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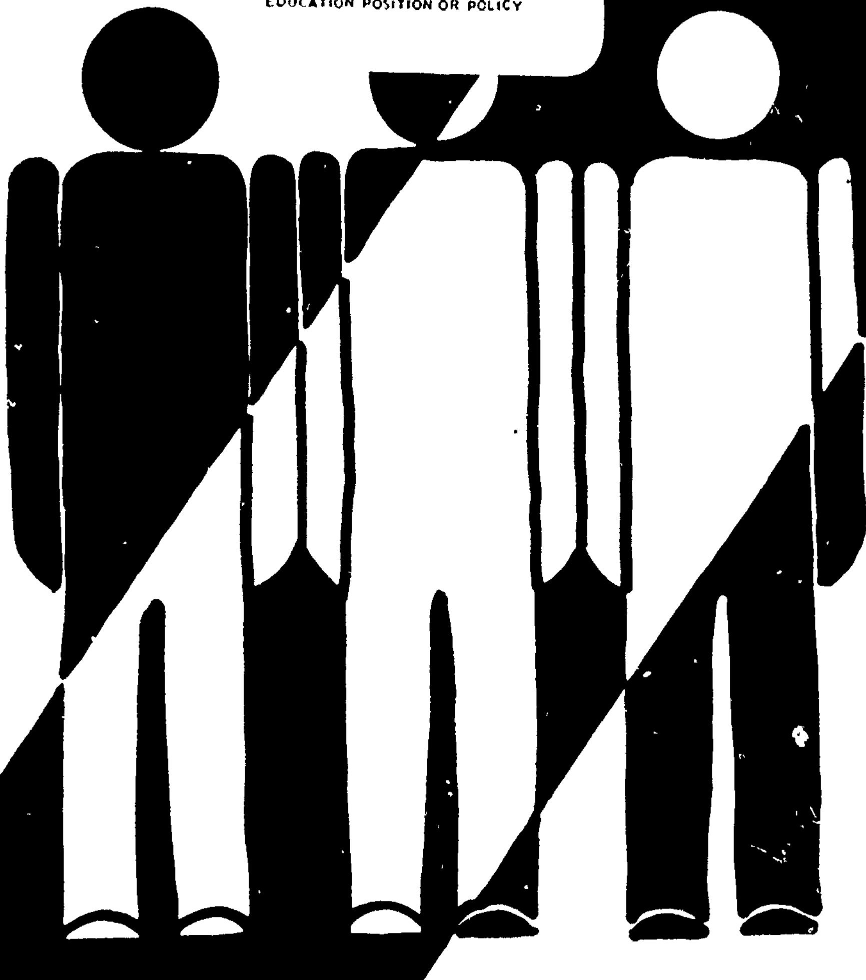
ABSTRACT

It is the purpose of this unit of study to acquaint students with the world of engineering. The activities are intended to simulate problems which might be undertaken by engineers and illustrate the sequence of events leading to their solution. The material is intended for use in the eighth or ninth grades as a supplement or for inclusion into the ongoing science, social studies, and mathematics program. The course is designed to run two to three weeks. Most of the activities are assigned to be completed in a single class period and are designed to produce student involvement. The format of the Teacher Guide includes: title of activity, the major ideas, the behavioral objectives and possible strategy types. Materials and equipment, as well as resources and references, are presented. Suggested answers to questions given and sample data for the experiments are provided. A student activity sheet is given for each lesson. (EB)

engineering



a piece of the action

ENGINEERING: "A PIECE OF THE ACTION"

A MINI-COURSE

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ROBERT LEWIS

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DELAWARE PROGRAM FOR MINORITY ENGINEERS

in Cooperation with

Del Mod System

and

State Department of Public Instruction

Dover, Delaware

DELAWARE PROGRAM FOR MINORITY ENGINEERS

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INTRODUCTION

In the near future the United States will be faced with a critical shortage of engineers. The latest figures indicate that 48,000 graduate engineers will be needed annually from the present to 1980. This figure is exclusive of the associated technicians and closely related content fields generally used to make up engineering teams. Job opportunities exist yet encouragement for youngsters to enter the field is lacking thus causing many youngsters to overlook the excitement inherent to engineering when making career choices.

When students are asked to state what an engineer is and does, the answers range from operating trains or other equipment to the construction and designing of buildings. It is also obvious that the students do not know the educational requirements for engineers. If one accepts the definition of engineering as the application of the knowledge of science and mathematics for utilization by society, then it is necessary for youngsters to acquire a better perception of the engineering field. It is the purpose of this material to acquaint students with the world of engineering. The activities are intended to simulate problems which might be undertaken by engineers and illustrate the sequence of events leading to their solution. It is not intended to serve as an industrial model but rather to stimulate the students' interest in further pursuance of an engineering career. The material is intended for use in the eighth or ninth grades as a supplement or inclusion into the ongoing science, social studies, and mathematics program.

The activities presented were developed largely from materials used in the Technology, People and Environment curriculum which is an outgrowth of the Engineering Concepts Curriculum Project, State University of New York at Stony Brook, New York Development of the material incorporated herein was made possible by a grant from the DuPont Company to the Delaware Program for Minority Engineers and in cooperation with the Department of Public Instruction and the Del Mod System.

Charlotte H. Purnell,
State Director
Del Mod System

John F. Reiher
Supervisor of Science and Environmental Education
State Department of Public Instruction

USAGE TECHNIQUES

- The course is designed to run two to three weeks.
- The activities are designed to allow the teacher flexibility in choosing those areas she or he believes will best meet the needs of the students.
- Most of the activities are designed to be completed in a single class period.
- The student activity sheet may be used one at a time or given in total to students.
- Folders should be provided so that finished activities can be kept to provide the students, as well as the teacher, with information about what is being learned.
- Detailed preparation before using any activity is essential. After the decision to use an activity is made, have the student activity sheets reproduced and gather all the necessary instructional materials as specified in the activity.
- The activities are designed to produce student involvement, so try not to dominate the discussions.
- When the students are working individually or in small groups, make sure to visit them and discuss their work as often as possible.
- The activity Nine Sticks should be used following the Probability With Dice activity. The Yellow Light activity should be used following the Response Time activity.

FORMAT OF TEACHER GUIDE

TITLE:-

MAJOR IDEA(S):-The main purpose(s) for doing the activity.

BEHAVIORAL OBJECTIVE(S):- Specific goal(s) that can be measured by student performance.

STRATEGY:- How to use the activity sheets to achieve the Major Idea(s) and Behavioral Objective(s).

PITFALLS:- Items where teachers may have problems.

MATERIALS AND EQUIPMENT:- Supplies needed for the activity.

RESOURCES AND REFERENCES:- Materials that provide enrichment, background, and extension ideas

SAMPLE RESPONSES:- Suggested answers to questions and sample data for experiments

STUDENT ACTIVITY SHEET(S).- Work and activity sheets given to the students for their use

MATERIALS AND EQUIPMENT

	ITEM	NUMBER
*	1. Film - "A Piece of the Action"	1
*	2. 10" Pipe Cleaners (Arts and Crafts Store)	100
	3. Ruler - Metric	30
	4. Stop Watch (cheapest, simplest)	1
*	5. Large Newsprint Pads (poster paper, art pads the size of newspapers)	2
*	6. Dice (pairs) (any gambling dice, cheapest possible)	30
*	7. IPS structure boxes (Damon Education Division, Needham Heights, MA 99156)	30
*	8. 100 m tapes (long cloth tapes that roll up, type used at track meets to measure javelin, discus)	5
*	9. Slides (Future Bus) (Robert Lewis, contact person)	3
	10. Decibel Meter (desirable, but not necessary)	1
*	11. Q tips	500

*must have

MAJOR IDEA (S) -

(a) Engineers design aircraft for different jobs.
(b) Engineers experiment with different ideas to achieve their goal (s).
(c) Machines in general are designed to match the job that has to be done.

BEHAVIORAL OBJECTIVE (S) - Students should be able to:

(a) match aircraft to their jobs.
(b) use the elements of decision-making in a contest.
(c) discuss why engineers develop many types of machines for different jobs.

STRATEGY -

(a) A brief discussion of the function of different aircraft should take place. Pictures of different aircraft (747, Vertical Take-Off and Landing, single engine plane, etc.) may stimulate discussion.
(b) Student directions are self-explanatory. It might be helpful if a demonstration plane were available when the rules the contest are discussed. Allow students to be creative and allow all aircraft that do not violate the rules.
(c) Stress that in a limited way each student is doing the work of an engineer.

PITFALLS -

(a) This is a very noisy activity, be prepared.
(b) When testing the distance criterion, you may have to go outside the classroom and use a hallway.
(c) Mark a straight line on the floor for the straight flight contest. Remember, planes must fly a minimum of ten feet.

MATERIALS AND EQUIPMENT -

Student Activity Sheets
8½ x 11 paper, paper clips, cellophane tape
Pictures of different aircraft
Stopwatch

RESOURCES AND REFERENCES -

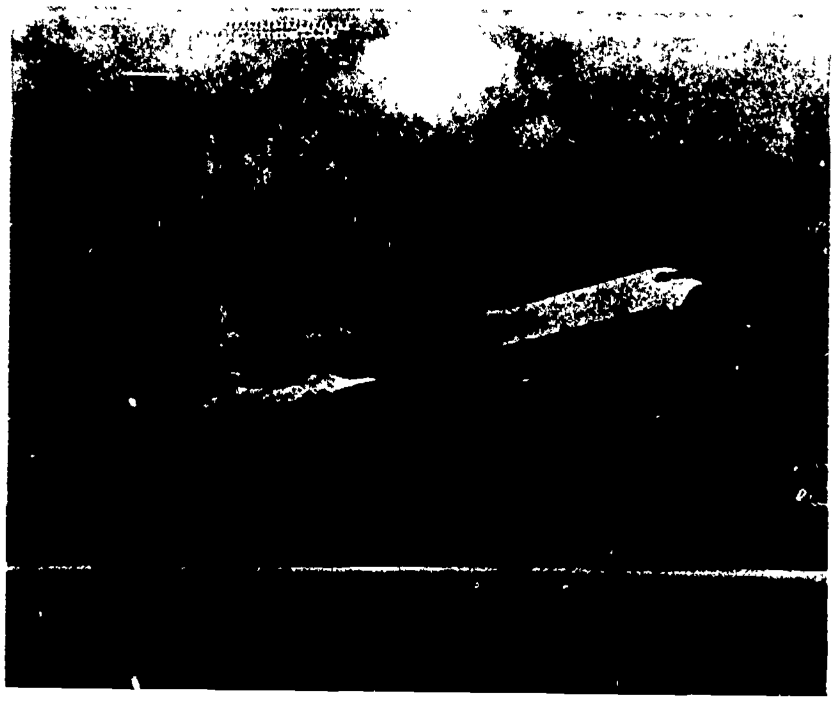
R. S. Barnaby. **How to Make and Fly Paper Airplanes**, New York: Bantam Books.
Mander, Dippel and Gossage. **The Great International Paper Airplane Book.** (First International Paper Airplane Competition conducted by Scientific American Magazine), New York: Simon and Schuster, 1967.

SAMPLE RESPONSES -

1. Responses will vary related to pictures shown and students' knowledge of aircraft.

AIRCRAFT PHOTOS

(May be duplicated for Distribution to Students)



Photos courtesy of Public Information Office, Dover Air Force Base

AIRCRAFT PHOTOS

(May be Duplicated for Distribution to Students)

11

Photos courtesy of Public Information Office, Dover Air Force Base.

STUDENT ACTIVITY SHEET

NAME:____________________
DATE:____________________

Paper Airplane Contest

Let us look at one engineering problem - manned flight - that has produced items that do different kinds of jobs.

Can you name the types of aircraft your teacher will show you?

Does each aircraft do the same job?

What are the reasons for your answers to the above questions?

Today you are going to design your own paper airplane to meet certain objectives.

PAPER AIRPLANE CONTEST

In order for you as an engineer to make a decision about what to do to win a contest, you need to know the rules.

For this contest the objectives for judging are:

distance in flight
time in the air
straightness of flight over ten feet

Model for contest (your engineering problem):
paper airplane

Limits to how you may build the model are:

1. Each plane must be composed of:
   a. one sheet of 8½x11 inch paper
   b. one paper clip for payload weight
   c. one-inch length of cellophane tape
2. Each engineer (you) must enter one plane in each category. You may enter the same plane in more than one category if you wish.
3. Each entrant must build and fly only his or her own airplane.

Record the information about your planes in the table provided. Make as many tests as you wish. The entire class will judge the results after you have finished testing your plane. The winner will be the person who best meets each of the objectives.

Airplane	Distance (Metres)	Time (Seconds)	Straightness (Distance from Center Line)
1			
2			
3			
4			
5			

THINGS TO THINK ABOUT

1. Did you win?

____

____

2. Did anyone have a plane that won in more than one category (class)?

____

____

3. How many different styles of airplanes did your classmate engineers design?

____

____

4. Do you think you could design a better plane now that you have had some experience?

____

____

____

____

____

____

Probability with Dice

MAJOR IDEA (S) -

(a) The study of probability is important for understanding the behavior of the real world.
(b) Some events have a better chance of happening than other events.
(c) The more engineers know about a situation, the more likely they can predict and control the situation.

(a) The study of probability is important for understanding the behavior of the real world.
(b) Some events have a better chance of happening than other events.
(c) The more engineers know about a situation, the more likely they can predict and control the situation.
(d) Engineers and technicians use graphs and tables to illustrate data.

BEHAVIORAL OBJECTIVES (S) - The student should be able to

(a) record his totals from the rolls of the dice in a table.
(b) find the number of possible combinations for getting each of the numbers on the dice.
(c) compare his own results with the theoretical results.

STRATEGY -

(a) The first 3 questions should start the students thinking about probability and the fact that many things cannot be predicted with certainty.
(b) After rolling the dice students should be convinced that some numbers come up more often than do others. You may make a composite graph on the board by finding the total number of 2's, 3's, etc. obtained by the entire class and then using this data to plot the graph. Using the composite graph, you should stress the idea engineers work together on many problems.
(c) The theoretical probabilities tables are included. Remember that since we are dealing with probabilities, it would be extremely unusual if all of the students had the same frequency distribution on their graphs as they find on the tables.
(d) You can extend the activity by letting the students write the odds in the form of a fraction to the right of table 9. The probability of getting a 6 would then be 5/36 for there are 5 ways of getting a 6 out of the 36 possible combinations of the two dice. The students could change these fractions to percent and then compare these percents with those that they can calculate from their own data on the graph where they rolled the dice. This extention is for very good, interested students.

PITFALLS -

(a) This is a very interesting activity for the students. It is important to stress engineers work a great deal with situations where probability is involved. The students may lose sight of the lessons goal because of their enthusiasm for the dice rolling.
(b) Students may have trouble recording their data on the tables. Check to see each person is recording correctly.
(c) Do not let the students get bogged down with mathematics. This can easily happen if you use the extention activity.

MATERIALS AND EQUIPMENT -

Student Activity Sheets, including three data tables

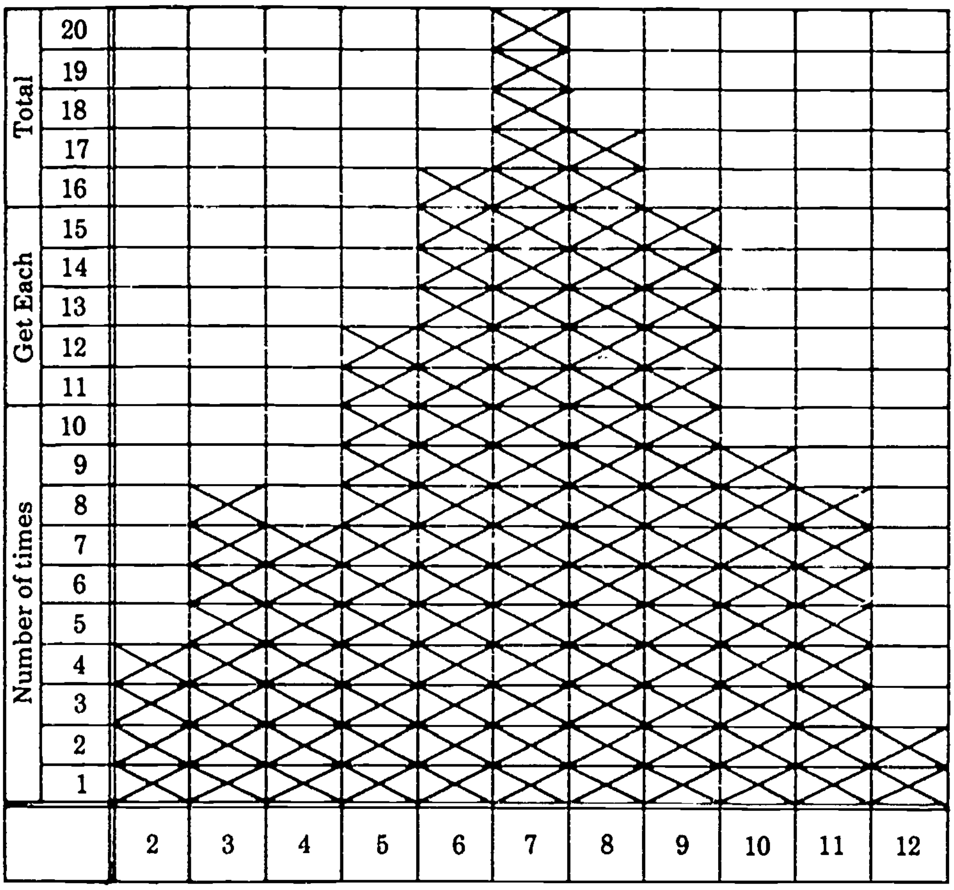
One pair of dice for each student or small group of students

RESOURCE AND REFERENCES -

Engineering Concepts Curriculum Project, The **Man Made World**, New York: McGraw-Hill Book Company, 1971

SAMPLE RESPONSES -

1. No
2. No
3. 6, 7, 8 (student responses will vary)
4. Sample Graph



5. 6, 7, 8
6. 2, 3, 11, 12
7. No

8\.

