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ABSTRACT

This document contains teachers' materials for a 10-module, 1-semester technology education course in product design offered in grades 11 and 12 in North Carolina. The document begins with a rationale for the development of the course; an explanation of the elements in an instructional system; a rationale for the course; a description of the course organization and teaching strategies, including a sequential list of the modules and their instructional intent; and the recommended length of time for each module. The instructional modules themselves typically include an overview of length, supplies, and purpose; student objectives; a synopsis; teacher's procedures; materials list; references; and appendices consisting of illustrated student handouts, sample forms, checklists, review questions and information sheets. The modules are: The Shape of Things; Failure in Use, Broken Things; Designs in Nature; Characteristics and Materials; How Things Are Made; Fasteners; Patents and Inventions; Product Liability; Drawings and Specifications; and Developing a Design. (CML)

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Department of Public Instruction

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ACKNOWLEDGEMENTS

The North Carolina Technology Education Curriculum is the product of a curriculum redirection process begun in the early seventies. As in any change process, many individuals have contributed their time and energies to provide North Carolina students with a curriculum designed to meet their needs to be technologically literate adult citizens. The following are recognized for their vision and leadership in setting the direction for Technology Education in North Carolina schools.

Members of the N.C. Curriculum Study Taskforce who charted the course for technology education in North Carolina schools. Their study report and recommendations provided the direction for a change in the identity of the discipline and a total redirection of the curriculum.

Members of the N.C. Curriculum Committee who validated the Technology Education Curriculum Guide as appropriate study for assisting students in understanding technological systems impacting on their lives. Further, industry representatives of the committee verified the appropriateness of suggested activities reflective of practices in construction, communications, manufacturing, and transportation.

N.C. Technology Education Association who provided a forum for redirection of the discipline. It was the association that led the profession in changing identity to technology education. The association also provided opportunities for professionals to develop competence in the classroom delivery of technology education through the sponsorship of in-service programs.

Individual technology education professionals who gave leadership to other professionals in the curriculum change process. These professional leaders piloted many technology education activities in their classrooms and served as role models for other professionals.

Members of the N.C. Council of Technology Teacher Educators who provided insight and support throughout the curriculum redirection process.

Indiana curriculum developers who provided curriculum materials adopted and adapted for North Carolina Technology Education programs.

INTRODUCTION

The North Carolina Technology Education Curriculum is a program to meet every citizen's need to be technologically literate. Some basic assumptions underlie the program, and these can be divided into content assumptions, and learner assumptions.

The curriculum was developed using the belief that the appropriate content for the field is technology, and its impact on individuals and society. It was further assumed that the content is best organized around human productive systems that have been used, are now being used, and will, most likely, continue to be used. These universal systems are communication, construction, manufacturing, and transportation. Finally, it was assumed that this content can best be addressed from a systems approach with its inputs, processes, outputs, feedback, and goals/restraints.

The curriculum was further based on the assumption that education should meet the needs of individuals and the human requirements of society. It was assumed that each person living in a technological society should have a basic understanding of and the ability to assimilate the knowledge about technology. People it was assumed, should be able to interact with the technological nature of society and help impact the type of future new technologies can provide. Additionally people should be able to be contributors to a society in their several roles, including citizen, voter, investor, consumer, worker, and leader.

These assumptions caused the curriculum to be developed in such a way as to:

1. Provide an overview of technology first, allow for more in-depth study in specific technological areas, and culminate with synthesis activities.

2. Be more teacher-directed, content-centered in early courses, and highly, student-directed, process centered in advanced courses.

3. Involve problem-solving and group activities of all courses.

4. Stress the how and why of technology and its relationship to our quality of life.

5. Be activity-centered learning, with the content being used to determine the appropriateness of each activity selected.

6. Be equally important to young women and young men, both of which must function in a technological society.

Finally, the curriculum was developed to be descriptive rather than prescriptive. The materials described what to teach and suggest ways of teaching the content. At no time are daily activities prescribed in such a way to preclude individualizing the presentations to meet local conditions.

THE CURRICULUM GUIDE IN AN INSTRUCTIONAL SYSTEM

Each course in the North Carolina Technology Education Curriculum is seen as a dynamic activity involving a complete instruction system. This system generally includes seven components: the teacher, the students, a textbook when available, the curriculum guide, laboratory sheets, apparatus, and a reference library.

THE TEACHER

The teacher plays the primary role in the system. This role entails being a curriculum developer. The teacher chooses the points to emphasize and to evaluate. Care should be taken to insure that the coverage of the subject is comprehensive. You should resist "picking and choosing" only modules and activities that are the most interesting, most familiar, or the easiest to implement. All modules and activities should be included. However, you are encouraged to redesign or replace activities with your own activities that contain equivalent content.

As a technical expert, the teacher gives presentations, demonstrations, and asks questions about the subject matter. Safety information, and the demonstration of teaching/learning activities, are the responsibility of the teacher.

The teacher is an instruction manager. Managers plan, schedule, direct, and control activities. The teacher, perhaps in cooperation with students, plan the instruction by identifying the instructional goals. The activities to reach these goals are scheduled. Through presentations and application activities students are directed through the learning activities. Finally, the student's work and the teacher's management is controlled through various forms of evaluation. Since evaluation instruments should be designed to measure success in reaching the goals, these instruments should be prepared by the teacher.

The teacher is the creator of the teaching/learning environment. In the designing process, the enthusiasm displayed by the teacher for learning and doing new things is "catching." The teacher's role as a "learner" is paramount. Learning from the experiments and the knowledge brought to the classroom and laboratory by the students can be a gratifying and never-ending experience.

The teacher's role is to show the students that when they are "fenced in" with unknowns, they can be creative; that the designing process is open ended; that there is always better ways of solving a specific design problem; that the best design of today will be replaced by a better design tomorrow. The design teacher's task is to criticize and compliment: to the student, your idea is good but you are smart enough to make it better.

THE STUDENT

The target population is the upper level of junior and the senior high school. Students will be called on to solve problems as a "loner" and as a team member.

THE TEXTBOOK

Due to the wide range of materials covered in this module, a resource material center is suggested in place of a single textbook. A specific location within the classroom for the placement of reference books, articles, magazines for student and teacher use is recommended.

