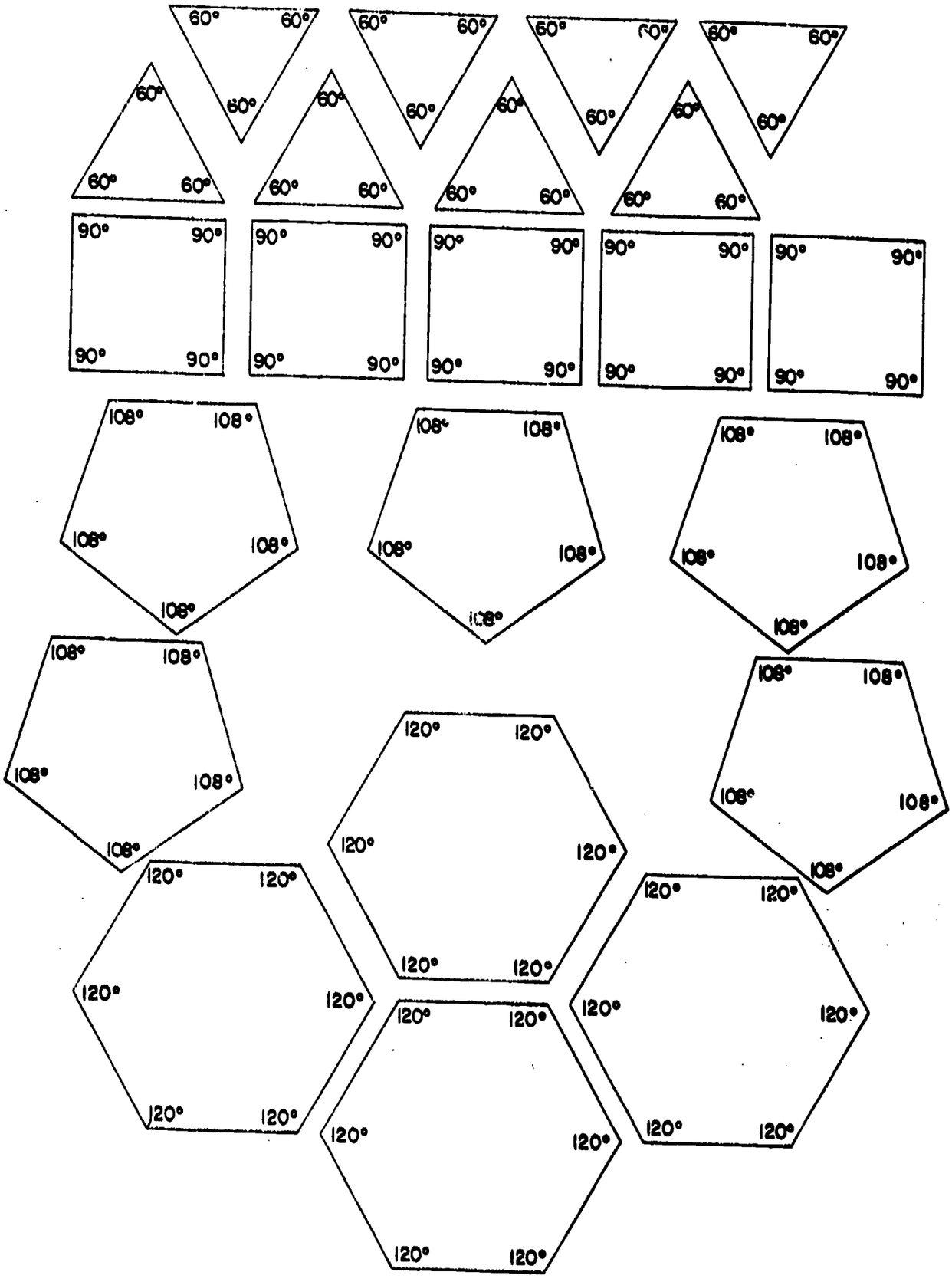
Try to make this design:



Make some other tile patterns.

FLOOR TILES: Sheet 3 NAME _____

Carefully cut out each regular polygon.



Answers to Geom. 6-D

Name of Polygon	Measure of Each Interior Angle	Number of Angles Meeting at Point	Total No. of Degrees	Can the Regular polygon be used as a tile?
Triangle	60°	6	360°	Yes
Square	90°	4	360°	Yes
Pentagon	108°	3	324°	No
Hexagon	120°	3	360°	Yes

Note to Teacher:

A related classroom activity could be to divide the class into small groups--a row may be convenient. Have each student create a design. Have each group select its best design, and the student who created it is to reconstruct it on an overhead projector, using colored transparencies.

E. S. E. A. Title III – PROJECT I–C–E 59–70–0135–4

Environmental:

Integrated with:

CONCEPT NO. 8 - Values and Attitudes

SUBJECT Geometry

ORIENTATION Environmental Ethics and Aesthetics

TOPIC/UNIT Logic - Geom. 7

BEHAVIORAL OBJECTIVES

Cognitive:

Make truth tables using "And", "Or", "If" and "Then".

Write statements, converse, inverse, contra-positives for environmental problems.

Affective:

Apply principles of logic to statements of causes and remedies for environmental problems:

a. In class.
b. In community.

Skills Used:

1. Truth tables.
2. Converse.
3. Inverse.
4. Contra-positives.
5. Logic exercises.

STUDENT–CENTERED LEARNING ACTIVITIES

In-Class:

A. Review or teach truth tables, writing statements, converse, inverse, contra-positives.
   1. Sample question statement: If A then B
      a. Find converse.
      b. Find inverse.
      c. Find contra-positive.

Outside or Community:

A. View the film, The Stream, ICE RMC, Film #320, and report on the logic involved.
B. Visit local council, Town Meeting, when some conservation issue is being discussed. Try to formulate "if, then" statements from the discussions.

SUGGESTED RESOURCES	CONTINUED OR ADDED LEARNING ACTIVITIES
Publications: The Good Earth - Tin Can Ecology, Mel Ellis, Milwaukee Journal AP, 1972 **Audio-Visual:** Films: The Stream, ICE RMC, Film #320 Urbanissmo, ICE RMC, Film #480 Kit: EQ Index, National Wildlife Federation, ICE RMC, KT 9 **Community:**	

Worksheet Geom. 7-C

Here is a summary of the connectives studied in this unit.

1. Negation — Symbolized as $\sim P$ read as "not P".

2. Conjunction — Symbolized $P \wedge Q$ read as "P and Q".

3. Disjunction — Symbolized as $P \vee Q$ read as "P or Q".

4. Implication — Symbolized as $P \Rightarrow Q$ read as "If P, then Q".

5. Equivalence — Symbolized as $P \leftrightarrow Q$ read as "If P, then Q and If Q, then P".

Complete the truth tables for each of these propositions.