		Second Die					
		1	2	3	4	5	6
First die	1	2	3	4	5	6	7
	2	3	4	5	6	7	8
	3	4	5	6	7	8	9
	4	5	6	7	8	9	10
	5	6	7	8	9	10	11
	6	7	8	9	10	11	12

9\.

Total of Both Dice	No. of Ways to Get Total
2	1
3	2
4	3
5	4
6	5
7	6
8	5
9	4
10	3
11	2
12	1

10. 6, 7, 8
11. 2, 3, 11, 12
12. No
13. Yes
14. Yes

STUDENT ACTIVITY SHEET-

NAME:____________________

DATE:____________________

Probability with Dice

Many times engineers try to predict what will happen in the future so they can help people be prepared.

The more engineers know about a situation the more likely they can predict the outcome of the situation. In this activity you will predict some events.

1. Is the weather man certain about the weather?
2. Do you know who will win the next Super Bowl?

Hearing the weather report helps you to decide what to wear. Knowing the records of the teams helps you to predict who will win the game. Although you still can't be sure that it will rain or which team will win, the more you know about the situation, the better your chances are of correctly predicting what will happen.

The meaning of the word probability will be clearer to you after you have rolled the dice in this experiment.

3. If you roll two dice at the same time, what are the three numbers most likely to come up?

It's now your turn to roll a pair of dice and see what you get.

(a) Roll the pair of dice.
(b) Add up the two numbers.
(c) Put an X in the graph above the number that you rolled.
(d) Continue rolling the dice and making X's until one number has come up 20 times.

Graphical Model of Your Dice Rolls

Number of Times Get Each Total											
20											
19											
18											
17											
16											
15											
14											
13											
12											
11											
10											
9											
8											
7											
6											
5											
4											
3											
2											
1											
Total on Dice	2	3	4	5	6	7	8	9	10	11	12

Now answer these questions.

5. Which 3 numbers come up the most often?

____

6. Which 4 numbers come up the least often?

____

7. Are the chances the same for getting each of the numbers?

____

____

____

____

Now it's time to find your chances without throwing the dice.

(a) Fill in each square in the left table with the number you would get if you got the numbers to the left of that square on one dice and the number above that square on the other dice.
(b) The 6 is already filled in as an example. (2 on the left plus 4 above equals 6.)
(c) Fill in the table at the right by counting the number of 2's, 3's etc. inside the double line in the left table

8.

First Die \ Second Die	1	2	3	4	5	6
1						
2				6		
3						
4						
5						
6						

9.

Total of Both Dice	Number of ways to Get Total
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	

10. Which 3 numbers do you have the best chance of getting?

_____ _____ _____

11. Which 4 numbers do you have the least chance of getting?

_____ _____ _____ _____

12. Do you have the same chance of getting each of the numbers?

____

13. Are the numbers that you have the best and least chance of getting using the tables almost the same as the numbers you got the most and the least often when you actually threw the dice?

____

MAJOR IDEA (S) -

(a) Most problems faced by engineers, students, etc., can be written in the elements of decision making format.
(b) Games are really only problems to be solved.
(c) Many games have step-by-step procedures (algorithms) which lead to their solution.
(d) Engineers use step-by-step procedures to solve problems and make predictions.

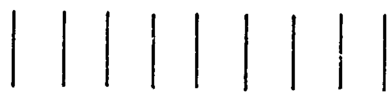
BEHAVIORAL OBJECTIVE (S) - The student should be able to

(a) follow the rules in playing the game.
(b) discover some strategies that will improve his chance of winning.
(c) see engineering as a series of problem solving situations.

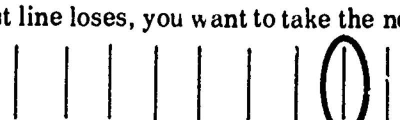
STRATEGY -

(a) This activity should follow Probability with Dice.
(b) After the students have read the rules, pair them up, give each pair 9 sticks and tell them to begin playing. The students should place an X in the correct place on the score card after each game. The 10 is no magic number so have students continue for as long as you desire.
(c) Engineers solve many problems. Stress the idea that problem solving can be fun and rewarding.
(d) You can make the game into a contest by letting the winning students play other winning students until you finally have a class champion. Don't get hung up if the students can't write down a winning algorithm.
(e) Don't run this activity into the ground, but don't stop if interest remains high. The game can be continued for another day by changing the number of objects to 13, 17 or 21, by changing the goal so that the person taking the last object wins, or by having players pick up 1, 2, 3, or 4 objects at a time.
(f) The following algorithm can be adapted to any of the above changes. For simplicity, lines will replace sticks or other objects.

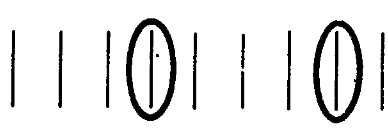
1. Draw 9 lines on the paper.



2. Start at the end and work backwards.
3. Since the person who takes the last line loses, you want to take the next to the last line. Put a circle around it.



4 To be sure that you take the circled line, you must take the fourth one back from it. (the four is one more than the maximum number of lines you are allowed to take in one turn). Continue backward marking every fourth line until you reach the beginning.



5 Be sure that you take the first circled line. Then take enough lines to make the sum of the ones you take plus those your opponent took on his turn equal 4. (Four is again one more than the maximum number of lines you are allowed to take in one turn.)

6 For 9 lines taken 1, 2, or 3 at a time, the person going first can win only if he can take one of the circled lines and then go on in groups of 4 from there. The second person should win every time by not allowing the first person to take one of the circled lines.

7 If students work out the algorithm they can predict who will win. Engineers solve problems and make predictions based on step by step procedures. Discuss this concept with students relating the procedure to other problems.

PITFALLS-

(a) Do not reveal the solution to any students until all classes have played the game. "The word" spreads quickly.

(b) After several games students will see they can't win or will win and want to start again. Encourage students to "play out" each game.

MATERIALS AND EQUIPMENT -

Student Activity Sheets
Nine objects for each pair of students (toothpicks, wooden sticks from book holder activity, etc.)

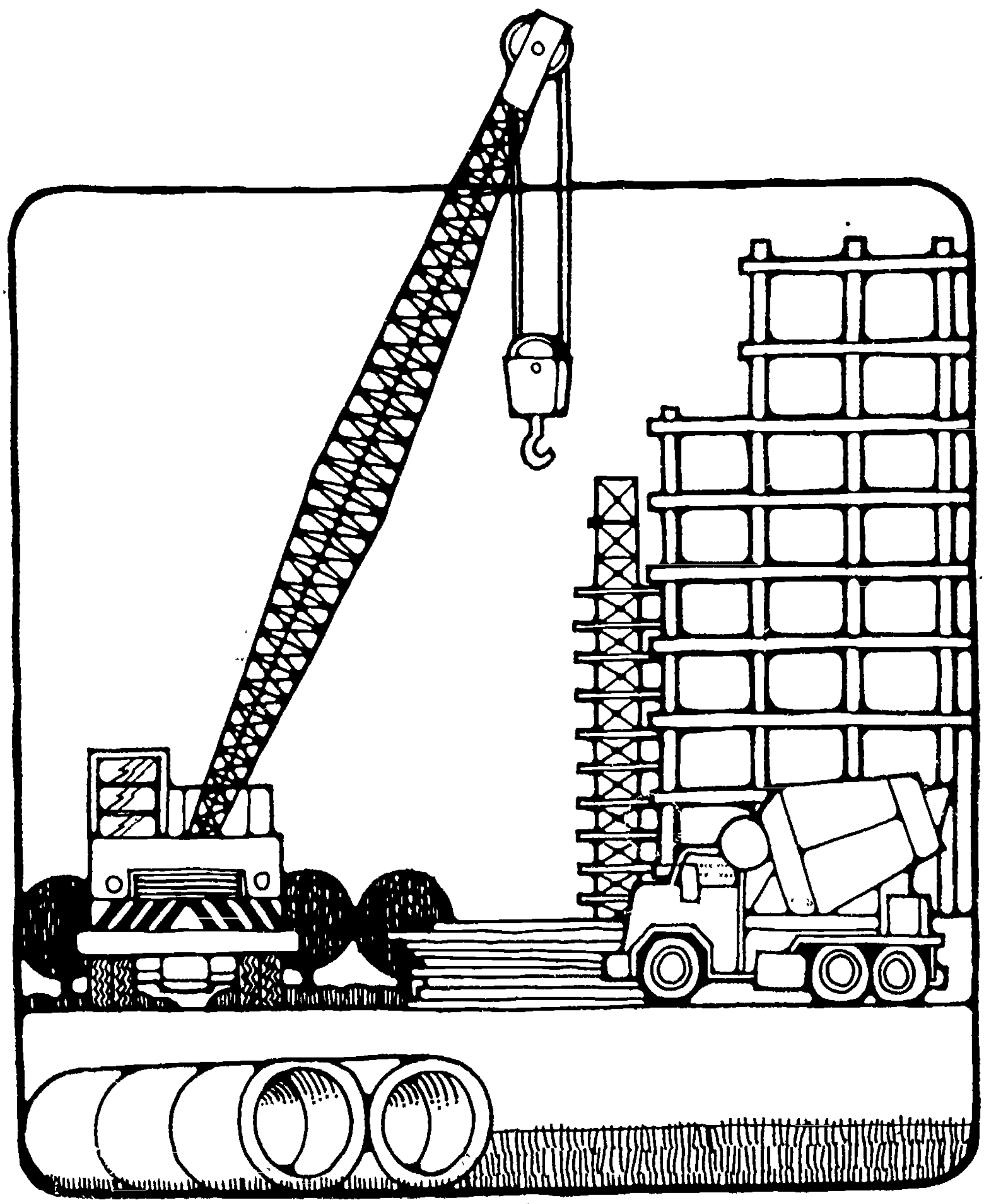
RESOURCES AND REFERENCES -

Engineering Concepts Curriculum Project, The Man Made World, New York: McGraw-Hill Book Company 1971

SAMPLE RESPONSES -

1. Second

2. Hopefully, yes.



STUDENT ACTIVITY SHEET -

NAME:________________
DATE:________________

Nine Sticks

Now that you have had some experience with probability and prediction let's play a simple engineering game. You may be able to figure a way to predict who will win every game.

Everyone likes to play games Usually we play them for fun but we often learn something from them. Games are really problems that have to be solved Engineers spend a great deal of time solving problems. Most engineers enjoy their work helping to solve problems.

All games have several things in common. First they give you something to play with - cards, pencil and paper, dice, or a playing board Next, they have a goal which you try to achieve. They also have rules. These rules list those things that you can and cannot do Finally, games have a winner. He's the one who first reaches the goal. He has solved the problem first.

It is sometimes possible to find a method for winning the game. You can predict who will win every time. That's your job for today.

The rules of this game are really quite simple.

Rules

1. Equipment - A pile of 9 objects
2. Players - Two students
3. Goals - To have your opponent pick up the last object.
4. Rules - Each player must pick up either 1, 2 or 3 objects at a time. Players take turns picking up objects.
5. Your Job - Find a method so that you can always win. You then can predict early in the game that you will win.

Score Card

Game	1	2	3	4	5	6	7	8	9	10	Totals
Won											
Lost											

1. Do you win more often when you go first or when you go second?________________

   If you win a lot, show your teacher your winning method.

2. Were you able to engineer (to manage) a way to always win?________________

MAJOR IDEA (S) -

(a) Decision making is an important process in engineering.
(b) It is easier to make individual decisions than group decisions.
(c) People can be trained to work well in groups.

BEHAVIORAL OBJECTIVE (S) - The student should be able to

(a) follow the directions in completing the activity.
(b) calculate his or her own score as well as the group's score for the activity.
(c) draw conclusions based on group discussion.

STRATEGY -

(a) Divide students into groups of four to seven persons.
(b) Discuss the survival problem carefully, checking to see that each person understands what he or she is supposed to do.
(c) Each group should complete the chart as follows:
  1. the first 10 minutes filling in the "Your Ranking" column.
  2. the second time interval will be much longer as students fill in the "Group Ranking" column.
  3. allow time for the score tallying and discussion.
(d) Scoring Key
Listed below are the correct rankings for the Lost on The Moon items, along with the reasons for the rankings provided by the NASA's space-survival unit.

(15)	Matches	Little or no use on moon
(4)	Food Concentrate	Supply daily food required
(6)	Nylon Rope, 15 cm.	Useful in tying injured, help in climbing
(8)	Parachute Silk	Shelter against sun's rays
(13)	Portable Heat Unit	Useful only on dark side of moon
(11)	Two .45 Calibre Pistols	Self protection devices could be made from them
(12)	Dehydrated Milk, 1 Case	Food with water for drinking
(1)	Two 100-Pound Oxygen Tanks	Fills respiration requirements
(3)	Star map, Moon's Constellations	One of principal means of finding direction
(9)	Life Raft	CO2 bottle for self-propulsion across chasms, etc.
(14)	Magnetic Compass	Probably useless-no magnetized poles
(2)	5 Gallons of Water	Replenishes loss by sweating, etc.
(10)	Signal Flares	Distress call within line of sight
(7)	First-Aid Kits, Injection Needles	Oral pills or injection medicine valuable
(5)	Solar Powered FM Receiver-Transmitter	Distress signal transmitter, possible communication with mother ship

(e) If you take time to work up some sound effects and have access to a cassett recorder, the results of a good recording session can be very satisfying. For example, an AM radio receiver turned between stations will produce a nice hissing sound to back up the class as they attempt to reach decisions. Try to dig up a recording of the 2001. A Space Odyssey sound track or other space music to use with the introduction to the problem. This can also be interspersed with the hissing of the radio during class.

PITFALLS -

(a) Students may have some difficulty getting started with their ranking. Remind them they must decide quickly.

(b) Since the group decisions must be unanimously acceptable, the discussions may become "heated" at times. An interesting idea here is to place the students so you have a group of quiet persons working together, while another group might be made up of more "outgoing" students.

(c) Check the scoring procedure. Remember, it's the difference (above or below) between their score and NASA's engineers that counts.