THE CURRICULUM GUIDE

The curriculum guide is to be used to help plan your instruction. The introduction consists of a structure for the content and a description of an instructional system with suggestions on how to use it.

The remainder of the curriculum guide briefly describes the modules. Each module consists of an introduction, objective(s), and a description of the activities. The description of the activities includes a schedule, presentation titles, application activities, and presentation titles, references, and safety guidelines. Suggestions for getting prepared and carrying out the activity are found in the teacher activity sections.

Suggestions for a variety of optional activities may also be found throughout the curriculum guide.

THE APPARATUS

Often the course guide contains plans for specialized apparatus useful in teaching the course. Drawings will be placed with the activity in which they are used. You can use drawings to construct the apparatus.

SUPPLIES AND SPECIAL EQUIPMENT

An effort has been made to design the modules around the typical equipment found in the current technology laboratories, however, each unit may require some specialized supplies and equipment. The teacher is encouraged to:

> LOOK OVER THE MODULES 3 OR 4 WEEKS IN ADVANCE OF THE PRESENTATION, ORDER THE SPECIAL SUPPLIES FOR THE MODULE IN ADVANCE OF THE PRESENTATION.

As compared with industrial organizations, school supplies are usually in small quantities and diverse units. While part of the student's designing experience is to locate material sources, and cost, it is the teacher's responsibility to be the back-up supplier. Some suggested school suppliers are:

Industrial Arts Supply Co. (IASCO)
5724 West 36th St.
Minneapolis, MN 55416-2594

Frey Scientific Co.
905 Hickory Lane
Mansfield, OH 44905
call toll free 1-800-225-FREY

Graves-Humphreys
1948 Franklin Rd. S.W.
P.O. Box 13407
Roanoke, VA 24033

Brodnead-Garrett
4560 East 71st Street
Cleveland, OH 44105

NOTEBOOK

A notebook is suggested as a means of:

1. Recording and keeping special information related to the module.
2. A record of the individual student's participation and response to assignments.
3. An aid for the teacher in evaluation of the student's performance.

DAILY LESSON PLANS AND EVALUATION

The planning of daily activities and an on-going evaluation system are the teacher's responsibility and rightfully so. Each teacher should adapt activities and presentations to insure they help students develop the identified concepts within local conditions. The teacher is encouraged to compliment and give credit for the efforts of all students in recognition of individual differences. Students are likely to give their best efforts in a classroom "atmosphere" without judgment or censor. Creative thinking is an emotional "lift." Students caught up in such an "atmosphere" will likely perform beyond standard expectations, and will lead the class for the teacher.

The curriculum guide is designed to help you present a relevant and exciting course. GOOD LUCK.

INTRODUCTION

Purpose and Rationale

This course in designing products is intended for the upper high school level. It is recommended that the students in this course should have successfully completed the general courses in math, science and have had some previous technology courses in technical drawing, and experiences in the laboratory with materials such as wood, metal and plastics.

The specific objectives are cited in each module. The course is organized to promote creativity, to develop, discover, and promote problem solving skills involving materials and processes.

One of the national traits that has made the Unites States a world leader has been its devotion to invention, new discovery and the industrial application of scientific knowledge. The course is designed to go beyond the typical hands-on, making-things course, to involve creative and inventive experiences. The student is encouraged to know why and how a material or a scientific principle is used or reacts to a set of conditions.

The hope is that the designing experience gained in this course will develop the student's attitude, that he or she is creative; that each generation is charged with taking the technological advances handed down by the previous generation, and to make a contribution for the advancement of civilization.

When our society was made of rural and small villages, most youngsters gained experience working with tools and solving problems following the activities of their parents. In an urban society, that experience which is said to have fostered our inventive society no longer exists. If we are to maintain our inventive world leadership, our young people need the opportunity to experience the joy of discovery: the feeling that comes to one who has invented, the desire to do something new and different. This course is designed to that end.

COURSE ORGANIZATION AND TEACHING STRATEGIES

The course is comprised of ten modules. Each module has a specific role to play in achieving the purpose or goals of the course. Make every effort to complete each module, with a minimum carry over. However, when a student becomes engrossed in a pursuit that requires time extension beyond the specific module, acknowledge and encourage the individual's efforts.

The following is a sequential listing of the modules and a brief explanation of the nature and role of each one.

Module 1, The Shape of Things, is to have the student become aware of the purposeful shapes. To understand shape as it relates to, function, utility, strength of materials, and manufacturing methods.

Module 2, Failure in Use, is an exercise in observation. An analysis of why things break or wear out.

Module 3, Design in Nature, is intended to introduce the philosophical concept that when a design is made, to best achieve its intended purpose, it is to be accepted. Cues related to good design are obvious in nature.

Module 4, Characteristics of Materials, is to have the students experiment and learn about the unique characteristics of materials as a body of knowledge to be applied in designing products.

Module 5, How Things Are Made. This module deals with the technology of shaping materials, the technology of processing as a body of knowledge, and experience to be applied in designing products.

Module 6, Fasteners. A study of the application features of fasteners as used in products.

Module 7, Patents and Inventions. A brief unit on patents, inventions, and inventors.

Module 8, Product Liability. A survey of the law of torts and the safety expectation of products.

Module 9, Drawings & Specifications. A review of drawing and its use and application in the designing process.

Module 10, Developing A Design. The final phase of the course is devoted to the development of an idea, through the various design stages to the making of a final prototype. This module is a semi- cook book approach to designing a solar lunch box. While it is the teacher's option to make a design problem substitute, the teacher's first experience with the module may require the structure of the "cook book" method.

COURSE OUTLINE

Module Number	Title & Content	Time (Days)
1	Shape of Things	3
2	Failure in Use	3
3	Designing in Nature	4
4	Characteristics of Material	10
5	How Things Are Made	11
6	Fasteners	5
7	Patents & Inventions	5
8	Product Liability	3
9	Drawings & Specifications	3
10	Developing A Design	30

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OBJECTIVES

Upon completing this module. each student should be able to:

1. Differentiate between purposeful utilitarian and cosmetic shapes.
2. Observe designs and be critical and analytical of its function and non-functional shape.
3. Design a product or component for maximum utility.