1. Negation

P	$\sim P$
T	
F	

2. Conjunction

P	Q	$P \wedge Q$
T	T	
T	F	
F	T	
F	F	

3. Disjunction

P	Q	$P \vee Q$
T	T	
T	F	
F	T	
F	F	

4. Implication

P	Q	$P \rightarrow Q$
T	T	
T	F	
F	T	
F	F	

(Continued)

Worksheet Geom. 7-C

Statement	Converse
If P, then Q	If Q, then P
	Inverse
	If not P, then not Q
	Contra-positive
	If not Q, then not P

5. Statement
If water is clean, then fish will live..Write the converse, inverse, contra-positive for this statement.

6. Statement
In order to stay alive, it is necessary to have a supply of fresh air to breathe.

P A person has fresh air

Q A person is alive

Write a statement and its contra-positive.

7. Complete the truth table below for the proposition.

$\sim(P \rightarrow Q)$

P	Q	$P \rightarrow Q$	$\sim(P \rightarrow Q)$
T	T	____	_____
T	F	____	_____
F	T	____	_____
F	F	____	_____

8. The proposition.

$(\sim P \vee Q) \wedge (P \vee \sim Q)$

requires that you construct $(P \vee \sim Q)$, $(\sim P \vee Q)$, and the conjunction of these two propositions.

Complete this truth table.

P	Q	$\sim P$	$\sim Q$	$(\sim P \vee Q)$	$(P \vee \sim Q)$	$(\sim P \vee Q) \wedge (P \vee \sim Q)$
T	T	___	___	_____	_____	_____
T	F	___	___	_____	_____	_____
F	T	___	___	_____	_____	_____
F	F	___	___	_____	_____	_____

Answers to Geom. 7-C

1. T
   F

2. T
   F
   F
   F

3. T
   T
   T
   F

4. T
   F
   T
   T

5. Converse

   If fish will live, then water is clean.

   Inverse

   If the water is not clean, then the water is not clean.

   Contra-positive

   If the fish will not live then the water is not clean.

6. If a person has fresh air, then the person is alive.

   If a person is not alive, then the person does not have fresh air.

7.

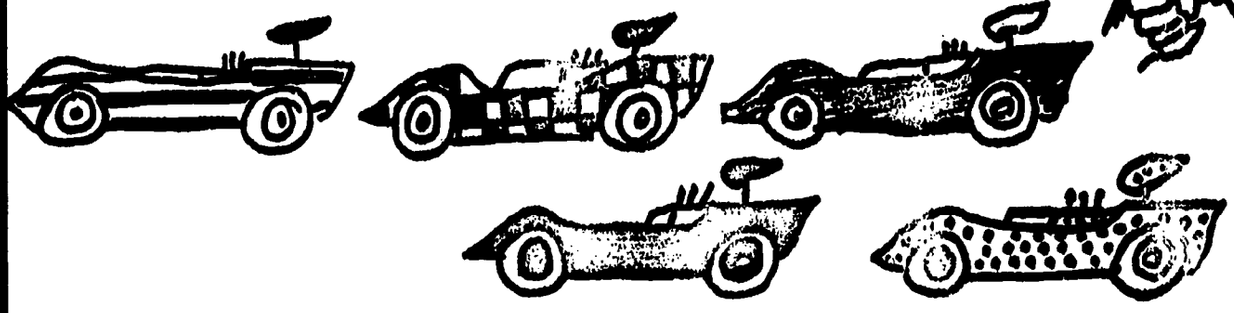
$P \rightarrow Q$	$\sim(P \rightarrow Q)$
T	F
F	T
T	F
T	F

8.

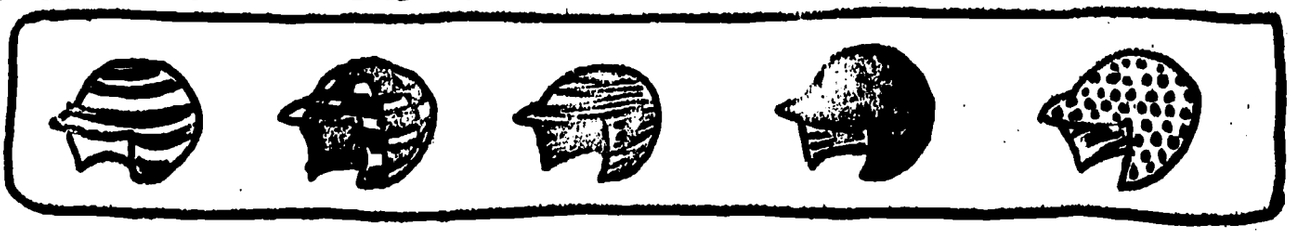
$\sim P$	$\sim Q$	$\sim(P \vee Q)$	$(P \vee \sim Q)$	$(\sim P \vee Q) \wedge (P \vee \sim Q)$
F	F	T	T	T
F	T	F	T	F
T	F	T	F	F
T	T	T	T	T

ONE FAIR FRIDAY IN FRANCE FIVE FEARLESS FELLOWS FORSOOK THE FREEWAYS TO FIND HOW FAST THEIR FERRARI'S FLEW.

THEIR CARS WERE...

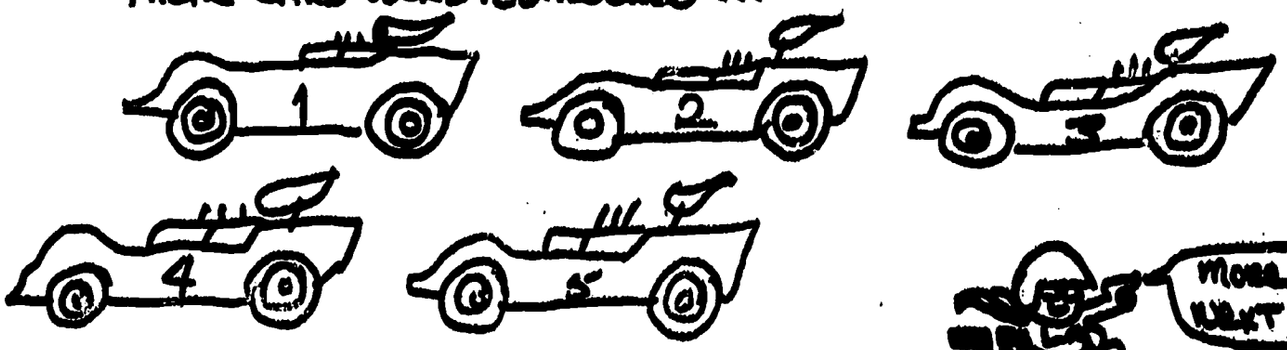


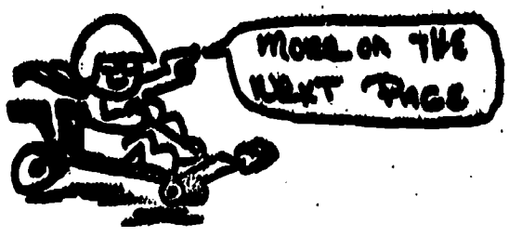
THEIR HELMETS WERE ALSO...