MATERIALS AND EQUIPMENT -

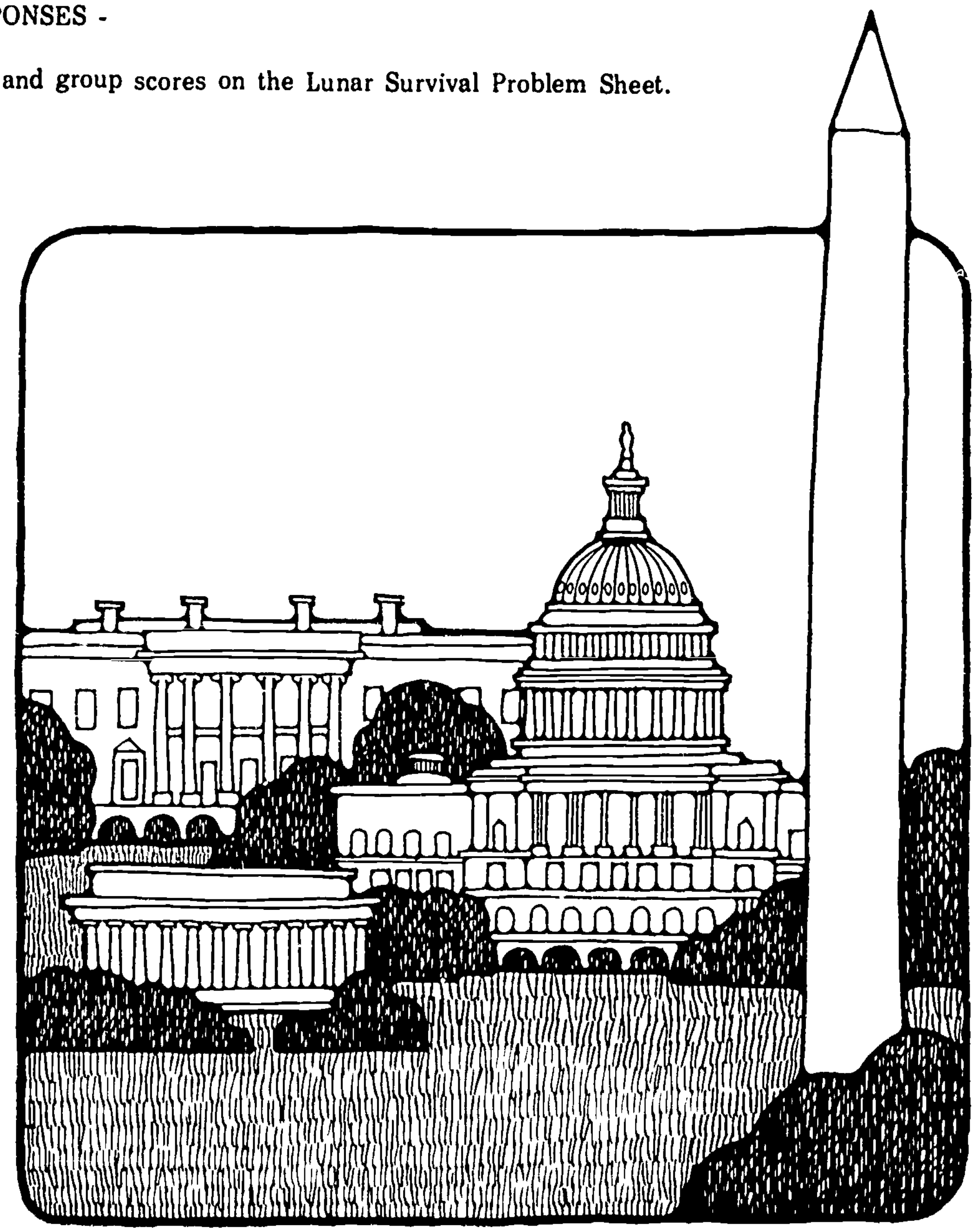
Student Activity Sheets
Paper and pencil
Cassette recorder and AM radio

RESOURCES AND REFERENCE -

Dyrli, Lanagan and Liao, Designing for the Future, Middletown, Conn.: Xeron Corporation, 1973.

SAMPLE RESPONSES -

1. Individual and group scores on the Lunar Survival Problem Sheet.



STUDENT ACTIVITY SHEET

NAME:____________________
DATE:____________________

Lost on The Moon

Engineers working alone or in groups must make many quick decisions. This activity will give you an opportunity to make decisions both by yourself and with a group.

Let's suppose you (an engineer) are a member of a NASA ground control team. Mechanical difficulties have forced the ship you are working with to crash-land at a spot 200 kms from its meeting point with the mother ship. The astronauts cannot remain in their ship because their life-supprot system has malfunctioned due to the rough landing. You must help the crew reach the mother ship before nightfall.

Your crew can make it to the mother ship if you make the "best decisions" as to what items they are to take with them from the damaged ship.

You should be aware of the following:

1. On the moon there is no atmosphere, no food, no water.
2. Temperatures are very cold in shadows and very hot in sun light.
3. 200 kms is a great distance to travel, even in the moon's gravity.
4. An item that weighs, say 60 kilograms on earth would weigh only about 10 kilograms on the moon.
5. About 0.3 kg. per hour of oxygen is a reasonable flow rate for a human's normal breathing.
6. A man on foot can travel faster on the moon than he can on earth.

Survival Procedure

1. By yourself rank each of the 15 items listed on your chart according to their importance so that the astronauts you are helping can complete the mission. In the column marked "Your Ranking" place a "1" by the most important item, "2" by the second most important, and on through 15, the least important.

2. After you have finished your own ranking, compare and discuss your answers with the other NASA engineers assigned to your group. All of you must arrive at a unanimously acceptable group decision. Record the rank order that the group works out in the "Group Ranking" column. Remember the crew is waiting for your decision.

SCORING PROCEDURE

Once you and your group have filled in the first two ranking columns on the Lunar Survival Problem Sheet, you are ready to compare your ratings with NASA Engineers.

1. Fill in the NASA Ranking column on the problem sheet by using the NASA answer key your teacher will provide you.

2. For each item find the difference in points between NASA ranking and your ranking.

   EXAMPLE: For the two items below, your ranking was three points away from NASA's. It does not matter whether the NASA rating was higher or lower than yours. Find the difference.

	Your Ranking	NASA Ranking	Your Error Points
Item X	4	7	3
Item Y	8	5	3

3. When you have completed the Your Error Points column, add the error points together to find your own total error points. The lower the error total is, the better your score.

4. Determine the error points for your Group Ranking and the total error points for your group in the same way as in Step 3. The lower the total is, the better the group ranking.

5 Compare Your Error Points column with your Group Error Points column. Did the group get a better score?

6. Compare your Group Error Points column with other groups. Did your group get a better score? Did your astronauts survive?

Engineers work together to solve many problems. Do you work well in groups? Dr. Jay Hall, the originator of the lunar survival problem has shown that most people can be trained to work well in groups.

Lost on The Moon Problem Sheet

Item	Your Ranking	Group Ranking	NASA Ranking	Your Error Points	Group Error Points
Matches					
Food Concentrate					
Nylon Rope, 50 m					
Parachute Silk					
Portable Heat Unit					
Two .45 Calibre Pistols					
Dehydrated Milk, 1 Case					
Two 100-kg Oxygen Tanks					
Star Map-Moon's Constellations					
Life Raft					
Magnetic Compass					
5 Kilolitres of Water					
Signal Flares					
First-Aid Kits, Injection Needles					
Solar Powered FM Rec.-Trans.					
			TOTAL ERROR POINTS		

MAJOR IDEA (S)

(a) The nation's use of electricity is rising at a rapid rate.
(b) The time may come when the individual's use of electricity may be limited.
(c) Engineers are seeking a solution to the energy problem.

BEHAVIORAL OBJECTIVE (S) - The student should be able to
(a) make a list of appliances that use less than a given amount of electricity.
(b) identify the criteria used for making the selection.
(c) list ways engineers can help reduce electrical use.

STRATEGY -

(a) In using the activity, emphasize the fact that our supply of electricity is limited and that this may soon have an effect on each student's life style. Ask the question - can engineers help?
(b) One way to introduce this activity is to bring in as many appliances as possible and then let the students guess the wattage of each. You can then plug them into a fused circuit showing the effect of overload; a clock and a radio do nothing while a toaster and an iron will blow a 15 amp fuse. Plugging the various appliances into a wattmeter can also be an effective demonstration. These demonstrations all show the wattages of appliances. You must remember that the student sheets are based on the annual kw-hr. which takes the time of use into account. The appliance using the most watts may not be first on the list since it may not be used as many hours in a year as one of fewer watts.
(c) Correctly answering questions 2 and 3 is really not important. What counts is that the students realize that different appliances use different amounts of electricity. The students can then compare their answers with the table on Sheet 2.
(d) Questions 4-6 point out some of the possible criteria that students could use in making their choices. Another aid in deciding could be whether or not a similar gas appliance is available - range or clothes dryer. Besides the constraint given - total kw-hrs. of electricity used in a year - the student could also be constrained by the cost of the appliances or the cost of electricity, making it not feasible to use the full 5700 kw-hr/yr. Question 7 should lead to a class discussion of solutions for the problem.
(e) The wattages of various appliances can be discussed from the table on the transparency master. Here you can have the class make choices as to which appliances they might use simultaneously if they were limited to a given power load.
(f) Students could go home and read their own electric meters on two consecutive days at the same time or else they could bring in a monthly electric bill. Using a rate schedule, they could then figure out what the bill should have been based upon by calculating the actual time they think each appliance was used during the day, month, or even year.

PITFALLS -

(a) Students may have trouble deciding what appliances to choose. Emphasize some things (clocks, stoves, etc.) are necessary, others are not.
(b) The extended activity is very effective if done for homework, then followed up in class the next day.

MATERIALS -

Student Activity Sheets
Optional-different appliances, fused electrical outlet, wattmeter
Rate schedule from Delmarva Power and Light Co.
Transparency and overhead projector

MASTER FOR THE TRANSPARENCY

WATTAGES OF VARIOUS ELECTRICAL APPLIANCES

Appliance	Wattage	Appliance	Wattage
Air-Conditioner	1100	Heat or Sun Lamp	300
Automatic Toaster	1200	Hot Plate	1500
Automatic Washer	700	Iron	1650
Broiler	1000	Light Bulb	60-100
Coffee Pot	1000	Oil Burner	250
Egg Cooker	600	Portable Fan	100
Deep Fryer	1320	Portable Heater	1650
Dehumidifier	350	Radio	100
Dishwasher	1500	Electric Range	8000
Dry Iron or Steam Iron	1000	Refrigerator	200
Electric Blankets	200	Rotisserie	1380
Electric Clock	2	Roaster	1380
Clothes Dryer	4500	Black-and-White TV	350
Freezer	350	Vacuum Cleaner	300
Fluorescent Lights (Each Tube)	15-40	Ventilating Fan	400
Griddle	1000	Waffle Iron	1320

RESOURCES AND REFERENCES -

Engineering Concepts Curriculum Project, **The Man Made World**, New York. McGraw-Hill Book Company 1971

SAMPLE RESPONSES -

1. Individual responses
2. Yes
3. Refrigerator, range, television
4. Clcck, toaster, radio
(Answers 3 and 4 are for a yearly basis. If you consider only the wattage, then the order would be electric range, toaster, and iron for the most and clock, radio, and refrigerator for the least.)
5. Yes
6. Yes
7. Yes
8. Individual responses. Example - Design more efficient appliances.

THE CITY OF DOVER, DELAWARE

ELECTRIC RATES

JULY 1, 1974

RESIDENTIAL SERVICE:	BILLING MONTHS June through October	BILLING MONTHS November through May
First 15 KWHRS @	13.33c per KWH	13.33c per KWH
Next 30 KWHRS @	7.00c per KWH	7.00c per KWH
Next 105 KWHRS @	4.42c per KWH	4.42c per KWH
Next 350 KWHRS @	2.80c per KWH	2.80c per KWH
Next 500 KWHRS @	2.70c per KWH	1.86c per KWH
Over 1,000 KWHRS @	2.70c per KWH	1.60c per KWH

OUTDOOR LIGHT RATES AVAILABLE BY REQUEST

+ Fuel Adjustment Clause Applies To All Rates

+ 5% Delaware State Utility Tax Applies to All Rates

For complete details concerning rates. please contact:
The City of Dover Electric Office at City Hall.

STUDENT ACTIVITY SHEET -

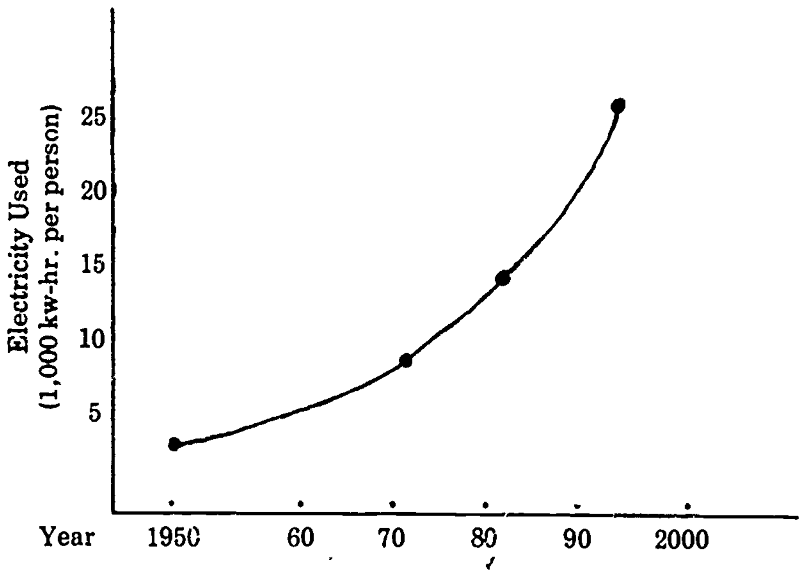
NAME:______________________

DATE:______________________

Power to the People - Electricity

The world is having an energy crisis. Engineers are working to solve this problem. Let us look at one small part of the energy problem.

1. Do we really need all the electricity that we use?______________________
2. Are we using more electricity year after year?______________________



3. What three electrical appliances in your home do you think use the most electricity in a year?

______________ ______________ ______________

4. What three electrical appliances in your home do you think use the least electricity in a year?

______________ ______________ ______________

The only thing that now limits the amount of electricity we use is the amount of money we can spend on appliances and on electricity. In the future, the government may have to limit the electrical energy that each house can use. If the government doesn't, we may not have enough electricity to go around.

The amount of electrical energy that an appliance uses depends upon the number of kilowatts and the length of time the appliance is used. If you were only allowed to use 5700 kilowatt-hours of electricity in a year, which of the appliances in the table would you use? Place a check before the appliances that you would use and then add up their total kilowatt-hours.

Appliance	Average Kilowatt Hours Used in a Year	Kilowatt-Hours of Appliances Chosen
Refrigerator	1800	
Electric Kitchen Range	1200	
Toaster	40	
Dishwasher	400	
Electric Coffeepot	110	
Hot Plate	90	
Radio	90	
Color TV	500	
Black-and-White TV	360	
Electric Blanket	150	
Vacuum Cleaner	50	
Automatic Washer	100	
Clothes Dryer	1000	
Iron	150	
Room Air-Conditioner	1400	
Electric Room Heater	180	
Electric Lights	1500	
Electric Clock	20	
		Your Total__________

(must be less than 5700 kwhr)

Look at the items you chose.

5. Do they make your work as easy as possible?____________________
6. Do they make you as comfortable as possible?____________________
7. Could you get by with fewer appliances?____________________
8. What can engineers do to help you save electricity in your home?____________________

MAJOR IDEA (S) -

(a) Recognition that in engineering there are priorities and that not everything can be placed directly in front of the driver.
(b) First-hand experience is gained in engineering a machine to a man.
(c) Introduce the idea engineers must meet certain criteria.

BEHAVIORAL OBJECTIVES (S) - The student should be able to

(a) draw a model of an automobile dashboard using the instruments listed.
(b) compare his model with the listed engineering criteria.

STRATEGY -

(a) It is important that the student read the questions. The questions are really the criteria that are used by designers. You may want to emphasize the idea that engineers have a reason for putting the instruments where they are. The instruments didn't just happen to get there.
(b) Variables that you may discuss include the size and the shape of the dials or gauges, the use of pull or slide switches, the use of gauges, or indicator lights, the placement of the instruments, and the vertical or horizontal movement of levers.
(c) The conflicting criteria could also be mentioned. Should an instrument give you a lot of information and be harder to read, or should it be easier to read but give you less information?
(d) Bring out the need for trade-offs based on priorities. Are "idiot" lights better than meters? ("idiot" lights are lights that indicate when oil pressure is too low, temperature is too high, or battery is discharging. the warning light goes on after the fact, instead of warning you as it gradually happens.)
(e) Remember that the main purpose of the exercise is to get the student to think about the reasons for doing things and to match the dashboard to the driver, rather than to get a prize-winning work of art. You may want the students to redesign the dashboard for homework. You may get some automotive manuals for samples. Also see transparency master.
(f) Consider the suggestions in Resources and References as either replacement or as extension activities.

PITFALLS -

(a) Students usually want to change their design after starting. Have plenty of erasers. Suggest students use pencil.

(b) Don't overlook the extension activities if some students do not seem interested in the dashboard design.

MATERIALS -

Student Activity Sheets
Pencils and erasers
Ruler for each student
Transparency and overhead projector
Automotive manuals

RESOURCES AND REFERENCES - Extension Activities

(a) Newspapers are good sources for pictures or line drawings of stoves and vacuum cleaners. Students can evaluate how these machines match the human user in any or all of the following aspects:

1. **Stoves**
   Gas vs. electric
   Position of burners
   Position of knobs
   Safety devices - protection from children's play
   Ease of cleaning
   Height of oven
   Convenience of broiler
   Wall ovens
2. **Vacuum cleaners**
   Convenience of on/off switch
   How do you remove dirt bag?
   Weight (is it heavy?)
   Ease of movement
   Does cord get in way?
   Can cleaner get into corners or under furniture?
   Is it repair free?