DESIGNING PRODUCTS

Module 1 : Introduction, The Shape of Things

Length 3 Days

Special Supplies - paper - 8 1/2 x 5 1/2 20#; 12 common bricks; stapler; glue; tape

The function of this module is:

1. To introduce the purposefulness of shape.
2. To establish an analytical method of thinking about how and why the various shapes of objects were designed or evolved.
3. To introduce the structural and functional advantage of shape variation.
4. To introduce some terms applied to designs.

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SYNOPSIS

The purpose of this module is to alert the student's observation skills in the analysis of why products are shaped as they are. Shapes may be due to utility, method of manufacturing, characteristics of the material, custom or sales appeal.

The professional designer must "straddle the fence" sometimes. Automobile designers are said to be concerned with the MAYA principle. Most Advanced Yet Acceptable. The air-flow Chrysler of the thirties was most advanced but not acceptable. It was ahead of the times.

The generally accepted principle of current designers is that a product should be shaped for maximum utility; that we should learn to accept the appearance, even when it is out of line with traditional style or shape: that a shape is best when it is not accidental, when it is designed as being the best that can be conceived for the intended purpose.

Students as well as teachers may have difficulty accepting the principle that will be referred to here as "true design" meaning a design straight to the mark, no gingerbread or no frills. Examples of true design may be found in nature, a separate module to be taken later, or in items such as:

A straight pin.
A jet airplane.
An ax, hoe, toilet paper holder.

The intent for the "true design" discussion is to have the student think about shapes and design concepts that they have never thought about before.

PRESENTING THE MODULE

Day	Activity
1	Administrative details

Class discussion

Ask the students to give a definition or example of good design. The student will most likely give examples of things which are thought of as being "pretty."

Direct the student's thinking toward items that best achieve the intended purpose:

An airplane - speed - carry people
Book shelf - to hold & display books
A can to hold garbage
A dinner plate - hold food, easy to clean

Discuss Design Terms

Honesty in design. The honest use of materials

Examples of dishonesty:

plastic flowers, fruit-wood printed plastic
leather shoes stamped as alligator

Ginberbread: A design with added decorative details that do not contribute to utility:

Carvings on the front of dresser drawer.
Hard to paint details on a house cornice.
Etched decorations on a silver tray.
Elaborated shaped handles on silverware.

Novelty: A design made of components not purposefully shaped as being the best for the structure:

A pump handle lamp.
A coat rack made from a horseshoe.
A hat rack made from deer antlers.
A floor lamp with a musket as its vertical structure.
A lighting fixture made to resemble a wagon wheel.

The Purposeful Shape of Things

Discussion:

Why are paint cans round, why not square?
Why are gallon milk containers square?

Why is an automobile made with smooth flowing curves?
The front of automobiles of the early nineteen hundreds were somewhat flat. Why were they different from current designs?
Why do metal garbage cans have flutes?
Why is a hammer handle larger at the end opposite the handle?
Why are steel lolly columns hollow, as a pipe, and not a solid bar?
Why are wooden table legs usually square and metal legs round?
Would a square door knob be better than round?
Why are corrugated boxes made of outside and inside sheets with a corrugated filler between?
Both books and newspapers receive the printed word. Why not use the same size for both?
Why are glass soda bottles made long and skinny, and metal soda cans made short and stubby?
Why is the handle of a grub hoe made larger on the hoe end?
Why is the regular wooden lead pencil made the same diameter its full length?
Why are writing pens made smaller on the ends?
Some writing pens are made with an enlargement near the tip for a finger rest, is that a desirable shape?
Why are leaves flat and thin and the tree trunk round and thick?
Why do vines climb trees and not go on their own strength?
Why are salad bowls round, small at the bottom with angular sides?
Why are house roofs usually flat and not round like a silo roof?
Why is structural steel made in shapes like angle iron, I beams, and H beams?
Why is a baseball bat not the same diameter the full length?

Homework Assignment: select one only.

A. Have the student observe an object, make a sketch of the shape, and explain the "why" of the shape.

B. Observe, sketch and explain an observed dishonest use of material.

C. Observe, sketch and explain an item with "gingerbread."

2 Take up homework. Have students explain their homework assignment.

Design Problem:

Give each student 8 1/2 x 5 1/2 pieces of paper. The problem is to support the most bricks at a height of 5 1/2". The support is to be made of two pieces of paper 5 1/2 x 8 1/2.

The glue, staples, and tape is to be used as a fastener only, not as a paper stiffener. The paper may be cut or shaped in any way as long as the first brick is suspended 5 1/2" in the air. See testing, Appendix A.

Suggestion: Show students how their structure will be tested. Allow time in laboratory to make and try out some designs. Give students extra paper to take home. Have structure ready for testing at next class. Each student allowed two entries.

3 Test the structures.

Discuss the design or designs that supported the greatest weight.