BUT NO DRIVER HAD A CAR WITH THE SAME COLOR OR DECORATION AS HIS HELMET. (THE DRIVER OF THE WHITE CAR DID NOT WEAR A WHITE HELMET, ETC.)

THEIR CARS WERE NUMBERED ...

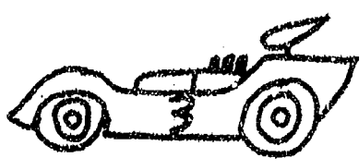




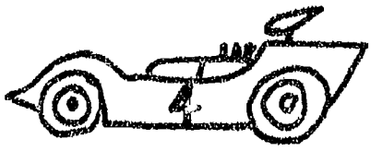
CAN YOU COMPLETE THIS CHART?

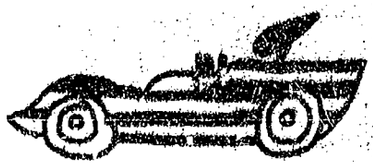
CAR #	CAR COLOR OR DECORATION	HELMET COLOR OR DECORATION	FINISH IN THE RACE
1			
2	MAKE YOUR OWN CHART		
3			
4			
5			

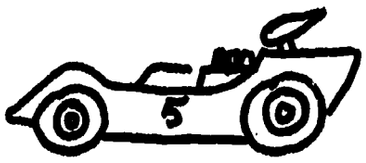
1 NO CAR FINISHED THE RACE IN A PLACE THAT CORRESPONDS TO ITS NUMBER.
(CAR #1 DID NOT FINISH 1ST, CAR #2 DID NOT FINISH 2ND, ETC.)

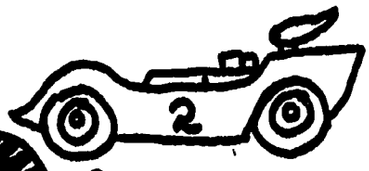
2 CAR  DID NOT FINISH IN THE FIRST 3 PLACES.

3 THE DRIVER WEARING  WON THE RACE.

4  WAS 

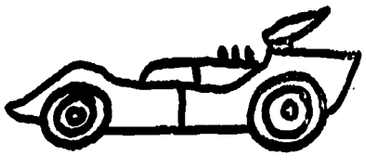
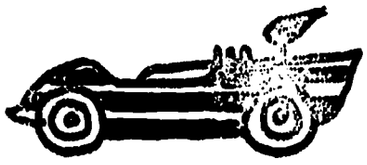
5  FINISHED BEHIND 

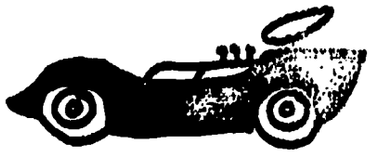
6.  FINISHED IN 3RD PLACE

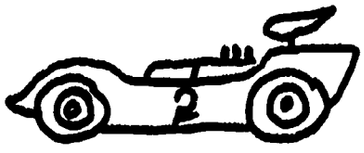
7. THE DRIVER OF  HATED THE DRIVER WEARING  BUT LIKED THE DRIVER OF 

8. THE DRIVER OF  WORE A 

9. THE DRIVER WEARING  FINISHED AHEAD OF THESE THREE DIFFERENT CARS.

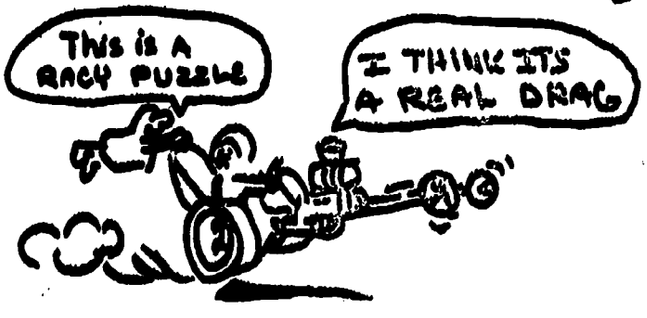
  

10.  FINISHED LAST.

11.  WAS NEITHER  OR 

12.  BUMPED  ON THE FIRST LAP.

13. THE DRIVER THAT FINISHED LAST WISHED HE COULD HAVE BEEN WEARING 



E. S. E. A. Title III – PROJECT I-C – 59-70-0135-4

Environmental-

Integrated with:

CONCEPT NO. 9 - Management

SUBJECT Trigonometry

ORIENTATION Water Shade and Water Conservation

TOPIC/UNIT Trigonometric Ratios & Hero's Formula - Trig. 1

BEHAVIORAL OBJECTIVES

Cognitive:

Describe several ways in which watersheds are managed and how these are used to change man's environment, using research methods.

Determine the line transect, area, height (elevations), difference and perimeter using the principles of trigonometry.

Affective:

Advocate or reject man's use of a given practice in watershed management for his immediate and material gains based on his values.

Form a judgment as to who's responsibility it is to manage the lands within a given watershed area.

Skills Used:

1. Research at the library.
2. Reporting.
3. Critical reading.
4. Evaluation.
5. Problem solving.
6. Trigonometric ratios.
7. Hero's formula.

STUDENT-CENTERED LEARNING ACTIVITIES

In-Class:

A. List as many ways as possible of man's use of watershed control.
   1. Use library.
   2. Report on different programs.
   3. Evaluate the worth of existing programs.
   4. Discuss pros and cons (buzz groups).

B. Worksheet Trig. 1-B. Using trigonometric ratios and Hero's formula on problems dealing with watersheds.

Outside or Community:

A. Take field trip to several watershed areas.

B. Check with nearest university officials to see what is being done in the area.

C. Invite resource people from water control units or from university.

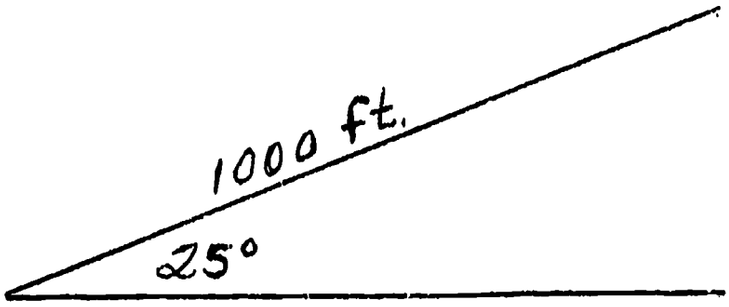
D. Construct drawings using geometric designs of watershed management areas, showing use of land.