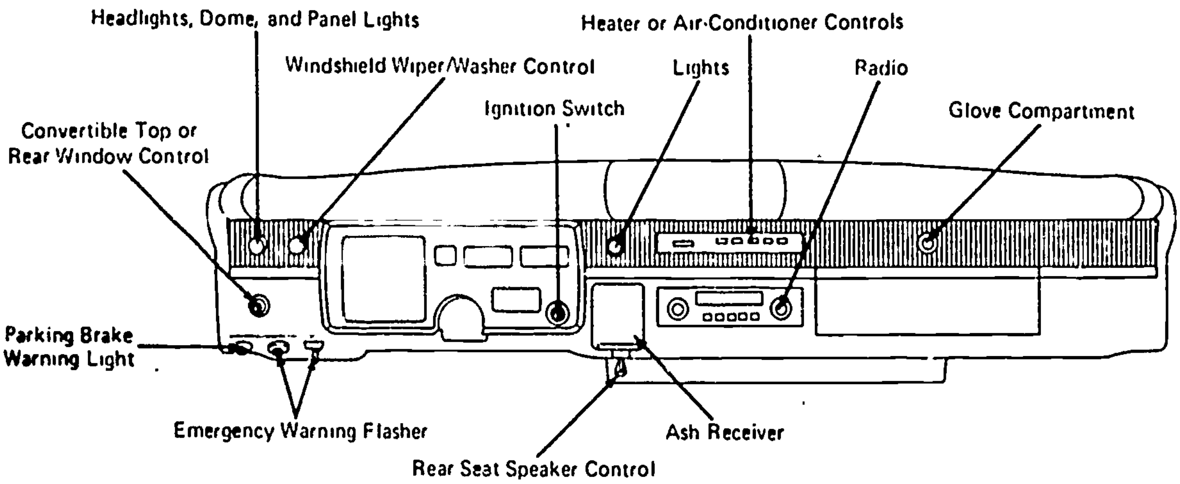
(b) Back issues of Consumer Reports.

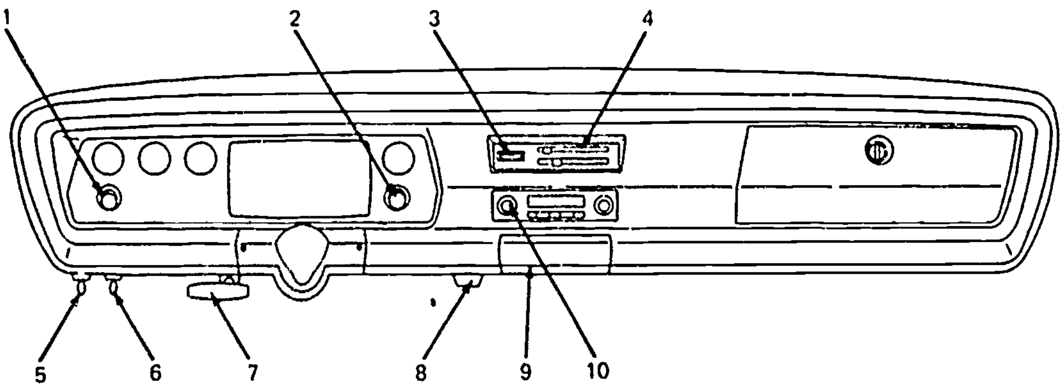
SAMPLE RESPONSES -

1-5. The answers are very subjective and depend on the student's dashboard design. No answer or design is really "wrong." Ideally the answer to each question is yes.
6. Answers will vary depending on dashboard design.
7. Same as Question 1-5.

MASTER FOR THE TRANSPARENCY

AUTOMOBILE DASHBOARD LAYOUT





1. Headlights, Dome, and Panel lights
2. Windshield Wiper and Optional Washer Controls
3. Fan Switch
4. Heater or Air-Conditioner Controls
5. Rear Defogger Control (Optional)
6. Map Light Switch (Optional)
7. Parking Brake
8. Reverse Light (Manual 4-spd. trans.)
9. Ash Tray and Lighter
10. Radio Controls (Optional)

STUDENT ACTIVITY SHEET -

NAME:____________________
DATE:____________________

Automobile Dashboard Layout

Airplanes and automobiles have controls and instruments on their dashboards. These controls and instruments are necessary for the safety and comfort of the passengers. Engineers design and place instruments so that pilots or drivers can use them.

All machines must be matched to the abilities of the person using the machine.

Why are instruments placed on a dashboard in certain locations? On your "layout" sheet you will be asked to design an automobile dashboard.

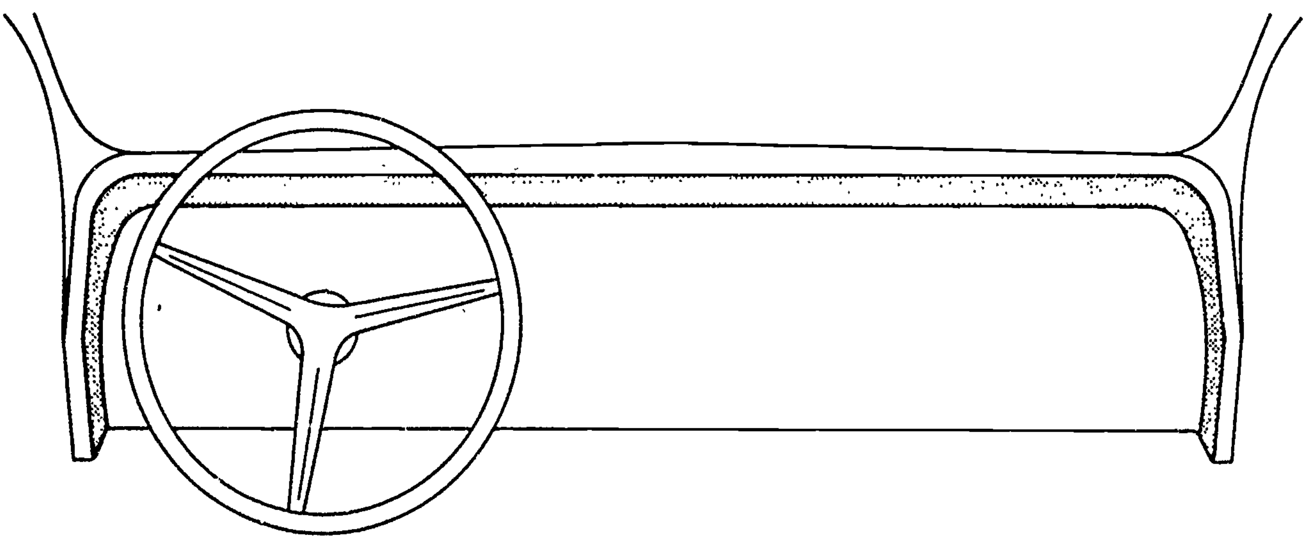
I didn't see the telephone pole, because I was looking for the Radio Switch.

Read these questions and keep them in mind while you are drawing your dashboard. Don't answer them now.

1. Is the most important instrument the easiest to read?____________________
2. Can the driver reach all of the switches and knobs?____________________
3. Can the driver read the instruments quickly so that he doesn't have to take his eyes off the road for a long time?____________________
4. Could someone who has never been in the car quickly figure out where everything is located?____________________
5. Would it make any difference if the person were left handed?____________________
6. If a person were handicapped (one arm or leg, etc.), what difference would this make when designing a dashboard?____________________

Draw a dashboard layout for an automobile in the space below. Include the following switches, gauges, and lights. You may make them any shape or size. Label the instruments with the letters from the list below.

A=	Air-Conditioner Control	H=	Heater Control	S=	Speedometer
C=	Clock	L=	Light Switch	T=	Temperature
F=	Fuel Gauge	O=	Oil Pressure	TS=	Turn Signal Light
G=	Generator	R=	Radio	W=	Windshield Wiper
GC=	Glove Compartment	AT=	Automatic Transmission		



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TEACHER GUIDE - **What's The Problem? - Abandoned Cars.**

MAJOR IDEA (S) -

(a) Brainstorming is a technique used by engineers for getting new ideas.
(b) Automotive technology has brought with it problems.
(c) One automotive problem is disposal of old cars. In this case the problem is the people's lack of concern.
(d) Engineering technology can be used to help solve the problems created by the automobile.

BEHAVIORAL OBJECTIVE (S) - The student should be able to

(a) state several consequences of leaving cars on the street.
(b) state several consequences of having abandoned cars removed from the streets.
(c) make an evaluation of the good or bad nature of the consequences.
(d) state several possible solutions to the problem.
(e) make an evaluation of the good or bad nature of the solutions.
(f) work in groups using brainstorming techniques.

STRATEGY -

(a) Divide the class into groups of four or five students and get one student to be group recorder for his group. (Recording and display can be done with large newsprint sketch pads and felt tip markers, if available.)
(b) Each group should do all the questions. The groups should spend
   1. the first ten to fifteen minutes just getting ideas recorded
   2. the second five minutes eliminating duplicate and irrelevant items and arriving at a list of the most important items (typically less than six or seven items)
   3. the remaining ten minutes ranking the items according to importance. The reasons for their choice should be recorded. The students should be aware that their criteria for ranking importance determined the final sequence.
(c) Compile a class list of one of the questions on the board (or hand newsprint page).
(d) Ask class to eliminate duplicate items and then open the floor for additional items now that everyone can see all the ideas.
(e) Discuss possible solutions, but do not feel a solution must be agreed on.
(f) Discuss the brainstorming techniques. The idea that one person or group combined with a second, third, etc. brings new pathways of thought to the surface quickly and usually easily.
(g) The procedure used in this activity can be used on any article from the newspaper. The more specific the problem, the easier it is to get it started with new groups.

PITFALLS -

(a) Students may have difficulty beginning the activity. Move from group to group giving hints and suggestions.

   EXAMPLE. Have you ever seen an abandoned car with parts that look like they could be used? Why would people throw away good material?
(b) Once groups "get into" the activity discussion can be very loud and forceful. Be ready to quiet some groups.
(c) You may have to urge students not to discuss some ideas too long. Remind them of the time schedule.

MATERIALS AND EQUIPMENT -

Student Activity Sheets
Felt tip markers
Recording pads (large newsprint pad)

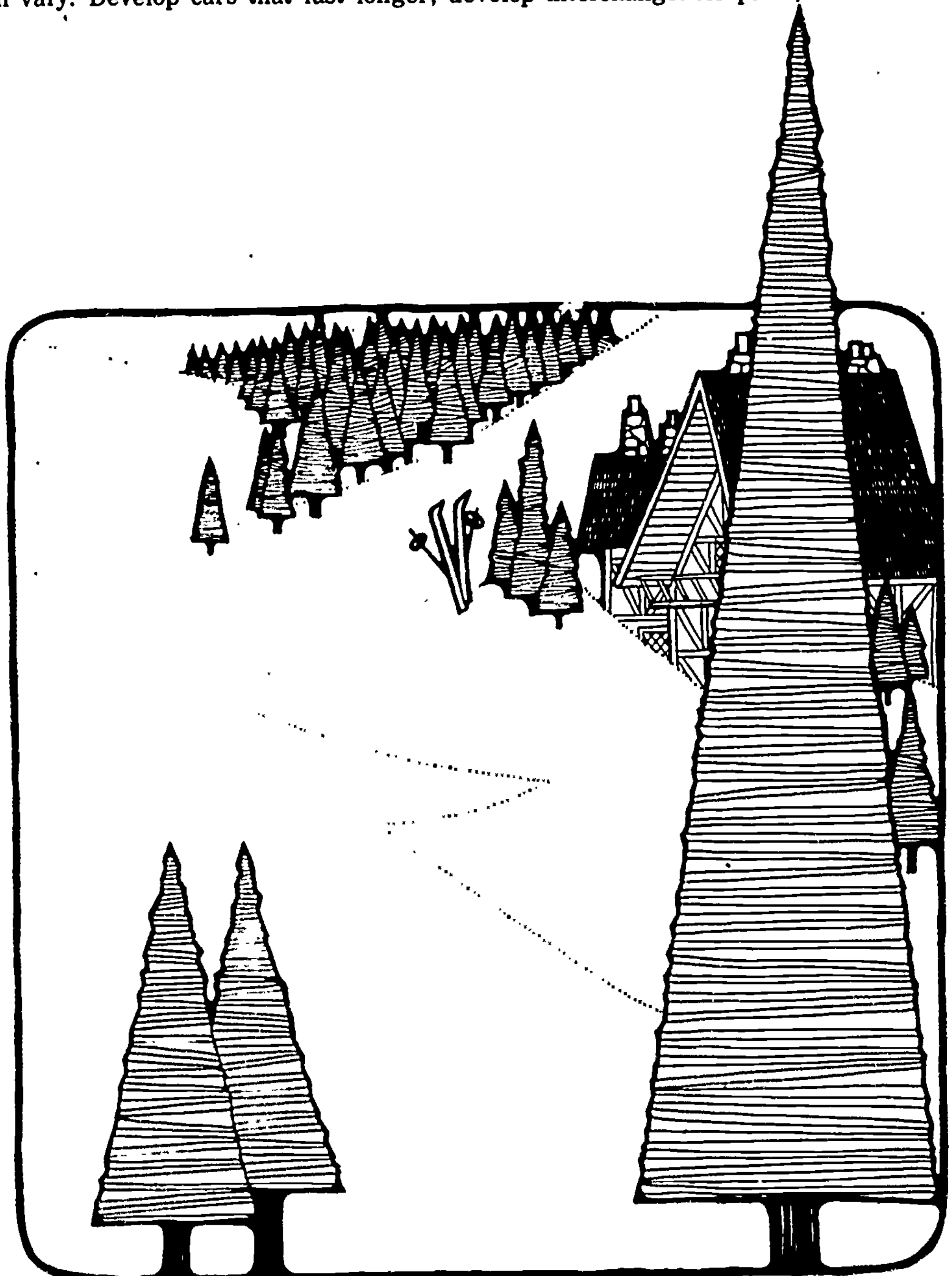
RESOURCES AND REFERENCES -

Selwyn Enzer, "A Case Study Using Forecasting as a Decision-Making Aid", IFF Workingpaper, WP-2, Institute for the Future, Riverview, Conn. 06457, December, 1969. A letter to them can get you a catalogue and perhaps a copy of this paper.

Engineering Concepts Curriculum Project, The Man Made World, New York: McGraw-Hill Book Company, 1971

SAMPLE RESPONSES -

1. Answers will vary: it was stolen from the owner, they had to because the car was traced to them as owner, it wasn't running, etc.
2. People are abandoning the cars; etc.
3. Answers will vary. Attractive nuisance (children hurt in it, etc.) can't clean the streets, attract rats and other vermin, fire hazard, etc.
4. Cost; where to bring the cars; how to tow a car with no bumpers, wheels, etc.; a stripped car being towed frequently ends up adding to the litter on the roadway.
5. Answers will vary: Develop cars that last longer; develop interchangeable parts, etc.



TUDENT ACTIVITY SHEET

NAME:

DATE:

What's The Problem? - Abandoned Cars.

This is a news article:

JUNKED AUTOS COST THE CITY A PRETTY PENNY

The cost to the city of Wilmington for removing abandoned cars from streets has reached a very high level. For the past 10 years the number of abandoned cars has been steadily increasing until in 1973 it reached 987 cars. By the end of 1974 the City of Wilmington may have to spend $20,000 to remove abandoned cars. According to police, learning who actually abandoned the cars is very difficult.

Engineers are working to overcome many of the problems automobiles cause. It is not an easy job.

Bizarre as the idea might seem these days, there once was a time when the automobile was seen as the perfect answer to urban pollution. That was back at the turn of the century, when horses provided virtually all of the motive power for society--and daily deposited some 2½ million pounds of manure and 60,000 gallons of urine on the streets of New York City alone. Small wonder that turn-of-the-century scientists hailed the development of the auto as a clean, quiet, and efficient means of transportation. . .But no one foresaw that the auto would someday create pollution problems much more severe than did the horse it replaced.

Newsweek, March 6, 1972.

You as an engineer cannot solve all the problems of the automobile, at least not today. Today you will look at the problems of abandoned cars.

WHAT'S THE PROBLEM?

1. Why did some people junk their cars while so many others did not?

The news article is about one part of the abandoned car problem. It talks about the number of abandoned cars and the cost of removing them. Now you will look at other parts of the problem.