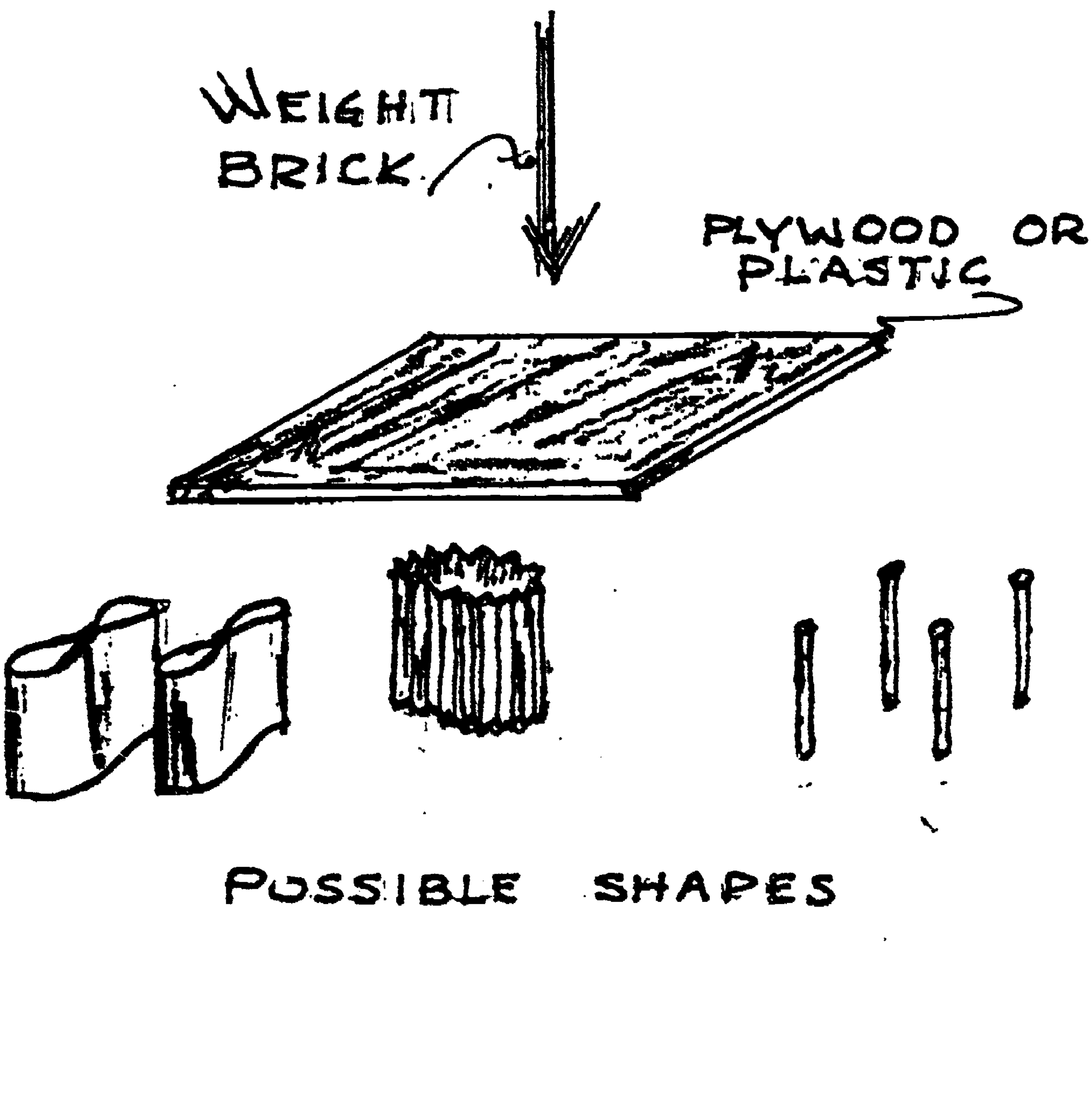
Teacher: Make an effort to make all the students feel good about their design effort. Compliment the winners, but explain to other students: If you learned, you won.

Discuss the idea that a good designer must accept failure as a step toward success. The many failures of Thomas A. Edison proves this point.

Discuss the idea that a designer must become a good critic and observer.

APPENDIX A

Testing The Paper Structure



Module 2 : Failure in Use, Broken Objects

Length 3 Days

Special Supplies - a broken object

The function of this module is:

1. To promote observation and causation analysis of products and product components which have failed due to faulty design, inappropriate material, abuse, misuse or environmental conditions.

OBJECTIVES

Upon completing this learning module, each student should be able to:

1. Observe a broken object and make a reasonable judgment of the cause of failure.

2. Anticipate the probable usage and conditions of a product or component that would lead to failure in use.

3. Become aware and critical of goods that failed to meet consumer expectation due to an improvable feature.

4. Suggest better designs that would promote longer service.

SYNOPSIS

This module is organized to promote analytical observation of products that have broken and require replacement or repair. Few objects reach their full time of service without having some part fail. With the automobile, it may be the door handle; on the oven, the broiler unit or eyes; a bicycle foot pedal; a table leg; rocking chair rocker; the bottom rusting out of a garbage can; a fan with a broken switch; a sauce pan with a broken handle; a faulty fast ner. In many instances, had the manufacturer and designer added perhaps 10% effort and reinforcement to the broken part, longer service would be achieved.

Original designs of good quality are sometimes cheaply made from an inferior material. An example would be a claw hammer made of cast iron instead of forged steel, one drop on concrete and the claws are broken.

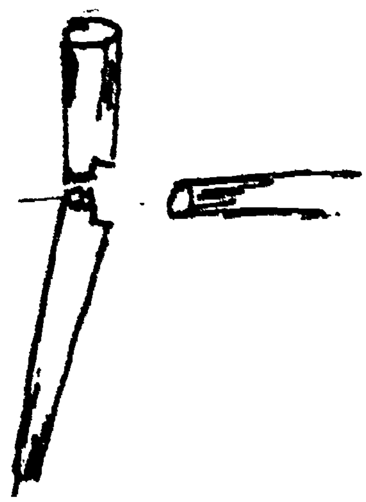
PRESENTING THE MODULE

Day	Activity
1	Administrative details. Explain the objective and purpose of the module. Go over teacher's examples of a broken object. Use example, Appendix A, or substitute example. Hand out broken objects investigation form, Appendix B. Suggest sources for broken object items: in the attic, storage room, automobile, kitchen stove, furniture, bicycle, garden tools, ask your mother or father. Homework: Have each student find a broken object and complete the investigation form for the next class. Students may wish to bring in actual objects.
2	Collect homework. Have students use the board, sketch and explain their broken object. Use the board and see if a pattern can be developed for failure causation such as: shape, wrong material, rusting, fastener, weathering.
3	Finish student reports. Return reports, evaluate, have students file reports in notebook. Review purpose of the module. Ask students how the module will influence their designs. Return and dispose of examples or items brought to class Ask if students are familiar with body injuries associated with a faulty part or product that failed in use.

APPENDIX A

Teacher Example: Broken Object

A chair leg broken at the rung position.



Description of Fault:

At the position of the rung, a hole was bored to receive the chair rung. The boring of the hole decreased the volume of wood at the rung position creating a weak point.

Reason for Failure:

Weak section of the leg. If on a back leg, leaning back would place an unusual breaking pressure on the leg.

Suggested Improvement for Longer Service:

Make the cross section of the leg larger at the rung position. Stagger the rungs. Place the rung higher on the legs to decrease leverage due to leaning back. Use different type, stronger wood.