E. 1. Measure a quadrat of land--one acre.
   2. Make a Line Transect.
   3. Make a Belt Transect.

SUGGESTED RESOURCES	CONTINUED OR ADDED LEARNING ACTIVITIES
Publications: Fundamentals of Ecology, ICE RMC, 520 0d Environmental Management, Course Concepts and Organization, ICE RMC, VF	
Audio–Visual: Films: One Day At Teton Marsh, ICE RMC, Film #200 River Systems and Man, ICE RMC, BAVI The Gifts, ICE RMC, Film #280	
Community:	

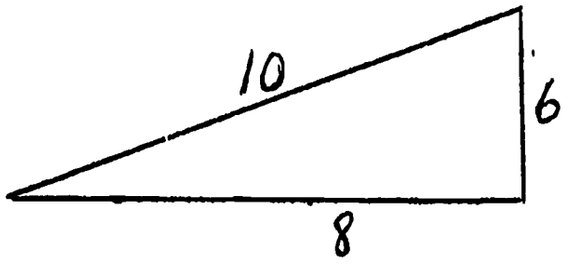
Worksheet Trig. 1-B

1.



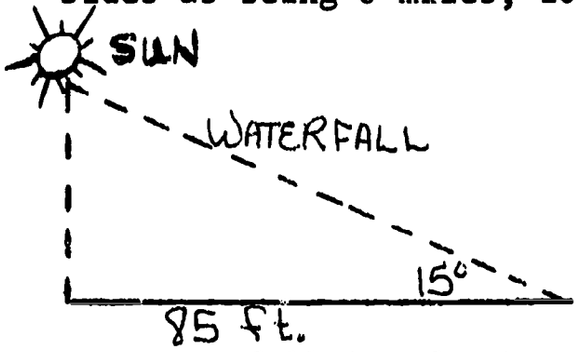
The above diagram shows a corner of a watershed area. We are at a point 1000 feet from the tip of the area. Find the shortest "line transect" to the other side of the watershed area.so we may construct an overflow drainage tile with the least amount of cost.

2.



Our watershed area is in the shape of a large triangle. Find the area of our watershed using the length of the sides as being 8 miles, 10 miles and 6 miles.

3.



Our waterfall is of unknown height. Standing at a point 85 feet from the base of the waterfall, we observe the angle of elevation to be 15° just as the sun sets behind the waterfall crest. How high is the waterfall?

4. The ecosystem unit for practical management must include for every acre of water at least 20 acres of terrestrial watershed. Using these figures, would an area of 5,250 acres of terrestrial watershed support a water area of 250 acres?

Answers to Trig. 1-B

1. 422.6

2. 48 / $\overline{42}$ or 311.08 square miles

3. 22.77 feet

4. Yes

E. S. E. A. Title III – PROJECT I–C–E 59–70–0135–4

Environmental:

Integrated with:

CONCEPT NO. 5 - Air

SUBJECT Statistics

ORIENTATION Air and Lung Pollution

TOPIC/UNIT Measures of Central Tendency - Stat. 1

BEHAVIORAL OBJECTIVES

Cognitive:

Interpret data regarding causal relationship between smoking and the death rate due to lung cancer presented in the form of either a chart or graph.

Affective:

Form opinions regarding the validity and reliability of the evidence presented for/against cigarette smoking.

Collect evidence that supports/rejects the causal relationship between smoking and the death rate due to lung cancer.

Skills Used:

1. Researching material.
2. Graphing statistical facts.
3. Using sampling techniques.
4. Computing correlation.
5. Determining mean, median, mode and standard deviation.

STUDENT–CENTERED LEARNING ACTIVITIES

In-Class:

A. Use Worksheet Stat. 1-A.
B. Read assigned material (see back publications).
C. Graph the relationship between time in years and the number of smokers in the U.S. by a line graph.
D. Graph, by use of a histogram, the percentage of smokers in the U.S. in relationship to every 10 years starting with the year 1900.
E. The student shall determine the correlation between number of packs of cigarettes vs. the death rate.
F. The student will, from their sample in "C", find the mean, median, mode and standard deviation of the number of cigarettes per day of the smokers.
G. Compute the cost for a person who smokes two packs of cigarettes a day at 50¢ a pack over a ten year period.

Outside or Community:

A. Develop a questionnaire that determines the number of cigarettes a person smokes a day.
   1. Determine by using a random sample of 50 people.

SUGGESTED RESOURCES	CONTINUED OR ADDED LEARNING ACTIVITIES
Publications: Smoking and Death Rates - A Riddle in Cause and Effect, E. Cuyler Hammond Effect of Smoking, E. Cuyler Hammond, W.H. Freeman and Co. Lung Cancer Death Rates in Relation to Smoking, Amercan Cancer Society Chart Book in Smoking, Tobacco, Health, U.S. Dept. of Health, Education and Welfare The Health Consequence of Smoking, U.S. Dept. of HEW **Audio-Visual:** Films: Let's Discuss Smoking - No Smoking, BAVI No Smoking, BAVI Smoking and You, BAVI Smoking: It's Your Choice, BAVI **Community:** City health official, doctor visit class	

Worksheet Stat. 1-A

1. Data - amount of CO_2 in the world's air in ppm (parts per million).

1959	313
1961	314
1963	315 1/2
1965	317
1967	319
1969	321

Construct a line graph showing the rise of CO_2 in our atmosphere.

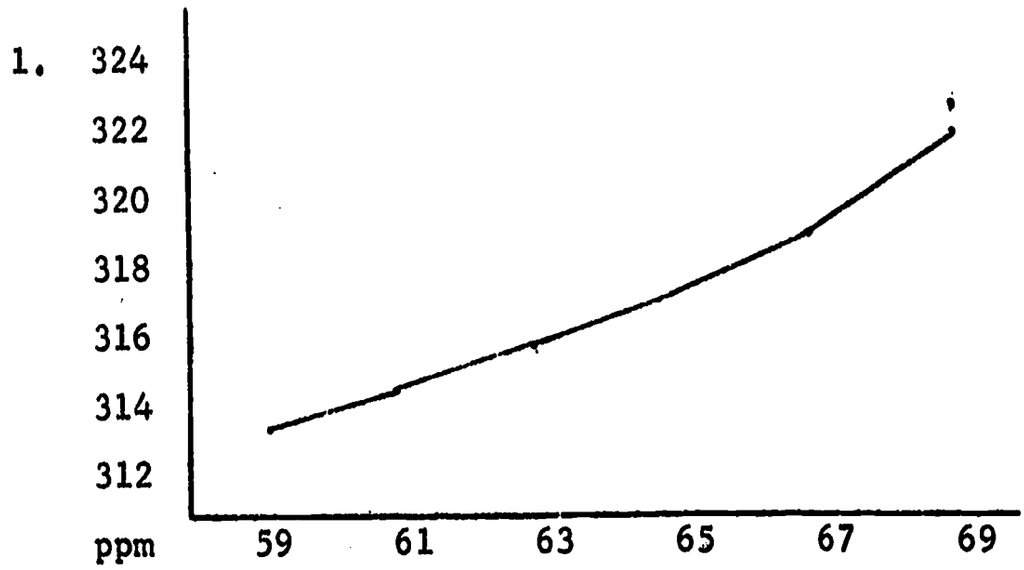
2. Data:

Sulfur oxides	33.4	Amount of pollutants in air (millions of tons)
Particulate matter	35.2	
Carbon monoxide	151.4	
Hydrocarbons	37.4	
Nitrogen oxides	23.8	

Graph, by use of a histogram, the percentage of air pollutants produced in the U.S. in 1969.