2. What is the cause of the problem?

3 Why not let the cars stay on th: street?

4. What are some of the problems caused by taking the cars off the street?

5. What are some solutions engineers might use to solve the problem of abandoned cars?

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MAJOR IDEA (S) -

(a) Buses of the future will be designed to meet the needs of the people.
(b) Decision making is an important process in engineering.
(c) "Brainstorming" is a tool engineers may use to investigate the future.

BEHAVIORAL OBJECTIVE (S) - The student should be able to

(a) follow the directions in completing the activity.
(b) draw conclusions based on group discussion.
(c) discuss group conclusions related to a slide presentation.

STRATEGY -

(a) Divide students into groups of four to seven persons.
(b) Discuss the general feature categories. These are the criteria for design.
(c) Each group should complete the chart as follows:
    1. The first 5 minutes filling in the Your Transbus Ideas column.
    2. The second 10 minutes filling in the Your Groups Transbus Ideas column.
    3. Remainder of period slide presentation and discussion.
(d) The analysis of the development of this new transportation vehicle will allow students to re-enforce the concept of the importance of engineers matching technology to the needs of society, the human user and his environment.
(e) The slide presentation will give students a chance to compare their design ideas with the prototype buses being developed by AM General Corporation of Wayne, Michigan, General Motors Truck and Coach Division of Pontiac, Michigan and Rohr Industries of Chula Vista, California for Booz-Allen of Bethesda, Maryland.

PITFALLS -

(a) Students may have trouble getting started listing design ideas. A brief example may be of help.

    Example - Passenger comfort - air conditioning, more comfortable seats, etc.

(b) You may have to read and interpret the slides for students. They were developed by Booz-Allen and have a rather advanced vocabulary.
(c) Students enjoy the pictures of the buses themselves. They tend to dwell on this aspect too long.

MATERIALS AND EQUIPMENT -

Student Activity Sheets
Slide projector
Slides - Transbus

RESOURCES AND REFERENCES -

T. Liao, The **Man Made World Bulletin**, May, 1974, Stony Brook, New York. ECCP New York University.

SAMPLE RESPONSES -

1. Individual and group charts - Transbus Design Ideas.

STUDENT ACTIVITY SHEET

NAME:____________________
DATE:____________________

Transbus

TRANSBUS is the name given to a remarkable new vehicle that will contain the first basic changes made in urban transit in more than fifteen years. The United States government is sponsoring and financing a program to design and build these new buses. Booz-Allen Applied Research of Bethesda, Maryland is in charge of overseeing the design and construction of Transbus. The question is, what do new buses need that the older type do not have? Today you will investigate Transbus.

Let's suppose you are an engineer working for Booz-Allen. What new features do you think should be in the new buses your company is designing?

1. By yourself make a list of the features you feel necessary to make Transbus meet the needs of the people. (The chart provided you may be of some help). Try to list at least ONE suggestion for each major General Feature.

TRANSBUS GENERAL FEATURES	Your Transbus Ideas	Groups Transbus Ideas
1. Passenger Comfort	1.	1.
2. Reduced Urban Congestion, and Increase Revenue	1. 2. 3.	1. 2. 3.
3. Safety	1. 2. 3.	1. 2. 3.
4. Environmental	1. 2. 3.	1. 2. 3.
5. Maintenance	1. 2. 3.	1. 2. 3.
6. Removal of Travel Barriers to the Elderly and Handicapped	1. 2. 3.	1. 2. 3.

After you have finished your own ideas for the Transbus, compare and discuss your answers with other student engineers assigned to your group. Make a list of your groups' suggestions.

You will then have a discussion using slides. This discussion will enable you to compare your ideas with Booz-Allen engineers.

MAJOR IDEA (S) -

(a) Man's senses limit him in gathering information and constructing a mode.
(b) Engineers using technology can help man gather information about things he cannot see.
(c) The student will be introduced to the process of model building.
(d) Problems can be solved with the use of models.
(e) Models can be tested.

BEHAVIORAL OBJECTIVE (S) - The student should be able to

(a) construct a model using his senses.
(b) list four elements of the modeling process.
(c) describe why engineers make models.
(d) test a model.

STRATEGY -

(a) The box used in this activity consists of two parts approximately 1½" x 4 5/8" each. It is made so that the two parts can be separated without disturbing the sticks and washers. The sticks are crisscrossed; two through one side and one through the other. The desired arrangement can be set with the washers and sticks through the top portion alone before slipping the bottom into place. This makes it easy to change arrangements. Make certain that students do not open the boxes. Stress the need to collect information before pulling rods out. See drawings at the end of this discussion.
(b) Guide students through the modeling process and the problem-solving techniques used by the doctor faced with a sick patient.
(c) After passing out sheets and equipment, discuss the fact that removing a rod creates an irreversible change.
(d) Activity works best if there are at least four different arrangements. Each of these should be numbered. There should be one for two students. You should have extras for the faster student.
(e) Keep one of each numbered box for comparison with collected information.
(f) Here is a good place to reinforce the process of modeling. Show how the student actually performed each step.
(g) Stress concept that engineers use models and that models are easy and fun to make.

PITFALLS -

(a) Impress upon your students the need to make careful observations and to record them. Roughly shaking the boxes will not be nearly as revealing as carefully tilting them.

SAMPLE:

1. Tilted the box in several directions; a sliding noise is heard coming from the bottom of the box, followed by a thump on the lower side.
2. etc.

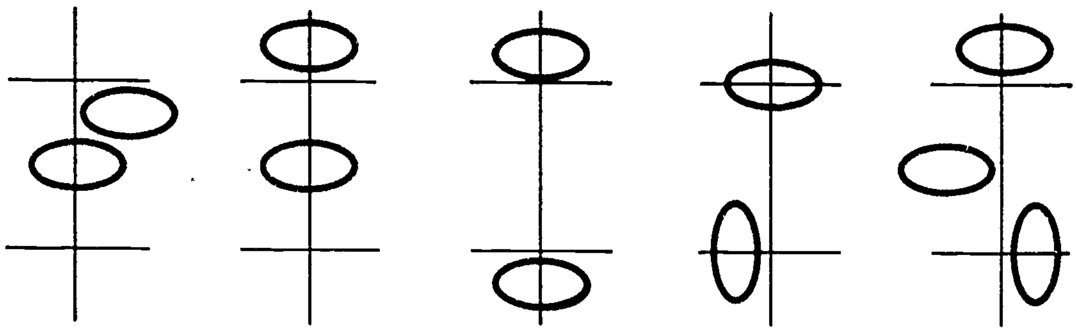
(b) Students want to "pull" the rods too quickly
(c) Stress the use of models in engineering. This will keep the activity moving.
(d) The soda machine problem can lead to a very "lively" discussion.

MATERIALS AND EQUIPMENT -

Student Activity Sheets
IPS, structure boxes - Boxes can be obtained from Damon, Education Division, Needham Heights, Mass. 99156

A simple and suitable box can be made as follows: Make a ditto master using the outline indicated in the attached sheets. Take standard letter size folders and cut to 22 cm. wide. Make your ditto imprint onto the folder cardboard instead of onto paper. Fold where indicated. Tape corners. Use 3.175 mm. (1/8-inch) dowel as the sticks and use metal washers.

The following are some suggested arrangements for the internal structure of the boxes.



Knitting needles and small gift boxes work well.

RESOURCES AND REFERENCES -

. Haber-Schaim et al, Introductory Physical Science, Englewood Cliffs, New Jersey: Prentice-Hall, Inc. 1972.

SAMPLE RESPONSES -

1. Make the patient better.
2. Answers will vary.
3. He makes a diagnosis of what is wrong and decides on treatment.

4.-7. Model-making process as it relates to Doctor-Patient relationship:

Model-Making Process	Doctor-Patient Interaction
a. Collecting information	Takes history - asks "What's Wrong?"
b. Building the Model	Gives patient various tests
c. Comparing the Model to the real world	Treatment
d. Accepting or Rejecting the Model	Patient gets better Patient gets worse No change

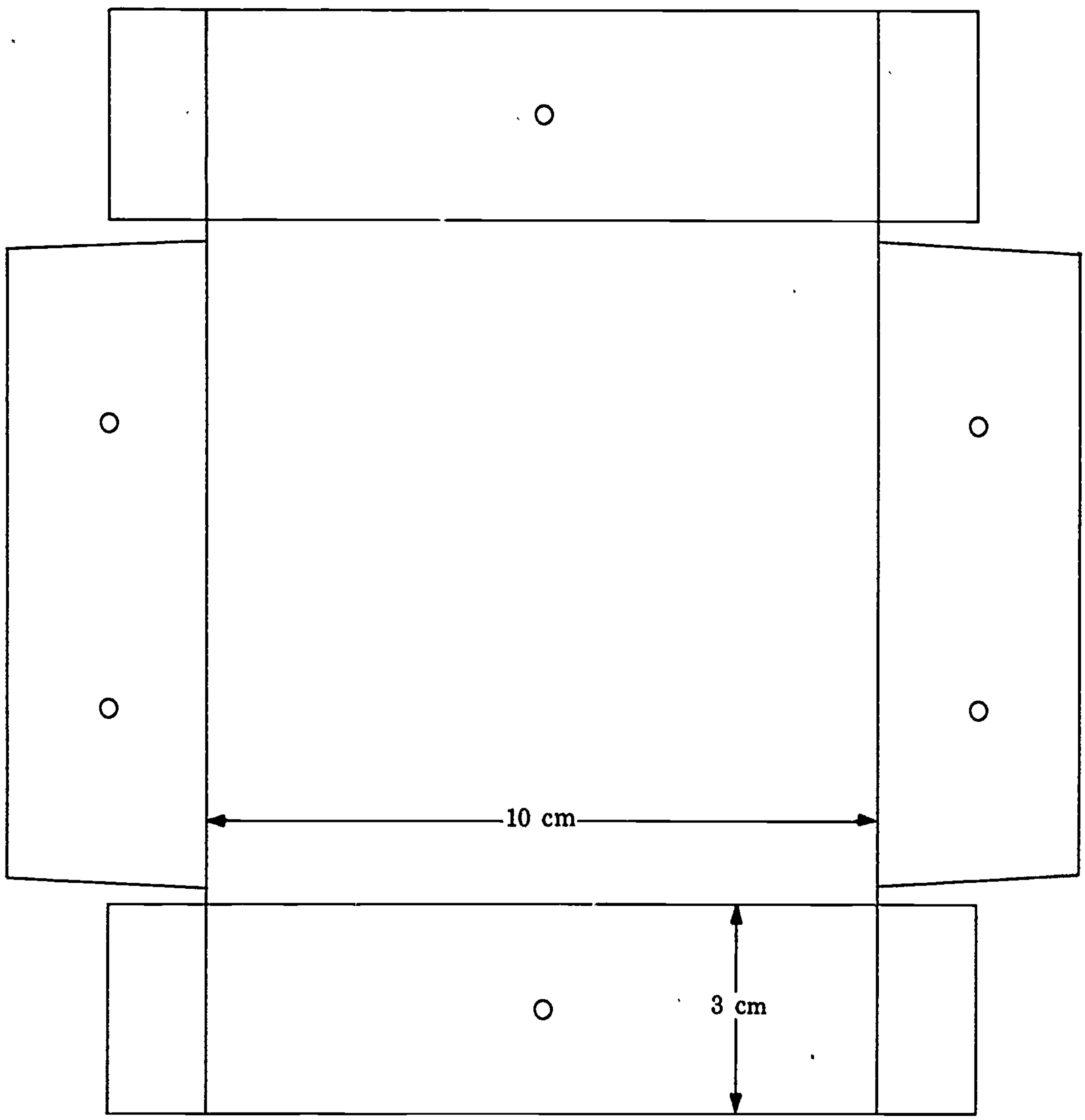
8. Hopefully, yes.
9. Collect Data (Information).
10. Building the Model.
11. Hopefully, yes.

Soda Machine Problem:

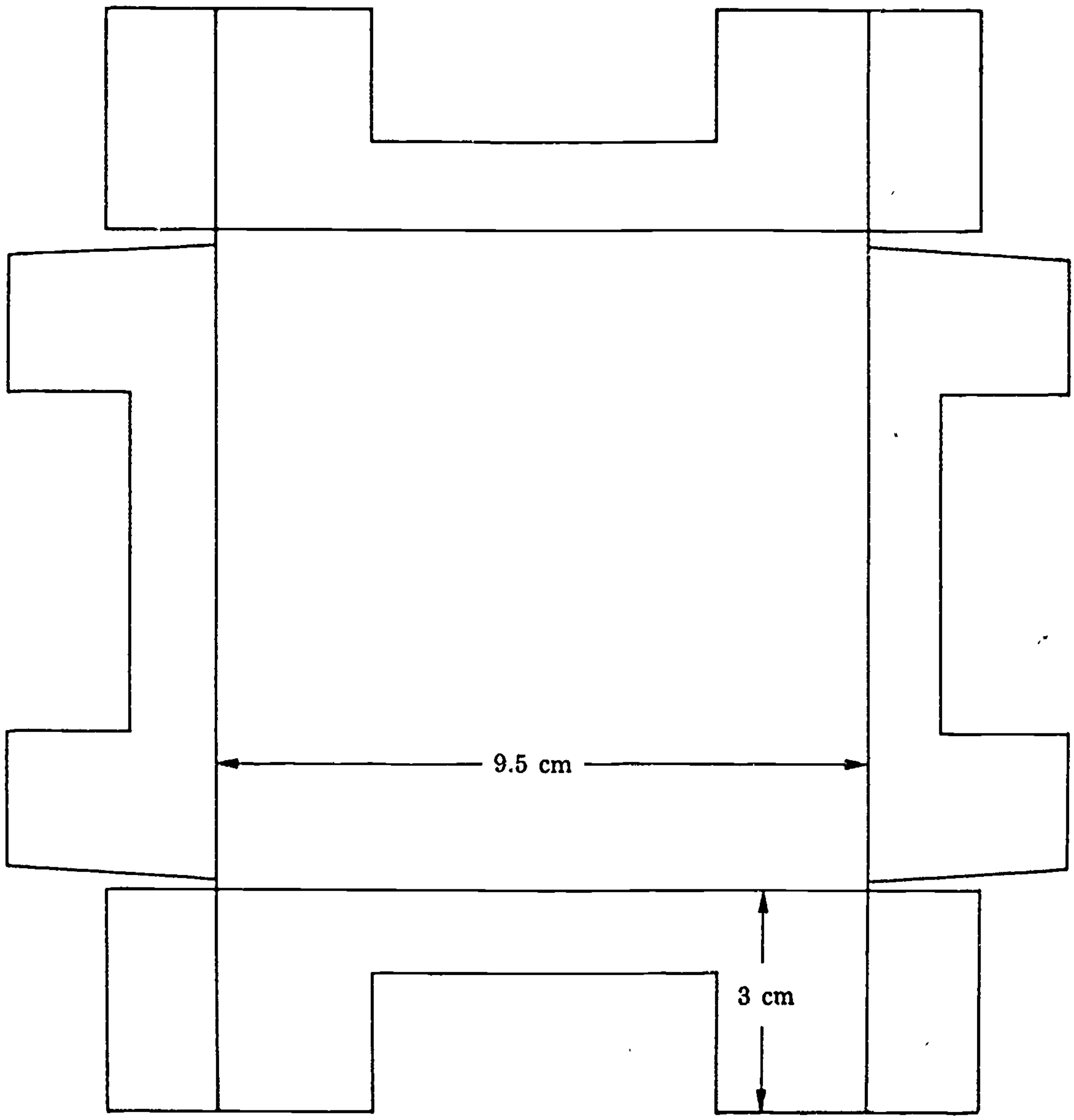
Answers will vary. Some suggested ideas to test the model are as follows:

1. Take the plug out - test the machine.
2. Observe the machine for -
   a. Food intake
   b. Waste removal
3. Observe for off duty activities.
4. Odor, sound, etc.

DITTO MASTER FOR MAKING STRUCTURE BOXES [TOP]



DITTO MASTER FOR MAKING STRUCTURE BOXES [BOTTOM]



STUDENT ACTIVITY SHEET

NAME:________________________________
DATE:________________________________

The Little Box - Stretching the Senses

If you became ill, you may go to a doctor. When the doctor examines you, he will want to "look" inside you to find out what is wrong. He has to find out the condition of what's inside - the structure - without harming the patient.

Many times engineers are confronted with the problem of finding out what's inside a structure without harming the structure. Today you will explore the arrangement inside a structure without seeing inside that structure.

1. Why does a doctor want to "look" inside a patient?
2. What limits him in examining inside the human body?
3. After he examines you, what does he do?

Doctors, engineers, scientists, etc., build mental pictures of some things they cannot see. Models are mental pictures of such things. Let's see how the doctor might build a model (mental picture) of the inside of your body.