APPENDIX B

Broken object investigation form

Student ______________________

Object Observed:

Description and Sketch of Fault:

Reason for Failure:

Suggested Improvement for Longer Service:

Module: 3: Designs in Nature

Length: 4 Days

The function of this module is:

1. To introduce the idea of observing objects of nature for possible design application.

2. To illustrate the concept "that when a design accomplishes the intended purpose," appearance will be an inherent part of the whole.

OBJECTIVES

Upon completing this module, the student should be able to:

1. Accept the appearance of a design as being "right" if it is deemed the best product for accomplishing the intended purpose.
2. List at least 5 objects of nature that have been copied by humans.
3. Observe objects of nature with an inquiring mind that may lead to problem solutions beneficial to humans.
4. Have greater appreciation for the nature of planet Earth and its designs.

SYNOPSIS

Humans have been fascinated with nature throughout recorded history. One of the most copied features is that of flight. One of the earliest copies is the wings of angels and the winged characters in Greek mythology. In April of 1988, a human powered plane, designed and made by students, faculty and alumni of Massachusetts Institute of Technology flew 74 miles from Crete to the island of Santorina. The event was featured in the August, 1988, National Geographic.

Submarines copy fish in their ability to float and sink. Other applications used by humans are: the sonar of bats, heat exchanges found in the ears of jack rabbits and the flippers of seals; missiles find their target with heat detecting devices as do rattle snakes locate their prey. Camouflage found in nature is copied in the color and design of combat military clothing. The silky hair of milkweed, dandelion, willow and cottonwood is similar to our parachutes. Velcro is like cucklebur. The tentacles of a hydra plant has its glue capsules. The Antarctic ocean turned cold thousands of years ago, one of the fish, Notothenioidea, developed its own antifreeze in response to the change of global climate.

Should we copy some of nature's designs such as making an automobile like an egg, we may be able to eliminate head-on collisions.

As a "teacher," nature is our best lead to the principle of design, "that the design that is best to accomplish the intended purpose will also be pleasing to the eye."

REFERENCES

One of the best references is the encyclopedia. A variety of nature books, The Scientific American, and National Geographic contain in-depth study of nature's marvels. Science and nature films may be available through the school's science department.

Film: Designs in Nature, International Film Bureau, 332 Michigan Avenue, Chicago, IL 670604 - 19 minutes, rental - $25.00.

Books:

Design-Serving The Needs of Man, G. C. Beakley & E. G. Chilton, MacMillian, N.Y.

Design for the Real World, Victor Papanek - Van Nostrand Reinhold Co. N.Y.

A Strange World of Insects, George Bush, G. P. Putnman's Sons, N.Y.

How Insects Live, Blaney Elsevier-Phaidon, Oxford, England.

Living Insects of the World, Klots, Doubleday.

Life on Earth, Attenborough, Little Brown & Co.

A Miracle of Flight, Stephen Dalton, McGraw Hill Book Co.

Aquatic Insects of North America, Merritt & Commings, Kendall-Hunt Pub. Co., Dubuque, Iowa.

The World You Never See, Insect Life, Rowland & Entwistle, Rand McNally & Co.

Small World Close Up, Grillone & Gennaro, Crown Publishers, NY, 1978.

Hidden Worlds, Nat. Geog. - 1981.

Science It's Changing World - Natl. Geog. - 1946.

DAY	ACTIVITY
1	Administrative Details.
	Orient the students as to the purpose and objectives of the module.
	Discuss and ask for student input about things they know about that have been copied from nature such as: airplanes from birds, velcro from cucklebur, radar from bats, scuba diving from aquatic insects.
	Assign or have student select a topic for investigation. See Appendix A. Report to be written on investigation form, Appendix B.
2	Follow up and record student's selected topic for investigation.
	Help student locate resource material.
	Assign problem 1. Appendix C. Explain how the problem somewhat duplicates nature's way of spreading seeds: Explain what materials will be allowed, and how the design will be tested.
	Allow work time in class, or item may be completed at home and brought back to the class room for testing.
3	Answer questions about the design problem.
	Student nature-study reports.
4	Test student design.
	Review of module objectives.
	Test.

APPENDIX A

Investigation Ideas and Topics

1. The way seeds of plants are scattered; flotation of the coconuts, the "parachute" structure of the milkweed, dandelion, and thistle, the aerodynamic rotation of the maple seed.

2. The camouflage and color change of animals and insects for concealment and heat absorption from the sun.

3. The ingenious methods used by plants and animals for trapping their prey, the antlion, spider, archer fish, venus fly trap, and pitcher plant, the shooting seeds of violets, witch hazel plant.

4. The unusual slipperiness of ice.

5. Nature's containers, the bee's honey cell, peas in a pod, and eggs.

6. The structure of a leaf, the chlorophyll factory of energy, the stomata that close when water is scarce, the curling leaf that funnels the dew.

7. Split the base of a feather and observe the truss-like structure under a microscope, the connecting loops of the air-catching portion of the feather.

8. Collect and observe the hollow structure of a bird's bone, a piece of bamboo.

9. Observe the geometric arrangement of the seeds of a sunflower.

10. Observe the rotation of a climbing vine, morning glory and briar.

11. Investigate the protective system of plants, nicotine, the alkaloid poison in tobacco, poison ivy, thorns on roses and trees.

12. Study the "air-conditioning" system of the prairie dog tunnels.

13. Water spiders that take air bubbles under water for use.

14. Drop a dry pine needle in water. Notice the support by surface tension. Add soap and see the surface tension destroyed. (The water strider.)

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APPENDIX B

Nature Investigation Form

Title:

Write-up. Give information about the topic. What was learned. The object of the research, experiment or observation.

Possible utilization of the principle by humans.

Sketch, explanation or photo-copy of the item investigated.

Source of Information.

APPENDIX C

1. Design Problem.

   Supplies: Give each student a standard size marble and several sheets of regular paper, 8 1/2 x 11 - 20 #. Students are allowed to use tape, glue, string.

   Objective: With one sheet of paper, cut, glue, fold or shape a structure that when released 8 feet in the air will transport the marble the greatest horizontal distance from the starting point.

   Suggestion for Testing:

   An open floor with an area of 15 to 20 feet is suggested. The distance measured at the point the marble touches the floor. Allow the student two drops. Give distance of the best drop for class standing.