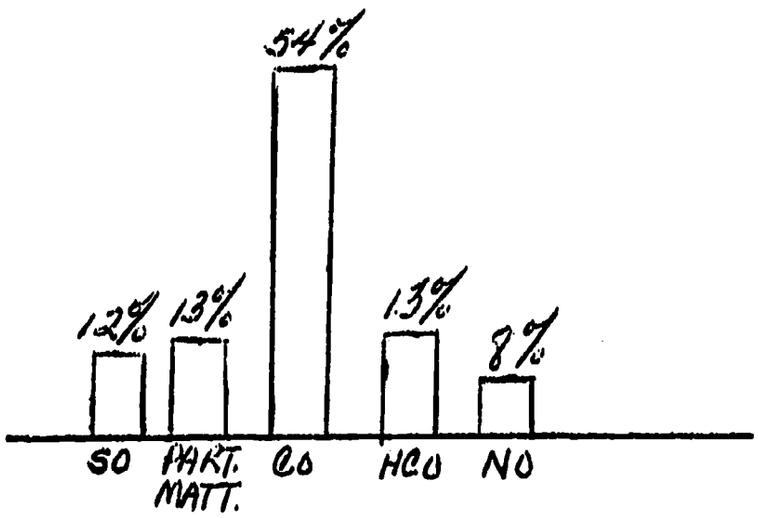
Answers to Stat. 1-A

1.



2. %'s

Sulfur oxides	11.88% ~ 12%
Particulate matter	12.51% ~ 13%
Carbon monoxide	53.84% ~ 54%
Hydrocarbons	13.30% ~ 13%
Nitrogen oxides	8.47% ~ 8%



E. S. E. A. Title III – PROJECT I–C–E 59–70–0135–4

Environmental: **Integrated with:**

CONCEPT NO. 4 - Water **SUBJECT** Statistics

ORIENTATION Water Quality and Supply **TOPIC/UNIT** Graphing and Central Tendency - Stat. 2

BEHAVIORAL OBJECTIVES

Cognitive:

Define fresh water intake, brackish or salt water, consumption, discharge, water ratio and thermo-pollution.

List five ways water is polluted by industry.

Use principles of graphing available data to compare & contrast efforts of several companies and communities (Cont.)

Affective:

Attempts to determine the expense and problems involved in correcting or reducing industrial pollution of water.

Praise and support those industries who attempt to solve their pollution problems verbally.

Skills Used:

1. Histograms.
2. Mean.
3. Median.
4. Mode.

STUDENT–CENTERED LEARNING ACTIVITIES

In-Class:

A. After the plant tour, the students will collect the data they gathered and put it in systematic order. (See outside resources and community activities for information.)

B. Since much survey work has already been done on this and has been published, purchase Water in Industry, published jointly by National Association of Manufacturers, Chamber of Commerce of the U.S., in cooperation with National Technical Task Committee on Industrial Waste, $2.

C. Have students study problems from the above-mentioned publication. They will be able to find figures and facts for an industry similar to the one in their community.

D. Students can make graphs and studies comparing (Continued)

Outside or Community:

A. Visit a large industrial plant in the area. Make note of the following:
   1. Location of plant.
   2. Fresh water intake.
   3. Brackish or salt water used.
   4. Reused and recirculation of water.
   5. What water treatment is used?
   6. Cost of waste water treatment.
   7. How much water is actually consumed?
   8. What water is discharged?
      a. Chemical and waste pollution.
      b. Thermo-pollution.
   9. Water plans for the future.

B. Become conscious of industry water pollution and what some companies have done and can do. Talk about these with parents and people in the community. Encourage the adults to urge government representatives to vote for water pollution control measures.

SUGGESTED RESOURCES

Publications:

Clean Water for the 1970's, A Status Report, June, 1970, U.S. Dept. of Interior

A Primer on Waste Water Treatment, Oct., 1969, U.S. Dept of Interior, Federal Water Pollution Control Administration ICE RMC, VF

Clean Water - It's Up To You, free, Izaak Walton League of America, Illinois, ICE RMC, VF

To Watch the Water Clear, a report to employees of Kimberly-Clark

Audio-Visual: (Continued)

Film:

The Stream, ICE RMC, Film #320

Kimberly-Clark and American Can in Neenah have filmstrips showing what they are doing. May be obtained from the Public Relations Department

Community:

Kimberly-Clark

American Can Company

CONTINUED OR ADDED LEARNING ACTIVITIES

CLASSROOM (Continued)

their industry with those surveyed for the report.

E. A very interesting book on ecology (all phases) is A Place In The Sun by Lois and Louis Darling, William Morrow and Co., N. Y., April, 1970. It is easy to read and is well written.

F. See Worksheet Stat. 2-F.

PUBLICATIONS (Continued)

Water...Our Most Abused Resource?, Scholastic, October 7, 1965.

The Crisis in Water: It's Sources, Pollution & Depletion, Saturday Review, October 23, 1965, pages 23-40

Water in Industry - A Survey of Water Used in Industry, National Association of Manufacturers and Chamber of Commerce of U.S., 1965.

COGNITIVE (Continued)

in correcting or reducing water pollution.

Worksheet Stat. 2-F

Make a histogram using the data given below:

Phosphates in Detergents

Calgon	75.5%
Axion	43.0%
Biz	40.4%
Salvo	30.7%
Punch	25.8%
Ajax Laundry	25.2%
Spic and Span	23.0%
Breeze	22.2%
Cheer	22.0%
Fab	21.5%
Cold Water All	9.8%
Wisk	7.6%
Trend	1.4%
Ivory Snow	---
Vel	---
Lux	---

Compute the mean, mode and median (to the nearest percent) using the data given above.

Make an ogive using the data given above.