4. How does a doctor collect information about what is wrong with your body?
5. What does he do to build the model?
6. How does he compare the model to the real world?
7. What makes him accept or reject the model?

This exercise will give you a chance to try to decide the structure (the inside arrangement) of something you can't see. Engineers often model a device or system where they cannot obtain information directly. This may come about because of size (too large or too small) or location.

In some cases you would destroy the "thing" if you looked inside.

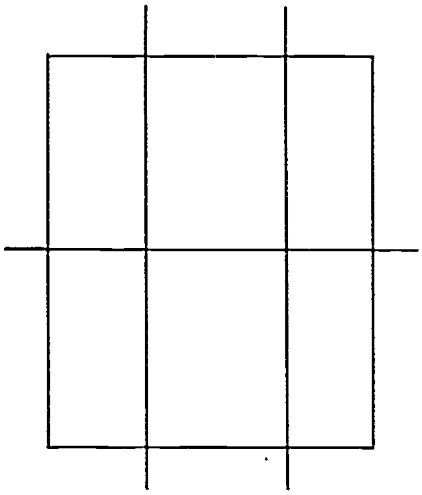
It is not important to know what is in the box. It is important to find out how the things are arranged inside. There is nothing inside the box except the rods and metal washers.

You and your team are to make a model of how the rods and washers are arranged in the box. Do not open any boxes. CAUTION: Watch out–once you pull a rod out, you can't put it back in. So think carefully--and test carefully before **you yank.**

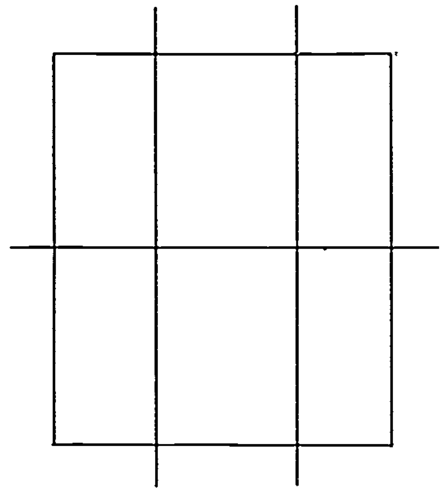
Try different things, but don't open the boxes; tilt and listen, shake, and turn upside-down.

Once you have collected all the information about the rods and washers, draw your model in the space below.

First Try



Second Try



8. Make sure you check your model with the unaltered box. Does it agree? ____________________

9. The first step in the model-making process is ____________________

10. Once you have decided upon your model, what is the next step? ____________________

11. How well did you function as an engineer? Were you able to locate any of the washers? ____________________

The doctor constructs a model of your body. You constructed a model of the box. Bothmodels are similar in that they are made without seeing inside the structure.

Let's apply the use of a model to an engineering problem.

How Do I Get My Soda?

A small friend of yours insists that there is a man sealed inside the automatic vending machine and that he is responsible for dispensing the soda. How would you go about testing this model without taking the machine apart?

TEACHER GUIDE - **Noise - What Is It?**

MAJOR IDEA (S) -

(a) Society is taking note of noise pollution.
(b) Technological improvements have increased noise levels.
(c) Increased noise levels have made for hearing impairments and increased physiological stress.
(d) Engineers are attempting to reduce noise levels.

BEHAVIORAL OBJECTIVE (S) - Student should be able to

(a) list technological "improvements" which have increased noise levels.
(b) identify and list the noisiest places in the school.
(c) complete a public-opinion survey on attitudes toward noise.

STRATEGY -

(a) The introduction should make students aware that noise levels have not only increased because of technological improvements such as highways, jets, and construction tools, but have done so to the extent that individuals have sought redress in the courts. Urban centers have also been compelled to take action.
(b) Questions 1 through 7 will again bring about an awareness of noise pollution in the everyday technologies and conveniences that surround the student. This will be brought home even in school.
(c) Questions 8 through 10 give students insight to the problem, what is noise? They lead into the public-opinion survey.
(d) Public-opinion survey - A student activity sheet is included so you may conduct the survey. You can use this in class, collate * the results in class, and look for consensus opinions. A homework assignment that has been proven to be successful is this. have students survey three adults and three students (including themselves) then collate and compare the attitudes of adults and students. A check-off box is provided and you can have students do the collating.
(e) If you have a decibel meter available from AMF, have the students check the noisiest places in school.

PITFALLS -

(a) Students will have questions about the survey, whom to ask, when, where, etc. Don't worry about their selections. Assure them any other students will be fine.
(b) Collating the data can become very time consuming. Don't bog down with long data collating.

MATERIALS AND EQUIPMENT -

Student activity sheets
Decibel meter (if available)

RESOURCES AND REFERENCES -

"Decibel Scale" included.

*compare critically

SAMPLE RESPONSES -

1. Expressway traffic; trains; motorcycles; subways; jets; low-flying planes; buses; trucks.
2. Vacuum cleaners; air-conditioners; lawnmowers; dishwashers; snow blowers.
3. Pneumatic drills (jackhammer); typewriters; computer labs; power tools.
4. Garbage trucks; taxis; fire engines.
5. (a) Auto racing, mini-bikes, auto engines; (b) outboard motors (motor boats), amusement parks; (c) snowmobiles.
6. Automatic machinery; punch presses; factories.
7. (Not in order of intensity) - wrestling room; lobby; wood shop; gym; band room; auto shop; typing room; machine shop; cafeteria; sewing room; print shop.
8. No
9. No
10. Yes

DECIBEL SCALE
TYPICAL SOUND LEVELS

At Distance from Noise Source	Decibels	Environmental
50 HP (30 m)	140	(Eardrum Ruptures)
Jet Takeoff (60 m)	130	
		(Threshold of Pain)
	120	
Riveting Machine*	110	Discotheque
Jet Overhead (450 m)		
Cut-off Saw*	100	Electric Furnace Area
Loud Power Mower*		Thunder
Textile Plant*	90	Boiler Room
Subway Train (6 m)		Printing Press Plant
		Noisiest Spot at Niagara Falls
Pneumatic Drill (15 m)	80	Tabulating Room
		Inside Sport Car (90 km/h)
Freight Train (30 m)	70	Noisy Playground
Vacuum Cleaner (3 m)		
Speech (30 cm)		
	60	Expressway Traffic
		Large Store
		Accounting Office
Power Substation (60 m)	50	Private Office
		Light Traffic (30 m)
		Average Residence
	40	Residential Areas
Soft Whisper (1.5 m)		
	30	Studio (Speech)
	20	Picture Studio
		Rustle of Leaves
	10	
Threshold of Hearing	0	

*From Operator's Position

The decibel is the accepted unit of measure for loudness of sound. A minor decibel change makes a significant difference in the loudness of sound to the human ear. A 10 decibel change represents a doubling in perceived loudness. Thus, a 60 decibel noise level is twice as loud as a 50 decibel sound.

STUDENT ACTIVITY SHEET

NAME:____________________
DATE:____________________

Noise - What is it?

"Noise in American cities has doubled since 1954"

"If the volume of noise continues to rise at present rates, everyone living in a city could be stone deaf by the year 2000."

"Very few people were concerned about the effect of noise on the human body until 1948 when an employee (worker) won the first lawsuit based on occupational deafness."

Engineers are attempting to control the noise level. One problem they face is, just what is noise? Let's look at that part of this very large problem.

Under the headings below, list some of the things that have:

1. improved transportation, but made it noisier.

2. made housework easier and more comfortable, but made it noisier.

3. made work in industry and business faster, but made it noisier.

4. improved city services, but made it noisier.

5. improved reacreation facilities, but made it noisier.

   (a) year round

   (b) summer

   (c) winter

6. made things cheaper, but made it noisier.

7. List the noisiest places in school

Study your answers to questions 1 - 7. Next to each question suggest ways to decrease (cut down) the amount of noise produced by the objects listed.

8. Do all objects make the same amount of noise?____________________

9. Do all objects make the same type of noise?____________________

10. Do different people hear things in different ways?____________________

PUBLIC OPINION SURVEY - ATTITUDE TOWARD NOISE

	Very Annoying-Hate It		Not Annoying-Don't Mind		Don't Come in Contact with It	
	Student	Adult	Student	Adult	Student	Adult
Alarm Clock						
Barking Dogs						
Lawnmower						
Radio/T.V.						
Trains-Subway						
Sirens-Fire Engines						
Firecrackers						
Road Traffic						
Jet Airplanes						
Thunder						
Ocean Waves						
Jackhammer						
Vacuum Cleaner						
Rock Band						
Cafeteria						
School Bells						
Baby Crying						
Garbage Trucks						
Chain Saw						
Motorcycles						
Scratchy Noises						
Air-Conditioners						

MAJOR IDEA (S) -

(a) A finite response time is one of man's limitations.
(b) Engineers must know people's reaction time if they are to build machines that we can use.
(c) Engineers use mathematics to solve problems.

BEHAVIORAL OBJECTIVE (S) - The student should be able to

(a) measure his response time by catching a ruler.
(b) solve problems using distance, time, and space relationships.

STRATEGY -

(a) One of the most effective introductions to this lesson is for you to drop a dollar bill and have various students try to catch it. If you feel rich, allow them to keep it if they catch it. Flatten the bill and crease it slightly down the middle so that it will fall as fast as possible. Have the student hold his hand so that his thumb and index finger are on either side of the bill near its center. Be sure that the student does not lower his hand as the bill falls. Hold the bill as loosely as possible between your thumb and index finger and let it slip out without giving advance notice. The questions relate reaction time to various events in the real world. Students guess their reaction times and distances before actually doing the experiment. You may have them refer back to their guesses after they have completed the experiment.
(b) Demonstrate the following method of releasing and catching the ruler to get the students started.

1. Each student will need a partner since the experiment requires two students working together.
2. One student will rest the heel of his hand on the edge of a table (or desk) in such a way that his index finger and thumb extend over the edge of the desk.
3. His partner will hold a 30 cm ruler upright so that the zero end of the ruler is at the first student's thumb level and he is holding the ruler at or near the 30 cm mark.
4. The partner will drop the ruler without notice-the first student's job is to catch it as quickly as possible-but only by closing his thumb and index finger. No other movement is permitted.
5. Note the inch value where the student's fingers are on the ruler. He should then place an X in the appropriate column beside trial one. Also note the response time in seconds, below inch value, since the number of inches the ruler falls is a measure of the response time.
6. Have the students run through five trials and then change places with their partner.

(c) Students look at their own data and then do some problems related to real world situations. Engineers solve problems using mathematics. You will probably have to help the students find the average time for question 5. The last answers can be found by showing the students that distance = speed x time for question 7, and time - distance/speed for question 8.

You can then discuss with the students the effects on our world if man had a very fast or a very slow response time. The fact that we have a finite reaction time means that we often need computers and other machines to aid us in our control tasks.

PITFALLS -

(a) Students may want to continue with the dollar drop. Set a limit before you start the activity.
(b) Students forget to record their distances on the data sheets.
(c) Give students help with the math problems. This is a good place to mention mathematics is important to engineering.

MATERIALS AND EQUIPMENT -

Student Activity Sheets
One ruler for each pair of students

RESOURCES AND REFERENCES -

Engineering Concepts Curriculum Project, **The Man Made World**, New York: McGraw-Hill Book Company, 1971.

SAMPLE RESPONSES -

1. No.
2. No.
3.-4. Guesses (the exact answers don't matter).
5. Found from students' own data. Averages approximately .2 s
6. No, faster than shortest reaction time.
7. Answers will vary. (Example: distance=speed x time 27mls x .20s = 5.4m)
8. a. time/distance/speed 18m/30m/ 6.6 s
   b. time=18 m/45 m/s = .4 s
   c. Probably not because time of .4 seconds leaves only about .2 seconds to swing the bat after taking out the .2 seconds response time. The batter also needs a little time to figure out where the ball is going.

STUDENT ACTIVITY SHEET

NAME:____________________
DATE:____________________

How Quick Am I - Response Time

You jump back on the curb just as the ca- speeds by. You duck just in time to keep from getting hit by the ball. You grab the glass just as it begins to tip over. You hit the brakes just as the light turns red. All of these actions depend on your response time. You know that you can react fast, but just how fast?

Engineers must know response time if they are going to design and build machines that can help us. Today you will test your response time.

1. Can you respond instantly to a situation?____________________

2. Do all people respond with the same speed?____________________

   If you hold a ruler so that it is between your partner's thumb and first finger how far will it fall before he or she can catch it?

3. How many inches do you think the ruler will drop before your partner can catch it?____________

4. How much time will it take you to catch the ruler?____________________

			Fast				Average				Slow	
Distance (Centimetres) Time (Seconds)	2.5 .07	5 .1	7.5 .12	10 .14	12.5 .16	15 .18	18 .19	20 .20	23 .22	25 .23	28 .24	30 .25
Trial One												
Trial Two												
Trial Three												
Trial Four												
Trial Five												

You had to do two things before you could catch the ruler:
a. React - your eyes had to tell your brain that the ruler was moving.
b. Move - your brain had to tell your fingers to move. Believe it or not, this takes time. Your chart shows the time that it took you to respond. Therefore, we can say:

Total Response Time = Time to React + Time to Move.

5. What is your longest response time?____________________ What is your shortest time?________________ What is your average time?________________

6. Could you control a machine which required a response time of .07 s (7/100th of a s)?______Why?___

7. Using your longest response time---how many feet would a car you were driving go during that time? Assume the car is moving 96 Kilometre per hour (km/h) which is the same as 27 metres per second (m/s)____

8. In baseball, the pitchers mound is 18 metres from home plate.
   a. How much time does a batter have to hit the ball if the pitcher is tired and is throwing the ball at a speed of 30 metres per second (m/s)?____
   b. How much time does the batter have if a fresh pitcher comes in and throws a fast ball at a speed of 45 metres per second (m/s)?____
   c. Would a tired batter have time to hit the fast ball?____Why?____

Response time is important to engineers. In a latter activity you will see why.

TEACHER GUIDE - **The Yellow-Light Dilemma**

MAJOR IDEA (S) -

(a) A model based on quantitative data enables engineers to optimize more successfully.
(b) Technological decisions should be matched to the human user.

BEHAVIORAL OBJECTIVE (S) - The student should be able to

(a) demonstrate the ability to observe and record data.
(b) build a model using this data.
(c) Optimize the results.

STRATEGY -

(a) Use of student teams is recommended.
(b) If teacher believes that it is too risky to go outside, he can make the needed measurements himself before class.
(c) If the speed limit is unknown, write or call the traffic department.
(d) This is a two-day activity.
(e) If measuring the int rsection with tape is not feasible, pacing should be adequate. Point out that a "long pace" would be about 1 metre.
(f) Guide students to make an approximate scale model on graph paper you will provide (see transparency master). Be sure they understand that GO distance means they must clear the intersection and that STOP distance means they must stop before they reach the intersection. Don't spend too much time on the model of the intersection. The distances should be plotted after they have secured the data. Once they see the dilemma zone, you can ask them:
   1. What will happen if the yellow light is too long? (Traffic may back up.)
   2. What will happen if the yellow light is too short? (Motorists will run the danger of going through the intersection while the light changes.)
   3. What role does an engineer play in the time a yellow light is on. Why?

PITFALLS -

(a) Make sure each team knows its job before going outside. This will avoid a lot of running around.
(b) Working at an intersection is not dangerous if you have good class control. You may wish to try the activity first with a small group.
(c) Measurements do not have to be exact. Allow for some student errors.