   Evaluation: Your evaluation method should give all students who made a good effort a good grade. The establishment of a friendly competitive atmosphere in the classroom is important for the "spirit of the class."

   Example: If the best distance is 120 inches and the shortest distance is 60, a range of numerical grade 60 = 80 and 120 = 110 will encourage all students to try on the next problems.

   Other Problems

2. Give each student a 12 inch piece of balsa, 1/16 x 1/16. Have them design a creature to be supported by the surface tension of the water like a water strider. Test the structure by loading it with No. 1 paper clips.

3. Brainstorming Problem: A creature which lays eggs in the water requires the following conditions.

   1. The egg must be exposed to the sun, to float on top of the water for 4 hours.

   2. After 4 hours exposure to the sun, the egg is to sink to the bottom, away from flying predators and complete the hatching process.

   For individual response, have each student write out their ideas. Then improve by the brainstorming technique.

MODULE: 4: Characteristics and Materials

LENGTH: 10 DAYS

The function of this module is:

1. To introduce the student to material sources.

2. To explore and learn, through experimentation and observation, how to select and use material to the best advantage.

3. To develop the student's ability and skill to anticipate foreseeable conditions that design material may be subjected to.

4. To introduce to the student creative utilization of material.

5. To give the student hands-on experience with materials to enhance recall for subsequent application.

OBJECTIVES

Upon completing this module, the student should be able to:

1. Locate material sources.
2. Analyze design material requirements and make appropriate selections.
3. Have a knowledge of material testing techniques.
4. Sselect material in keeping with their natural and strongest characteristics.
5. Have a creative attitude in respect to experimentation and material utilization.

SYNOPSIS

Knowledge of materials, their use, shaping method, source of supply and cost can best be gained by experience. Due to the time restriction, the classroom method given in this module is intended to provide a learning base for the student designer.

The intent is to have the student learn by experimentation some of the striking charecteristics of material as selected and used in product design application. Once the student's power of observation and analysis has been tuned-up by experimentation, learning will likely continue.

The teacher is charged to learn from the students. To point out and lead the discussion regarding the application of the experimentations such as:

Aluminum heat transfer - lawn motor cooling.
Chopping block - end grain.
Wood expansion - boats and barrels.
Friction - steps, tires, bearings.

REFERENCES

PLASTIC TECHNOLOGY, Swanson, McKnight and McKnight.

INDUSTRIAL PLASTICS, Baird Goodheart-Willcox.

TECHNICAL METALS, Johnson, The Bennett Co.

METALWORK TECHNOLOGY AND PRACTICE, McKnight and McKnight.

MECHANICAL DETAILS FOR PRODUCT DESIGN, Greenwood-McGraw Hill, 1964, pp. 244-247.

FRICTION, AN INTRODUCTION TO TRIBOLOGY, Bowen and Tabor, Robert E. Kreger, Pub. Co., Malabar, Florida, 1982, Reprint.

WOOD HANDBOOK, WOOD AS AN ENGINEERING MATERIAL, U.S. Printing Office, Washington D. C. 20402.

NATIONAL GEOGRAPHIC - Wool, May 1988 - P552.

MATERIALS

- short candles
- empty soda cans
- eye dropper
- discarded ice tray
- aluminum foil
- scrap wood
- sand, cement
- polystyrene packing material
- gram scale
- small aluminum and steel rods
- dial indicator
- No. 18 wire nails
- thermometer
- spray paint
- plaster of paris
- zip-lock plastic bags
- rigid polyether foam (IASCO)
- propane torch

PRESENTING THE MODULE

DAY	ACTIVITY

0 Take roll and other administrative duties.

1 Discuss the nature of the module. A study of material, characteriscics, sources, cost and available forms.

Write on the board the materials and some of their unique characteristics for study and student investigation.

wood	ceramics - glass, clay, cement
aluminum	rubber
plastic	water, ice
leather	paper
steel	copper
bronze	brass
lead	nickel
	plaster of Paris

Hand out material investigation form, Appendix A. Go over sample investigation form, Appendix B, and check list, Appendix C.

2 Give student assignment or record student investigation choices to avoid duplication. Encourage students to investigate the "why" of material. Why does rubber snap back? The reaction of polymers in rubber and plastics. Why does some metals rust? Challenge the students to bring to the class information you do not know. Learning from the student helps the teacher.

Continue discussion of material characteristics.

3 Begin student reports and class discussion of materials. Assign Thomas Register exercise - see Appendix D.

4 Student reports selection and assignment of experiments. See Appendix E.

5 <u>Class discussion</u>

surface treatment of material	surface hardening
paint for metal	galvanizing
anodizing aluminum	impregnating
sandblasting - glass, metal, grave markers	burnishing
plating	wood finishing
enameling	knurling metal

6 Work on individual or group experiments.

7 Work on and begin demonstration of experiments.

8 Report, demonstration, and share experiments. Help students record their individual experiments for notebook credit.

9 Review material characteristics, the role of experimentation. Share material sources and distribute technical hand-outs. Discuss new developments. Review technical terms.

10 Test, inspect or take up notebooks. Dispose of demonstration units, models and materials. Announce the topic for the next module.

APPENDIX A

Material Investigation Form

Material:

How Purchased:

Cost and Supply Source:

Forming Methods:

Comm[illegible]ge:

Fastening Characteristics:

Advantages:

Disadvantages:

Good Use Examples:

Poor Use Examples:

Technical Terms:

Questions:

References:

APPENDIX B

Sample Material Investigation Form

Material: Wood

How Purchased: (Shape or measurement) logs, board feet, square feet, panels, sheets, veneer

Cost and Source of Supply: Local building supply, hardwood retailers, lumber brokers, saw mills

Forming Methods: Cutting, saw, jointers, laser, steam jets

Common Usage: Buildings, furniture, toys

Fastening Characteristics: Easy to glue, takes wood screws, bolts and rivets

Advantages: Replenishable, biodegradable, friendly material, "easy to the touch, low heat transfer," good insulation, takes fasteners, takes glue, easy to shape and cut, cost to strength ratio good.

Disadvantages: Anisotropic, weathering, combustible, swells and shrinks in use, weakens and rots by moisture.