Answers to Stat. 2-F

Mean 21%

Mode 22%

Median 22%

E. S. E. A. Title III – PROJECT I–C–E 59–70–0135–4

Environmental:

Integrated with:

CONCEPT NO. 5 - Air

SUBJECT Advanced Algebra

ORIENTATION Air Pollution

TOPIC/UNIT Problem Solving - A.A. 1

BEHAVIORAL OBJECTIVES

Cognitive:

Use principles of solving word problems and addition, subtraction, multiplication and division in solving calculation type problems of pollution effects, given appropriate data.

Affective:

Submit that the growth of pollution can be predicted through calculations and extrapolation of available data if conditions are not changed.

Skills Used:

1. Problem solving.
2. Equations and proportions.

STUDENT–CENTERED LEARNING ACTIVITIES

In-Class:

A. Class discussion on sources of air pollution. Sample questions:
   1. What are some of the pollutants found in the air?
   2. What are some of the sources of this pollution?
   3. Name one agency you can report a pollution source to.

B. Worksheet A.A. 1-B on problem solving.

Outside or Community:

A. Visit local industries to check what measures they are taking relative to air pollution control.
   1. What is the cost of the control measures?
   2. Determine the problems in control level of air pollution.

B. Interview medical personnel.
   1. What pollutants are most injurious to our health?
   2. What are the amounts of pollutants and the cost involved (medically)?

C. Check with city authorities about their air pollution regulations.

SUGGESTED RESOURCES	CONTINUED OR ADDED LEARNING ACTIVITIES
Publications: Appleton Post Crescent, Sunday, February 27, 1972, Section F, page 1 In Quest of Cleaner Air and Water, ICE RMC, VF **Audio-Visual:** Films: The Poisoned Air, National Medical AV Center, Chamblee, Georgia 30005 Air Pollution - A Series, WOR-TV, New York, New York The 2nd Pollution, ICE RMC, Film #460 Game: Smog: The Air Pollution Game, ICE RMC, SG 1 **Community:** Library City Hall Health Department Transportation Department Industrial Management Committee Local industries	

Worksheet A.A. 1-B

1. The number of automobiles in use in the United States in the year 2000 is predicted to be seven times as many as in 1947. The number in 1970 is 2.6 times as many as in 1947. If the automobiles in Los Angeles County are responsible each day in 1970 for putting 30 tons of deadly sulfur dioxide into the air, and the predicted growth of the United States automobile population is accurate, how many pounds per day of sulfur dioxide will be put into the air in Los Angeles County in the year 2000?

2. If air pollution, causing the sun's heat to be trapped, increases the average daily mean temperature of the earth by .1 degree C each year, and if the average daily mean temperature of the southern polar ice cap was -75 degrees F in 1970, by what year will the average daily mean temperature of the southern polar ice cap be 32 degrees F (ready to melt)?

3. The age of the air polluter now plus the age of the water polluter 6 years ago is 3 times the number of gallons of water used for bathing by an average American each day. Six years ago the air polluter was half again as old as the water polluter was. Fourteen years from now (in the future) the air polluter will be one and one-fourth times as old as the water polluter. How many gallons of water does an average American use for bathing in a week?

4. A 1965 automobile of a certain make and model pollutes the air 5 times as much as a 1970 automobile of the same make and model. The 1965 auto started at the beginning of a section of highway traveling 50 mph at a steady rate. Two hours later the 1970 automobile started at the same place and traveled in the same direction at a steady rate of 65 mph. If the 1970 car pollutes the air at the rate of n cubic feet per hour, how many n cubic feet of pollutants were emitted by each car by the time the 1970 car caught up to the 1965 car?

Answers to A.A. 1-B

1. 161,538 6/13 pounds

2. To 32° F. by the year 2563.

3. 130 2/3 gallons per week.

4. 1970 car: 6 2/3
   1965 car: 43 1/3

E. S. E. A. Title III – PROJECT I–C–E 59–70–0135–4

Environmental:

Integrated with:

CONCEPT NO. 2 - Ecosystem

SUBJECT Advanced Algebra

ORIENTATION Mathematical Patterns in Nature

TOPIC/UNIT Trig. (Fibonacci Sequence) - A.A. 2

BEHAVIORAL OBJECTIVES

Cognitive:

List five things in nature which illustrate the Fibonacci Sequence, Fibonacci Fractions or Geometric Shapes.

Explain why each of the shapes has a specific advantage for the plant or part of plant having that shape.

Affective:

Seek illustrations of the beauty of mathematics principles in nature.

Demonstrate awareness of the simple plants and flowers in nature by estimating approximate number in a given area or several areas.

(Continued)

Skills Used:

1. Fibonacci Sequence.
2. Sequence of Fibonacci Fractions.

STUDENT–CENTERED LEARNING ACTIVITIES

In-Class:

A. Students study the units of sequence and series.
B. As a special topic or math club project, they study some special sequences that are interesting because of their recreational value and relationship to nature.
C. Study these series in relation to the field trip.
D. Use Worksheet A.A. 2-D for class problems.

Outside or Community:

A. A field trip in the woods or park will help students to enjoy nature and try to preserve it.
B. Some of the things they should be able to find Fibonacci patterns in are: daisies, the way leaves grow on many stems, scales on a fir cone, etc.
C. They could also look for other geometric shapes in nature. The seeds in a sunflower are arranged in a pattern formed by spirals winding from its center. The honeycomb built by bees contains hexagonal cells in which the bees store the honey.
D. A study of series will be done at the same time.

SUGGESTED RESOURCES	CONTINUED OR ADDED LEARNING ACTIVITIES
Publications: Mathematics books The Giant Golden Book of Mathematics World of Mathematics, Volume 1, pp. 718-719 The Divine Proportion, H. E. Huntley, Dover, 1970 **Audio-Visual:** Film: Number Patterns, UW-LaCrosse Filmstrips: Ecology and Man Series, Set 1, Set 2, Set 3, ICE RMC, FS St 9, FS St 10, and FS St 11 **Community:**	AFFECTIVE (Continued) Appraise the mathematical patterns occurring in even simple plants.

Worksheet A.A. 2-D

We shall consider the Fibonacci Sequence as being set up as follows: (U_1, U_2, U_3, U_4,.....) Remember that U_1 and U_2 are both equal to 1. Each number in the sequence, thereafter, is equal to the sum of the two preceding numbers.

1. Make a list of the first forty numbers of the Fibonacci Sequence.

2. Does the difference of the squares of two Fibonacci numbers, whose subscripts differ by two, produce another Fibonacci number? Use numbers which will allow you to check this in the numbers you have set up in problem number 1.

3. If r is any integer, is U_n a factor of U_{rn}? Keep r small so you can again use your answers for problem 1.

4. Solve this Determinant.

$$\begin{vmatrix} 3 & 5 & 8 \\ 13 & 21 & 34 \\ 55 & 89 & 144 \end{vmatrix}$$

5. Will successive Fibonacci number determinants always yield this answer?

Answers to A.A. 2-D

1.