MATERIALS -

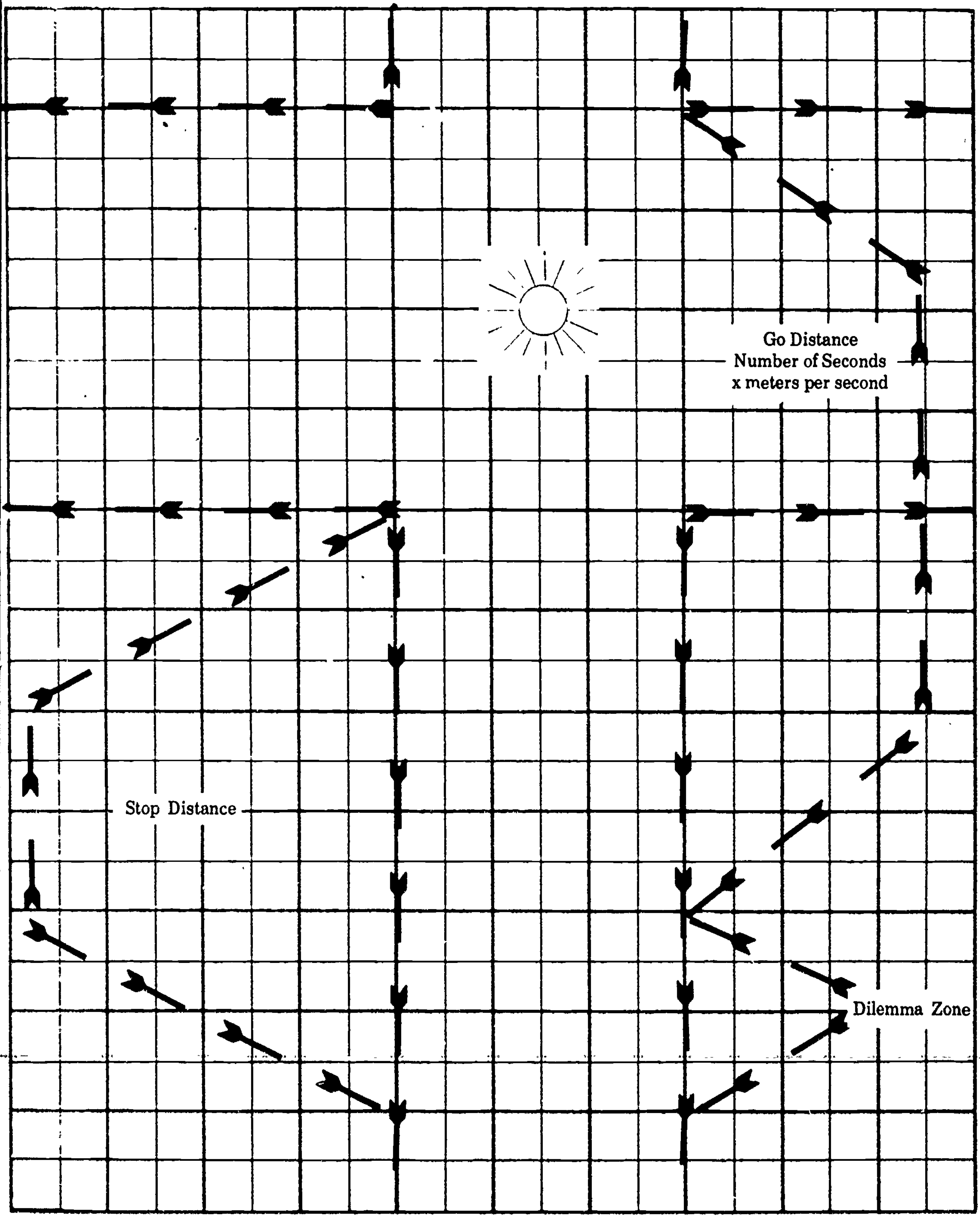
Student Activity Sheets plus two graphs
Meter stick
30 metre tape measure
Stop Watch
Clipboards (helpful - not necessary)
Graph paper
Transparency and overhead projector

RESOURCES AND REFERENCES -

Engineering Concepts Curriculum Project, **The Man Made World**. New York: McGraw-Hill Book Company, 1971. Sample student graph.

SAMPLE RESPONSES -

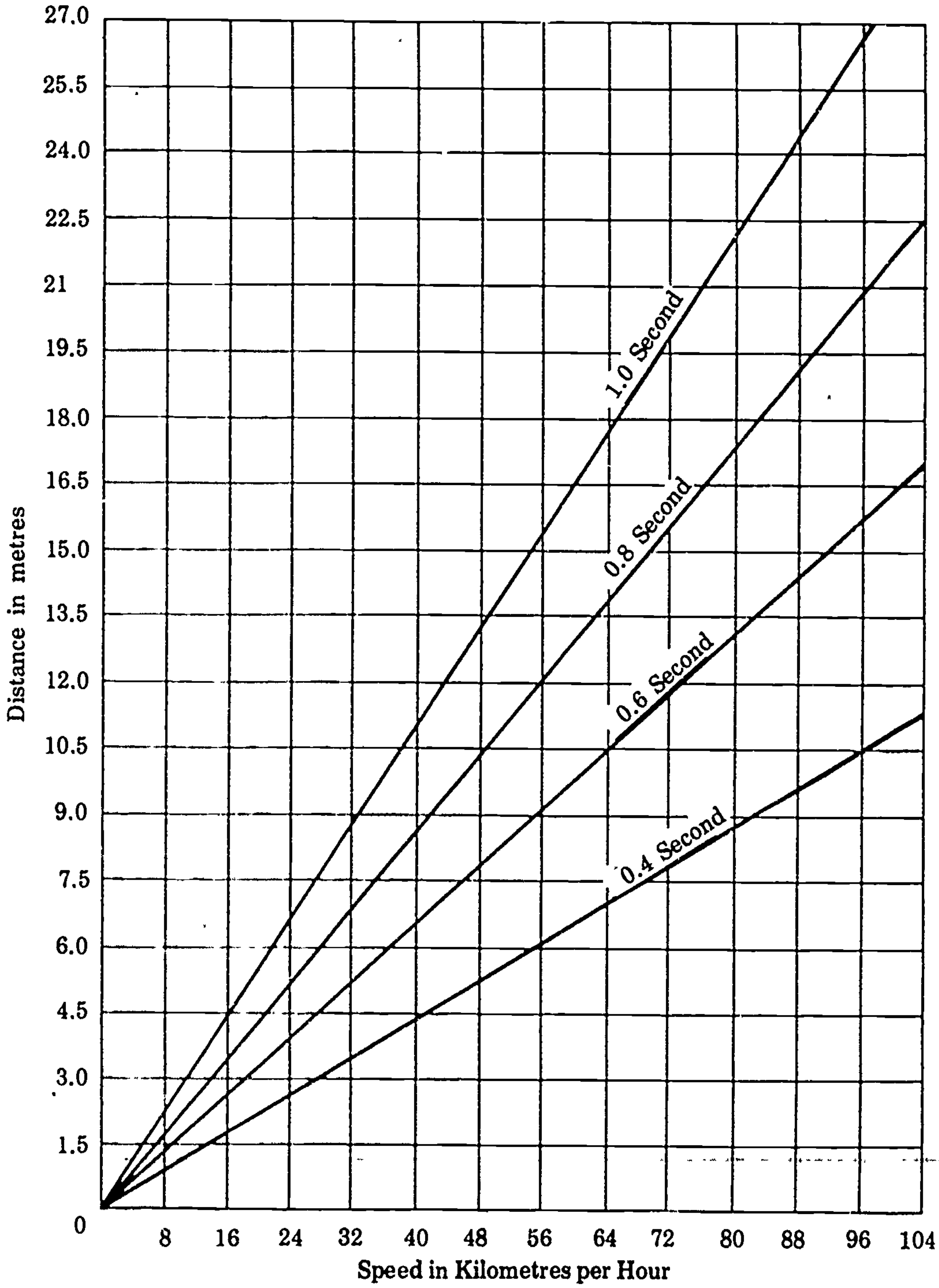
1. The choices are either to stop or to go through.
2. To warn the driver to be ready to stop should the light turn red.
3. Long enough to permit a driver travelling at the permitted (legal) speed limit, and has passed the minimum distance needed to stop comfortably, to travel that distance plus the intersection distance with safety.
4. The timing of the yellow light is usually done without matching it quantitatively to the human user. Sometimes accident records are used to change timing.
5. Answers to chart will vary.
6. Answers will vary.
7. Both lines should either start at the same point or the GO line should be the closer to the oncoming driver.
8. You now are faced with a dilemma-should you apply brakes and try to stop short of the intersection, or go and hope to make it.
9. Remember the problem is really not as simple as it appears. If you increase time of yellow light so as to reduce dilemma zone, you also increase GO distance.



Scale: 1 cm = 3.0 meters

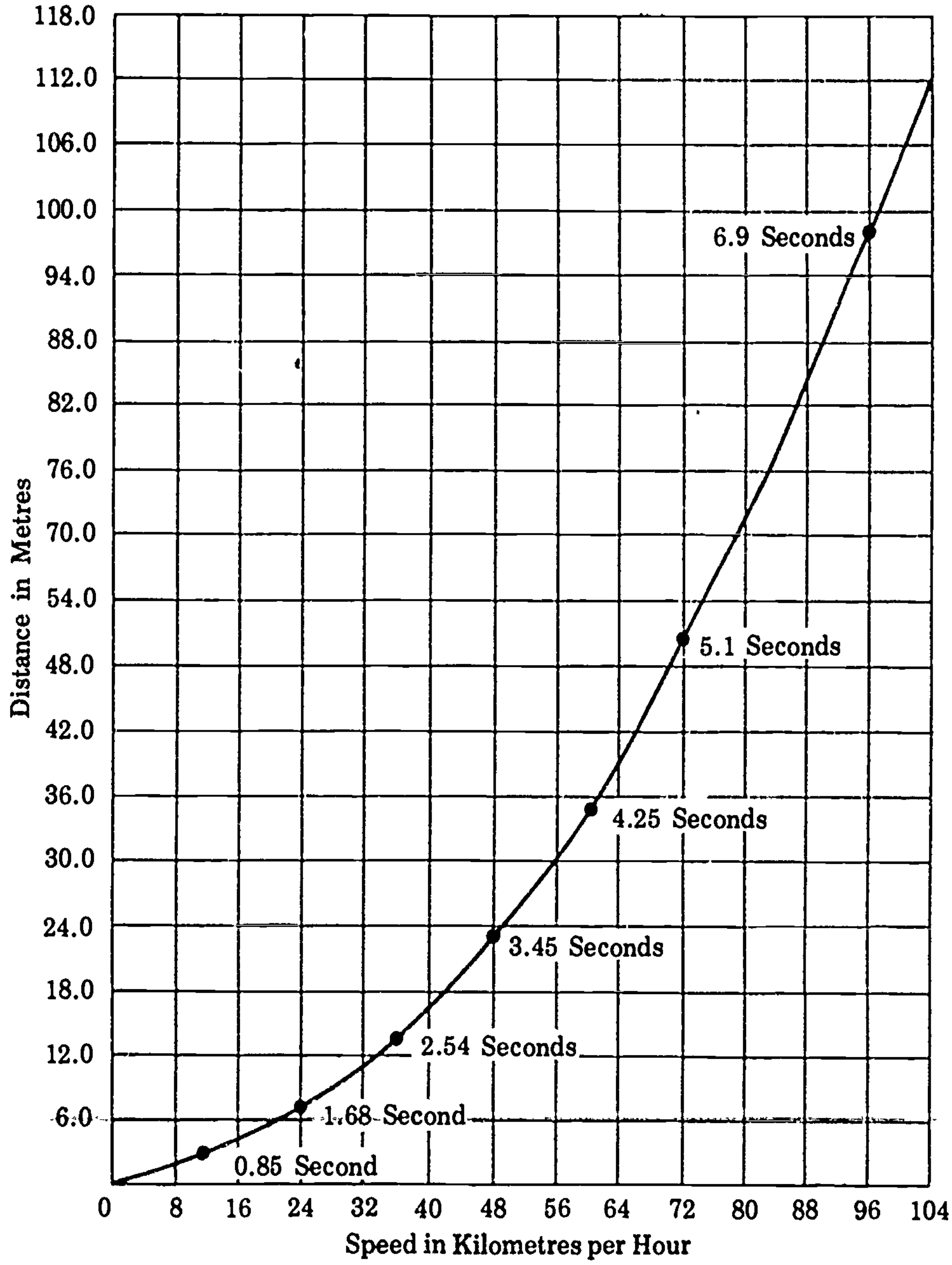
GRAPH A

Distance Traveled in Different Times for any Given Speed



GRAPH B

Every Second, Car is Losing 4 m/s of its Speed



STUDENT ACTIVITY SHEET

NAME:____________________
DATE:____________________

The Yellow-Light Dilemma

Let's say you are in a car and up ahead at the corner you notice that the light has changed to yellow. Why did the light change? Who is responsible for the time it takes traffic lights to change? Let's look at an engineering problem dealing with traffic.

1. If you were driving a car and the light changed to yellow, what choices would you have?__________

   If there is a policeman at the corner the decision is easier to make. In real like, there isn't a policeman on every corner.

   Today we'll examine a real-life situation and what will help you make the decision. (Remember: you can't stop "on a dime". It takes distance to react and stop.) We'll also see if engineers' timing of the yellow light is matched to reality.

2. What is the purpose of a yellow traffic light?__________

3. How long should a yellow light be on?__________

4. How do engineers decide how long the yellow light should be on?__________

5. Data chart

   Width of street to be crossed______metres — to be measured.

   Length of yellow light______seconds — to be measured.

   Speed permitted______metres per hour — if it isn't posted, find out.

   GO distance (if you go through to the other side of intersection)

   Distance traveled during time yellow light was on. (Use Graph A and get distance at the proper speed for the number of seconds light is on:)

   secs X metres per sec ________ Metres — Plot on diagram

   STOP distance (if you stop at intersection)

a. Reaction time plus time to brake (Use Graph A and .8 secs)

__________ metres

b. **Stopping time distance (Use Graph B) (time it takes for car to stop after braking)**

__________ metres

Total distance car will move from time your eye sees light to time that car stops. Add a. and b.

__________ metres Plot on diagram

Examine the diagram you have made from the above information.

6. Which is longer?
   - GO distance? ____________________
   - STOP distance? ____________________

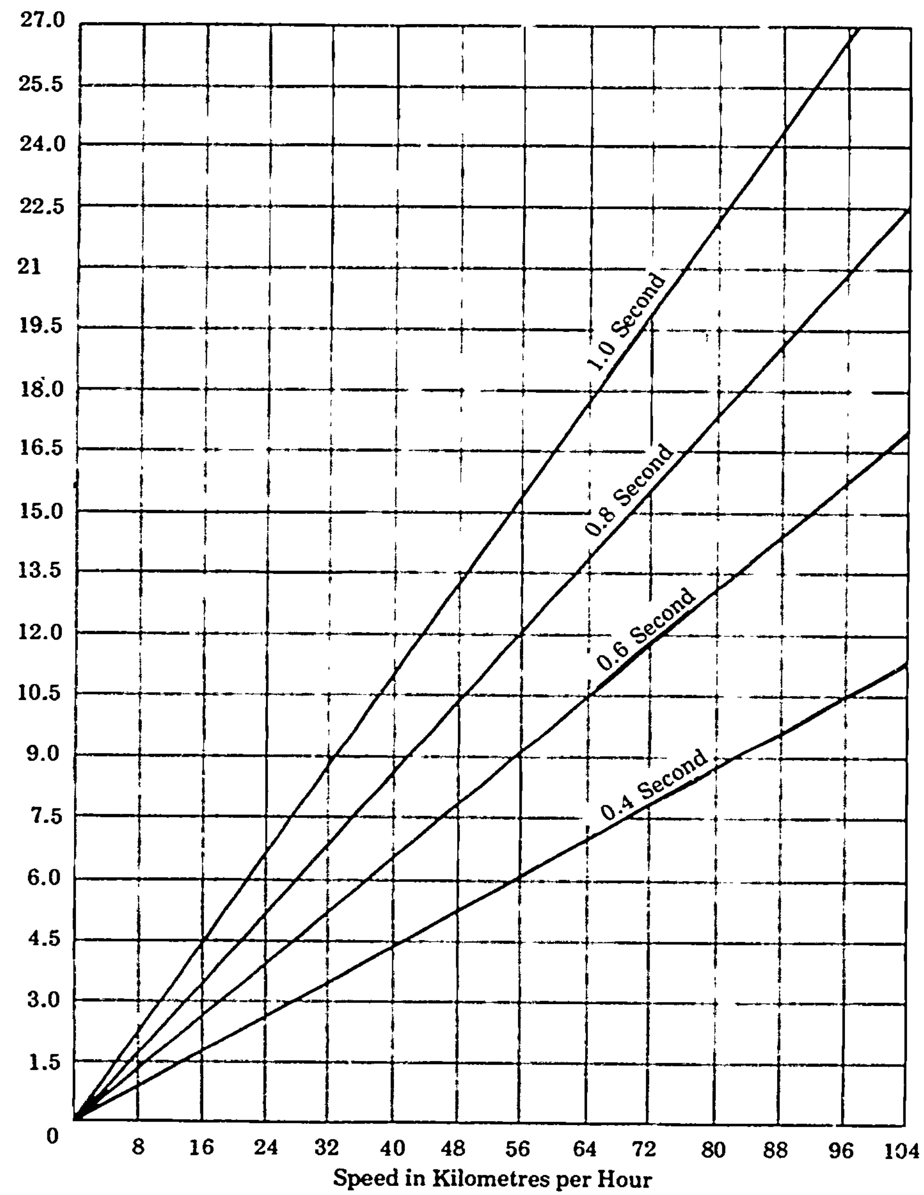
7. What should the situation be for best results? ____________________