Good Use Examples and Reasons
2 x 4 studs - cost, nailable. furniture, easy to cut, heat transfer, Barrels - swell and not leak.

Poor Use Examples
Parquet flooring around sink. real wood on old ranch wagon. untreated wood post and fences.

Technical terms, kerf, quarter sawn, fiber saturation point, side grain, end grain, growth rings, specific gravity, klin dry, compression strength, thermal conductivity.

References: Wood Handbook, U.S. Printing Office.

APPENDIX C

Material Investigation Check List

Chemical

corrosive
toxicity
flammable
explosive

General

decomposition
aging
biodegradable
absorbability
insulation value
slipperiness
acoustic

Mechanical

Weight to strength ratio
stability
impact resistant
castable
weathering
heat treatable
tensile strength
compression strength
heat and cold
weldable
glueable
extrudable
elastic force
fatigue factor
expansion
contraction
fastener acceptance
moisture
heat transfer
cutting quality
hardness

APPENDIX D

Using The Thomas Register

The Thomas Register is a publication of manufacturers of materials and processes, a valuable information resource for the designer. A set of books may usually be found in the city chamber of commerce, library, and many manufacturing organizations. A local industry or library may donate an old set for class use.

Class Assignment: Have each student write to some manufacturers for a brochure of their goods and services. Suggested items:

- solar panels
- bead chains
- plastic fasteners
- oil-less bearing (sentering)
- safety glass
- insulating materials
- wood turnings
- molded plywood
- tote boxes
- fire-retardants
- stamping
- investment casting
- wire forming
- tamper-proof screws
- plastic gears

A form letter written by the teacher attached to the student's letter has been found effective. Explain in the letter that the information and the samples will be used to build up a Resource Library for the design class.

APPENDIX E

Material Experiments

Note: Give the students an opportunity to design their experiments.

Example: Aluminum is a good metal for heat transfer. Design a simple class experiment for comparing the heat transfer action of aluminum with steel. If the students do not come up with an acceptable idea, use the cook-book ideas in this module. Item 1 and 2, Appendix F.

1. Heat Transfer: Dip the ends of two metal rods, one aluminum and one steel, into the melted wax of a candle. Make a set up to apply the candle flame to ends, and record the melting time for each. See Fig. 1, Appendix F.

2. Heat Transfer Experiment: See Fig. 2, Appendix F. Cut the tops from two soda cans and install aluminum and steel rods.

   Class Mini Problem: Drilling a 1/4" hole in a thin metal can is difficult. The hole becomes ragged, and the can bends. Have student bring in suggestions for drilling the hole.

   Note: A better response from students may be achieved if they are required to have the sketch of their ideas on paper to be collected at the beginning of the next class.

   Teacher Preparation for Next Class: Place water in a can and freeze. At the next class meeting, take up and discuss students' ideas. Pull out the frozen can and show how easy it is to drill a smooth hole with the ice back-up.

3. Anisotropic reaction of wood to moisture: Cut witn fine-tooth band saw several small pieces of wood, across and with the grain, approximately 1/8" x 1/8" x 3" from soft wood, such as white pine. With dial indicator and eye dropper, see Fig. 3, Appendix F, compare with and across grain expansion.

4. Cut 8 - 10 thin slats of wood, approximately 1/8" x 1" x 6". Secure with clenched wire nails. See Fig. 6, Appendix F. Apply water by rubbing with a wet cloth. Leave overnight and observe the curvature caused by the anisotropic characteristic of wood.

5. Effect of Heat and Cold: Mix samples of plaster of paris and cement and pour into ice tray. Seven samples each material. Scratch on identification 1-7. Allow to set overnight. Place one cube of each material in freezer. Place 6 samples each in tin-foil lined pan in kitchen oven. Bring heat to 150°F, remove sample 2, 200°F remove sample 3. Continue the operation at 250°, 300°, 350°, 400°. Allow the samples to thaw and cool, and examine for hardness, heat and cold structural damage.

6. Slipperiness, Coefficient of Friction: Coat or glue on the four sides of a brick different materials and calculate their coefficient of static friction, Fig. 5, Appendix F.

   Static friction of common materials:

book on table 0.3	wet tire on wet road 0.2
break material on break drum 1.2	copper on steel 0.7
dry tire on dry road 1.0	ice on wood 0.05

   Suggested test and applications:

   Hard wood against hard wood - drawer slides
   Sand on Paint - steps and shower floors
   Silicon carbide on ceramic tile - shower floor

7. Strength of Wood Related to Grain Direction and Species: Splitting test comparison with hatchet or chisel. Red gum, oak, walnut, ash, southern yellow pine, cherry, maple.

8. Color and Solar Collection: Pour one pint of water in two quart-size zip-lock bags. Spray aluminum foil different colors, and insert the sheets into the bags, and expose to the sun. Check the temperature every 20 minutes for an hour and record.

9. Compare expansion and contraction of metal and wood when exposed to heat and moisture. Fig. 6, Appendix F. Two units required. Place one unit in oven and observe change. Place one unit in water and observe change.

10. Cooling by Evaporation: Porous material. A water cooling system used by the Egyptians was to place the water in Bisque ceramics exposed to the night wind. "Sweating" cooled the water. Experiment: Slip cast two small containers, glaze one container, and leave the other unglazed. Place water in the two containers in front of a fan. Measure the water temperature at 30 minute intervals for two hours.

11. Cooling by Evaporation: Fill two soda cans with water. Place one can inside a wet wool sock. Expose to a fan for 2 hours and check water temperature. Wool - see National Geographic, May, 1988.

12. Mini Class Problem and Experiment:

    Problem: A textured surface is desired for a small flat area to be duplicated by molding plaster of paris. The surface, described as "hobnail," is a tiny, raised bubble like surface. How may such a surface be produced? Have students bring in their answers to the next class period.

Ideas: drill shallow indentations with small drill, hit soft surface with ball peen hammer.

The Easy Way: Have some hot water, and insert into the hot water a piece of packing material made of polystyrene beads. The hot water will cause the beads to bubble out. Take a cast of the surface.

Note: **This is a very unusual application, and reaction of a material. Such an application would most likely be discovered by accident.**

Experimentation leads to new ways.