$U_1 = 1$	$U_{11} = 89$	$U_{21} = 10946$	$U_{31} = 1346269$
$U_2 = 1$	$U_{12} = 144$	$U_{22} = 17711$	$U_{32} = 2178309$
$U_3 = 2$	$U_{13} = 233$	$U_{23} = 28657$	$U_{33} = 3524578$
$U_4 = 3$	$U_{14} = 377$	$U_{24} = 46368$	$U_{34} = 5702887$
$U_5 = 5$	$U_{15} = 610$	$U_{25} = 75025$	$U_{35} = 9227465$
$U_6 = 8$	$U_{16} = 987$	$U_{26} = 121393$	$U_{36} = 14930352$
$U_7 = 13$	$U_{17} = 1597$	$U_{27} = 196418$	$U_{37} = 24157817$
$U_8 = 21$	$U_{18} = 2584$	$U_{28} = 317811$	$U_{38} = 39088169$
$U_9 = 34$	$U_{19} = 4181$	$U_{29} = 514229$	$U_{39} = 63245986$
$U_{10} = 55$	$U_{20} = 6765$	$U_{30} = 832040$	$U_{40} = 102334155$

2. Yes

3. Yes

4. 0

5. Yes

E. S. E. A. Title III – PROJECT I–C–E 59–70–0135–4

Environmental:

Integrated with:

CONCEPT NO. 5 - Air

SUBJECT Advanced Algebra

ORIENTATION Air Quality

TOPIC/UNIT Probability - A.A. 3

BEHAVIORAL OBJECTIVES

Cognitive:

Solve problems which include data on air quality using appropriate probability formulas correctly.

Affective:

Specify dangers of air pollution.

Criticize the sources of air pollution, laws and persons within the community for allowing air pollution to continue.

Weigh alternative solutions to the air pollution problem in his community, asking appro-

Skills Used: (Continued)

1. Applying fractions.
2. Ratios.
3. Probability formulas.
4. Probability tree.

STUDENT–CENTERED LEARNING ACTIVITIES

In-Class:

A. Using the National Wildlife Federation EQ Index, discuss air quality. Sample questions:
   1. Name some of the most dangerous pollutants in the air.
   2. Find a source for each pollutant you have named.
   3. What can be done to control, or eliminate, these pollutants?

B. Review probability concepts and use Worksheet A.A. 3-B.

Outside or Community:

A. Troublesome Tail Pipes. Give Earth a Chance Series. ICE RMC, VF. Use this booklet to become aware of amount of auto pollution.

B. Use, A Citizen's Guide to Clean Air. Give an oral or written report.

C. Use game, Smog: The Air Pollution Game. This acquaints the students with the complexities surrounding control of air pollution.

SUGGESTED RESOURCES	CONTINUED OR ADDED LEARNING ACTIVITIES
Publications: Clean Air, The Conservation Foundation, Washington, D. C. World EQ Index, National Wildlife Federation Troublesome Tail Pipes, Minnesota Environmental Science Foundation, 1970, ICE RMC, VF **Audio-Visual:** Film: The 2nd Pollution, ICE RMC, Film #460 Filmstrip: Environmental Pollution, Our World In Crisis, ICE RMC, FS St 1 Game: Smog: The Air Pollution Game, ICE RMC, SG 1 **Community:**	AFFECTIVE (Continued) priate probability skills.

Worksheet A.A. 3-B

1. One day, at Hot Rod Harry's Used Car Lot; Harry had 12 1972 cars, eight 1971 cars, ten 1970, fifteen 1969 and fifteen cars pre-1969. All post-1970 cars have pollution control devices.

   a. What is the probability that Tom (a consumer) will buy a non-polluting vehicle?

   b. What is the probability that Harry's first three sales will be non-polluting cars?

2. In Smog City, at the annual clean air parade, they had six convertibles in the lead. One was a 1932 Stutz Bearcat. The others were 1973--an Olds, a Cadillac, a Buick, a Lincoln and a Ford. In how many different ways can the cars be arranged, with the condition that the 1932 polluter must be last?

*3. Donona, Pennsylvania, is a small town in the steep valley of the Monongahela River; in 1948, it had a population of approximately 12,000. During October, a temperature inversion formed, which trapped the smoke from factories and fog, to form smog. This lasted six days. Approximately 6,000 people became ill and 15 men and 5 women died. A temperature inversion of this sort occurs approximately 12 days each year (use 360 days per year).

   a. What is the probability that a person will die from smog pollution on a given day?

   b. What is the probability that a person will become ill from smog pollution on a given day?

*4. The lung cancer rate for men over 45 in the smoggiest part of Staten Island, New York, is 55 per 100,000. In less smoggy areas, the rate is 40 per 100,000. Approximately 1 out of 3 men over 45 live in the smoggiest area.

   a. What is the probability a given male over 45 living on Staten Island will have lung cancer?

* Data from Ehrlich and Ehrlich, Population, Resources & Environment, 1970, ICE RMC, 165 Eh

5. The hazard due to smog is great for about 10% of the population who have a predisposition to lung ailments. In 1970, the nitrogen dioxide level exceeded state safety standards on 115 days in the Los Angeles Basin. What is the probability that you, as an average citizen living in the Los Angeles Basin, would become ill due to smog? Use 360 days in a year.

Answers to A.A. 3-B

1. a. $20/60 = 1/3$ b. $\frac{20}{60} \cdot \frac{19}{59} \cdot \frac{18}{58} = \frac{57}{1711}$

2. $5 \cdot 4 \cdot 3 \cdot 2 \cdot 1 = 120$ ways $P(A) = \frac{12}{360} = \frac{1}{12}$

3. A = event of inversion
   B = event of illness
   C = event of death

   $\frac{6000}{6 \text{ days}} = 100$ per day

   $\frac{20}{6 \text{ days}} = 3\ 1/3$ per day

   $P(B/A) = \frac{1,000}{12,000} = \frac{1}{12}$

   $P(C/A) = \frac{10}{26,000} = \frac{1}{3,600}$

   $P(A \cap B) = P(A) \cdot P(B/A) = 1/12 \cdot 1/12 = 1/144$

   $P(A \cap C) = P(A) \cdot P(C/A) = 1/12 \cdot 1/3600 = 1/43,200$

4. A = event of lung cancer in male over 45 in Staten Island.
   B = event of living in smoggiest part of Staten Island.
   C = event of living in clearer sections of Staten Island.