8. If the stopping-distance line sticks out past the GO line, you have problems. Why? ____________________

9. How could you make this better? ____________________

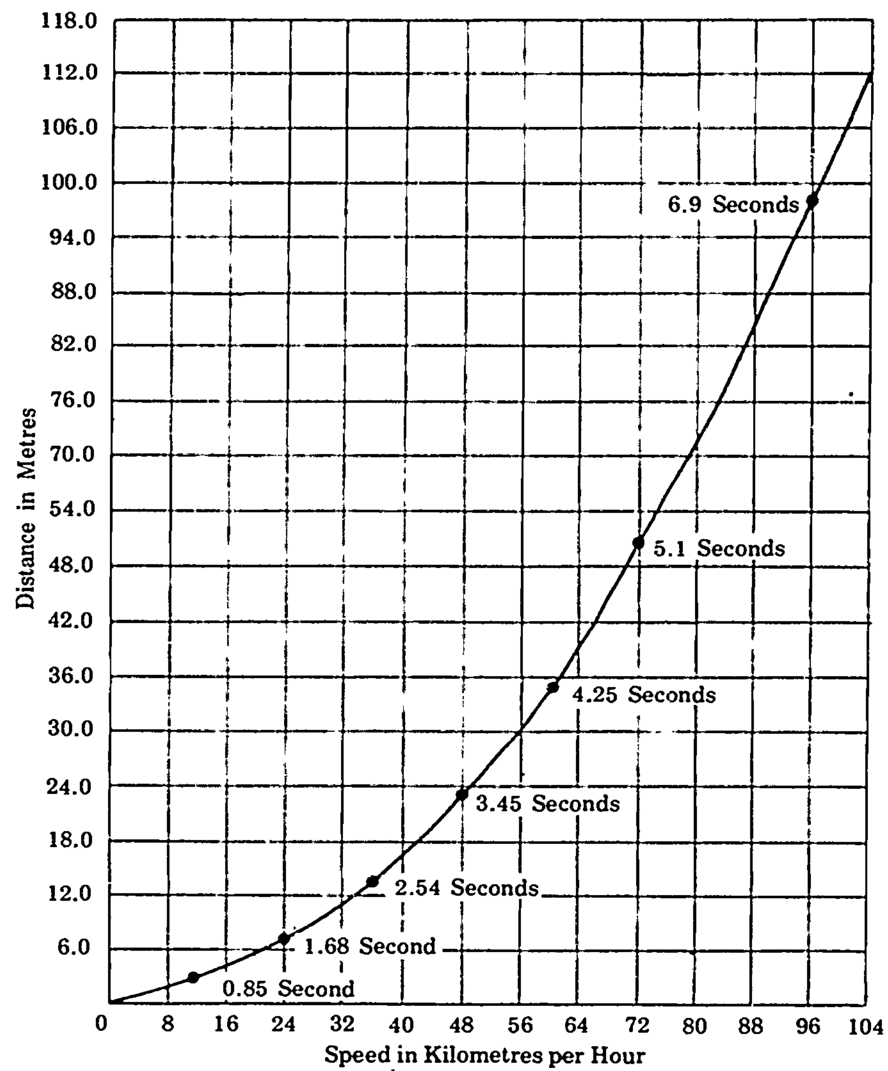
GRAPH A

Distance Traveled in Different Times for any Given Speed



GRAPH B

Every Second, Car is Losing 4 m/s of its Speed



TEACHER GUIDE - **The Book Rack**

MAJOR IDEA (S) -

(a) The design of a structure can vary greatly as the goals for its design vary.
(b) Engineers design structures to meet goals set forth for them by society.

BEHAVIORAL OBJECTIVE (S) - The student should be able to

(a) design a bookholder given specific criteria and constraints.
(b) build a bookholder based on these criteria and constraints.

STRATEGY -

(a) Have plenty of Q-tips and transparent tape available.
(b) Students should be encouraged to try various designs before settling on one.
(c) Be sure students fill in the data sheet.
(d) After the models are constructed, have a display area available.

PITFALLS -

(a) Students may have trouble understanding the goals. A sample model will help them.
(b) Have paper back books available for students to try with their models.
(c) Students can become very critical of each other. Limit comments to positive suggestions whenever possible.

MATERIALS AND EQUIPMENT -

Student activity sheets
10 to 12 Q-tips per student or team
Transparent tape
Paperback books

RESOURCES AND REFERENCES -

T. Liao, The Man Made World Bulletin, Nov. 1973, Stony Brook, N.Y..ECCP New York University.

SAMPLE RESPONSES -

1. To construct a bookholder which had minimum cost, beauty of design, creativity, neatness and ability to follow rules.
2. The major factor was cost.
3. Yes
4. Yes

STUDENT ACTIVITY SHEET

NAME:____________________
DATE:____________________

The Book Rack

A manufacturer wants to design a structure to meet the needs of the buyer. The product is to be a structure which can hold books. Before actually going into production, he decides that we will create working models and test them to find the best design. His primary objective is to build the cheapest structure; however, he wants a holder that has beauty of design as well as creativity.

As one of the engineers assigned to this project, you are to build a bookholder. After you have finished you will compare your bookholder with other student engineers' bookholders.

Follow the instructions listed below:

1. Make a structure which can hold a paperback book using Q-tips and transparent tape.
2. The objective is to build a structure that looks good, but is the cheapest that can be made.
3. Each Q-tip costs 10 cents.
4. Each inch of tape costs 5 cents.
5. The structure must hold the book at least 2.5 cm above the surface and be free-standing (no supports).
6. After you have finished the construction of the model record the following data for the bookholder:
   1. Number of Q-tips used -
   2. Cost of Q-tips used -
   3. Inches of tape used -
   4. Cost of tape used -
   5. Total cost of bookholder -

Answer the following questions when you have finished your chart.

1 What were the goals of the model?____________________

____

2 What factors limited how you built your model?____________________

____

3 Did you make a model that worked?____________________

____

4 Does your model look nice?____________________

____

After the class has finished their models compare your model with others. Use the following goals when comparing:

1. Beauty of design
2. Creativity
3. Cost
4. Neatness
5. Followed rules.

TEACHER GUIDE - **The Biggest Recreation Area**

MAJOR IDEA (S) -

(a) Engineers make better use of systematic (technological know-how) planning than random application.
(b) The modeling process will help engineers arrive at the optimum solution to a problem.

BEHAVIROAL OBJECTIVE (S) - The student should be able to

(a) build a model.
(b) optimize his results.
(c) secure data
(d) draw conclusions based upon this data.

STRATEGY -

(a) The students may bring up the idea that the shape of the area may be just as important as having the largest area size. Recognize this, but indicate that for this problem, the criteria must be the largest lize.
(b) Use 30 centimeters (cm) pipe cleaners from an arts-and-crafts store or regular pipe cleaners twisted together so that they measure 10 inches. You can use wire, but it must be single-conductor soft wire. Even bell wire is usually too stiff. Give the students a 25 cm length of pipe cleaner and the graph paper with the student activity sheets.
(c) Explain that 2 cm of wire represents 30 meters (m) of fence and, therefore, 25 cm of wire represents 300 m of fence. Use right-angle bends starting with a 2 cm at each end. Show them that if this is placed on the graph, there are 18 boxes in this space. Have students increase sides by a 2 cm and fill in table (question 5).
(d) After the first demonstration, they should have no problem. The graph paper with 1 cm squares was put in to avoid the problem of counting the many ¼-inch boxes that the standard 4 to the inch graph has and to move to use of meters.
(e) The purpose of question 8 is to bridge the gap between letters and cm to areas. If necessary, point out that length X width = area, just as counting the number of boxes in a X b.

PITFALLS -

(a) Students may have problems with the first measurement. Check each one carefully.
(b) Once the activity is underway it moves very quickly; be ready for some students to finish ahead of others.

MATERIALS AND EQUIPMENT -

Student Activity Sheets
Pipe cleaners or wires 25 cm or 15 cm
Rulers

RESOURCES AND REFERENCES -

Engineering Concepts Curriculum Project, **The Man Made World**, New York: McGraw-Hill Book company, 1971.

SAMPLE RESPONSES -

1. Yes
2. Test it either in the field or a scale model
3. No, not in a practical sense
4. Make a model

5.

a	b	Number of Squares
2 cm	9 cm	18
4 cm	8 cm	32
6 cm	7 cm	42
8 cm	6 cm	48
10 cm	5 cm	50
12 cm	4 cm	48
14 cm	3 cm	42
16 cm	2 cm	32
18 cm	1 cm	18
20 cm	0 cm	0

6. 10 cm and 5 cm
7. Yes; one is double the other
8. Yes

9.

a = Width	b = Length	(a X b) Area = Length X Width
15 m	150 m	2250 m^2
30 m	120 m	3600 m^2
45 m	90 m	4050 m^2
60 m	60 m	3600 m^2
75 m	30 m	2250 m^2

10. 45 m X 90 m
11. Yes
12. Yes; one is double the other
13. Yes

STUDENT ACTIVITY SHEET -

NAME:____________________
DATE:____________________

The Biggest Recreation Area

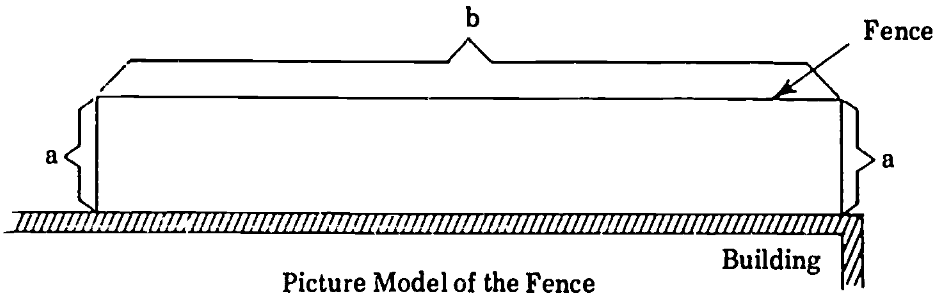
The block association has made a deal with the people in the neighborhood. If they will clean up the vacant lot next to a big brick building, they will receive 300 metres of fence to put up and can use the enclosed part as a recreation area.

The fencing must be shaped into three sides using the brick wall of the building as a fourth side to form a rectangle.

You are hired as the engineer to lay out the fence. You are interested in making the recreation area as big as possible.

THE BIGGEST RECREATION AREA

1. Would it make a difference how you shaped the fence?__________
2. How can you check this?__________
3. Can you go out to the field and start moving around 300 m of fence? __________
4. How can you test the different-size fields here in this classroom?__________



Picture Model of the Fence

You are going to gather information from a scale model and make a table model of different fence arrangements.

5. Fill in the table.

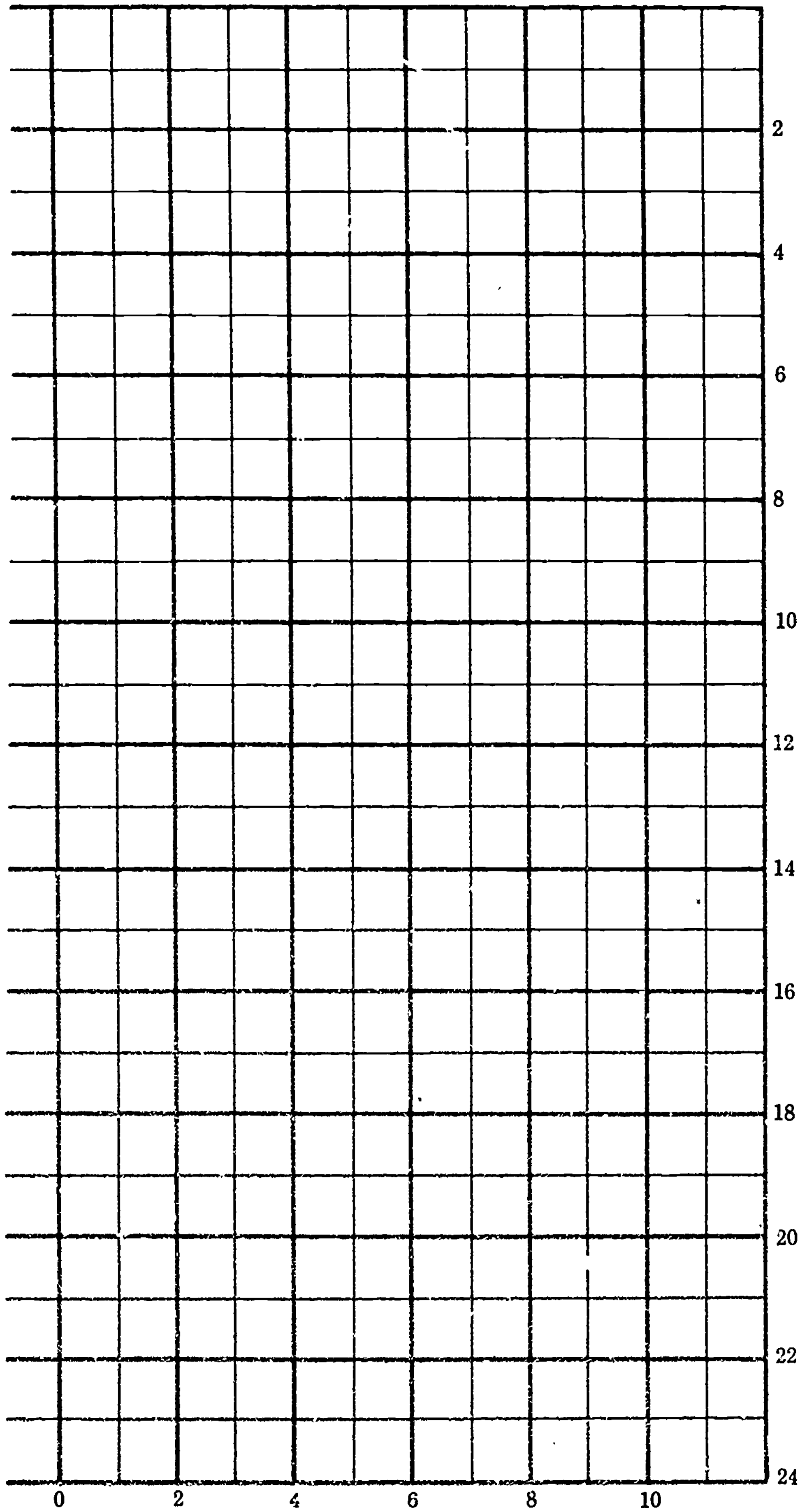
a	b	Number of Squares
2 cm	9 cm	
4 cm		
6 cm		
8 cm		
10 cm		
12 cm		
14 cm		
16 cm		
18 cm		
20 cm		

6. **Which pair of dimensions gives the largest are?**____________________
7. **Examine those dimensions. Is there a relationship between them?**____________________
8. **Do you think that this relationship would work for a** 185 metres fence and the same conditions?__________
   Try it - only this time use numbers of metres **instead** of centimetres and use only 15 centimetres of pipe cleaner **wire. Let** 1 cm = 15 metres.
9. **Fill in the table.**

a = Width	b = Length	(a X b) Area = Length X Width
15 m	150 m	
39 m		
45 m		
60 m		
75 m		

10. Which pair of dimensions gives the largest area?____________________
11. Examine those dimensions. Is there a relationship between them?____________________
12. Is the relationship in questions 7 and 10 the same?____________________
13. Do you think you would always get the same relationship for any length of fencing?__________

You are now ready to build your fence.


2
4
6
8
10
12
14
16
18
20
22
24
0
2
4
6
8
10

MAJOR IDEA (S) -

(a) Engineers are people who apply scientific principles to practical everyday problems.
(b) Engineers, scientists, technologists, technicians, and craftsmen work as a team when they tackle a problem.
(c) High school and college are necessary for a career in engineering.
(d) Engineering can be fun, interesting and rewarding for students.

BEHAVIORAL OBJECTIVE (S) - Students should be able to;

(a) Define what is an engineer
(b) List a few (4) things engineers do.
(c) Develop future plans that include engineering as a career choice.

STRATEGY -

(a) A brief introduction to the film is all that is needed.

PITFALLS -

(a) None

MATERIALS AND EQUIPMENT -

16mm sound projector
Film - "A Piece of the Action"

RESOURCES AND REFERENCES -

CC. Furnas and Joe McCarthy, The Engineers, New York: Time, Inc. 1966
Robet O'Brien, Machines, New York: Time, Inc. 1964
Nora Stirling, Wonders of Engineering, Santa Ana, Cal.: Doubleday and Co. 1966
Engineers' Council for Professional Development, New York.

Film Available From:

Modern Film Association
345 East 47th Street
New York City, N. Y. 10017