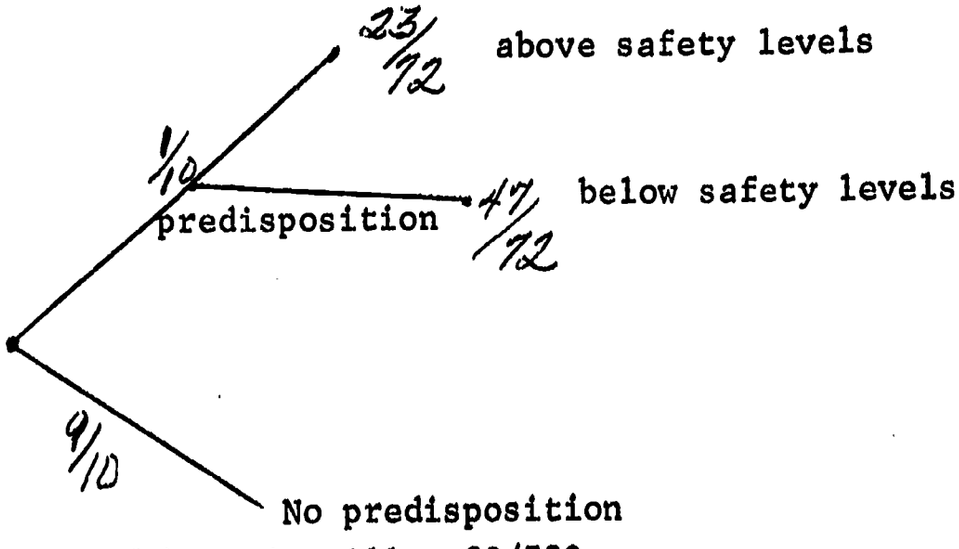
   $P(B) = 1/3$ $B \cap C = \emptyset$
   $P(C) = 2/3$
   $P(A|B) = 55/100,000$
   $P(A|C) = 40/100,000$

   $P(A) = P(A \cap B) + P(A \cap C)$

   $= P(B) \cdot P(A/B) + P(C) \cdot P(A/C)$

   $= 1/3 \cdot 55/100,000 + 2/3 \cdot 40/100,000$

   $= 11/60,000 + 16/60,000 = 27/60,000 = 9/20,000$

5. 

   Probability of becoming ill = 23/720

E. S. E. A. Title III – PROJECT I–C–E 59–70–0135–4

Environmental:

Integrated with:

CONCEPT NO. 7 - Land Use

SUBJECT Differential Calculus

ORIENTATION Resource Conservation

TOPIC/UNIT Max and Min - Calc. 1

BEHAVIORAL OBJECTIVES	STUDENT–CENTERED LEARNING ACTIVITIES	
	In-Class:	Outside or Community:
Cognitive: Solve min-max problems relating to environmental problems, given the appropriate data. Explain the role of min-max principles in the environmental problem solution.	A. See Worksheet Calc. 1-A.	A. Check with local industries--paper mills, etc.--to locate personnel who deal in maximizing profits or minimizing waste.
Affective: Recommend improvement of the efficiency of resources as a way of reducing pollution and utilizing resources to a greater extent.		
Skills Used: 1. Derivatives. 2. Locating minimums and maximums of functions.		

SUGGESTED RESOURCES	CONTINUED OR ADDED LEARNING ACTIVITIES
Publications: On The Shred Of A Cloud, Harper and Row, 1966, ICE RMC, VF	
Audio–Visual: Film: Men At Bay, ICE RMC, Film #250 Kit: Saving What's Left, ICE RMC, KT #28	
Community:	

Worksheet Calc. 1-A

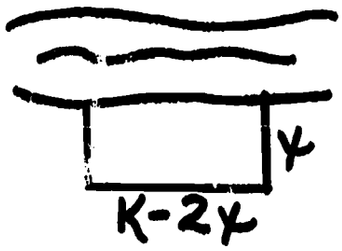
1. One side of an open field is bounded by a straight river. How would you put a fence around the other three sides of a rectangular plot in order to enclose as great an area as possible with a given length of fence?

2. An oil can is to be made in the form of a right circular cylinder to contain one quart of oil (= 57.75 in^3). What dimensions of the can will require the least amount of material?

3. On a small farm, the total cost of producing x acres of wheat each year is $\$(10x^2 + 350x + 25)$ and the price per yield is $\$(2000 - x)$. What should be the yearly output to obtain a maximum total profit? What is the maximum profit?

4. In the problem above, each acre produces 75 bushels of wheat (= approximately 225 cu. ft.). The farmer needs to build a cylindrical storage bin with an open top just large enough to hold his yearly harvest. What are the dimensions which minimize the amount of material used to construct the bin?

Answers to Calc. 1-A

1. 

k = length of fence
Area = x (k-2x) = $kx-2x^2$ = A

$\frac{dA}{cx} = k-4x = 0$

$x = \frac{k}{4}$

The plot should be k/4 wide and k/2 long.

2. 

$V = \pi r^2 h = 57.75 in^3$ $\quad h = \frac{V}{\pi r^2}$

$A = 2\pi r^2 + 2\pi rh$

$A = 2\pi r^2 + \frac{2V}{r}$ $\quad h = \frac{V}{\pi\left(\sqrt[3]{\frac{V}{2\pi}}\right)^2}$

$\frac{dA}{dr} = 4\pi r + \frac{2V}{r^2} = 0$

$4\pi r^3 = 2V$

$r^3 = \frac{2V}{4\pi}$ $\quad = \sqrt[3]{\frac{8V^3\pi^2}{2\pi^3 V^2}}$

$r = \sqrt[3]{\frac{V}{2\pi}}$ $\quad = 2\sqrt[3]{\frac{V}{2\pi}}$

$r = \sqrt[3]{\frac{V}{2\pi}}$ $\quad h = 2r = 2\sqrt[3]{\frac{V}{2\pi}}$ $\quad V = 57.75 in^3$

The height of the cylinder should be twice the radius.

3. Cost = C = $10x^2 + 350x + 25$
Income = I = $2000 - x$
Income/x acres $2000x - x^2$
Profit = P = I - C = $1,650x - 11x^2 - 25$

$\frac{dP}{dx} = 1,650 - 22x = 0$

x = 75 acres

The farmer should plant 75 acres.

4. Total volume = (75) (225) cubic feet = 16,875 $ft.^3$

$V = \pi r^2 h$ $\quad h = \frac{V}{\pi r^2}$

$A = \pi r^2 + 2\pi rh$

$\frac{dA}{dr} = 2\pi r + \frac{2V}{r^2} = 0$ $\quad 2\pi r^3 = 2V$

$r = \sqrt{\frac{V}{\pi}}$ $\quad h = \sqrt[3]{\frac{V^3}{\pi^3}\frac{\pi^2}{V^2}} = \sqrt[3]{\frac{V}{\pi}}$

The height should be equal to the radius.

$r = h = \sqrt[3]{\frac{16,875}{\pi}}$