13. Class Design Problem:

Design a device for making comparative tests for the effectiveness of insulating materials.

Considerations:

samples easy to insert
a convenient and consistent source of heat
a method of measuring heat transfer

Ideas:
small light bulb for heat source
can filled with water to receive the heat through the insulation.

Suggested materials for testing:

natures insulator for the pine tree, bark
plastic foam
glass insulation
concrete
glass
wood

14. Casting Foam: Rigid polyether casting foam adheres to most all surfaces except RTV rubber. Special molds are required for molding. The expansive characteristic of casting foam may be easily demonstrated by mixing a small quantity of the foam ingredients in a cup, allow to expand to a mushroom shape. Foam is a good insulator for ice chest, solar applications.

15. Compare water absorbing characterists of material: wool, cotton, rayon, nylon, and other synthetics, sponge, paper, wood. Determine dry weight. Expose to water and calculate percent of weight gain.

16. Place 1/2 gallon milk container in an oven at 250°F. for 30 minutes. Compare the shape of the results to an unheated example as a means of understanding thermoplastic plastic. Do the same experiment with thermoset (bakelite).

17. Heat a common nail to the red color. Cool it slowly in ashes, compare the change in temper to a regular nail.

APPENDIX F

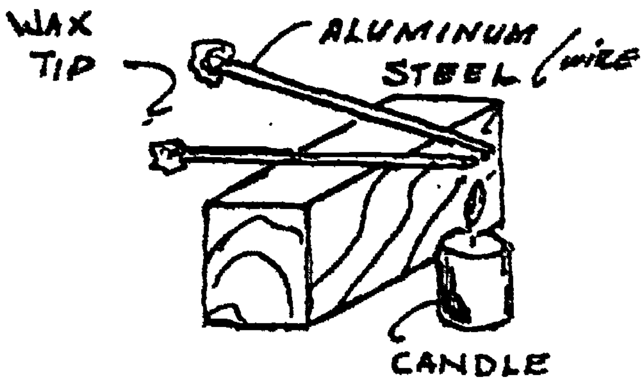

FIG-1

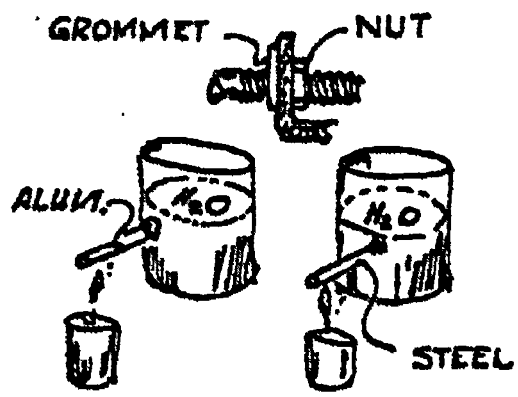

FIG 2

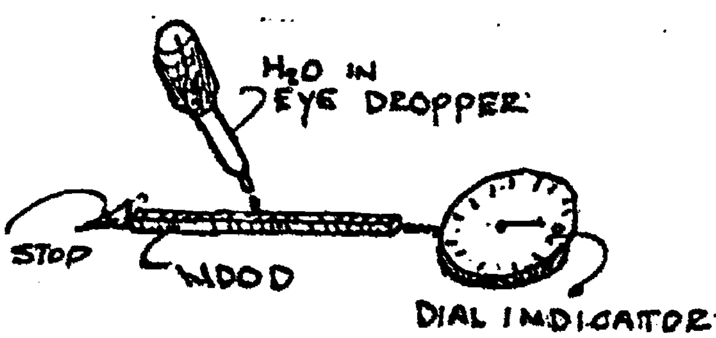

FIG-3

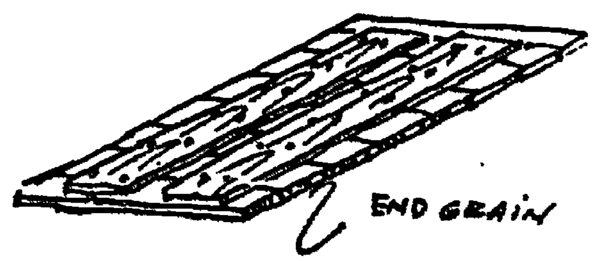

FIG 4

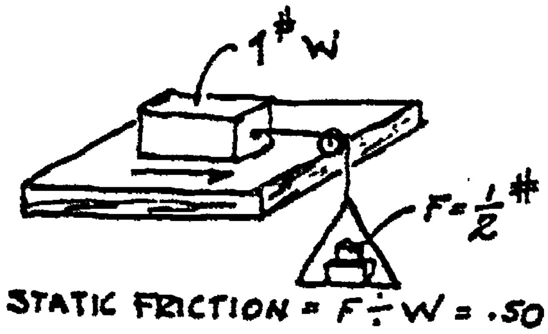

FIG-5

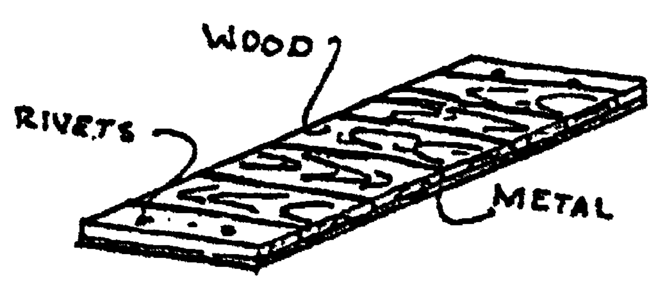

FIG-6

MODULE: 5 : How Things Are Made

LENGTH: 11 DAYS

The function of this module is:

1. To introduce to the student an overview of forming methods, manufacturing processes that may be understood by observing consumer products.

2. To help the student develop learning questions and observable answers related to function, materials, and processes of products.

3. To give the student experience working with forming and using materials that may be used in subsequent design work.

4. To lead the student through experiments that will enhance their learning about the origin, evolution, and utilization of products.

OBJECTIVES

Upon completing this learning module the student should be able to:

1. Understanding the manufacturing processes as related to product design.

2. Look at a common product and explain the production process, the reason for the material selection and shape.

3. Have technical observation skills for critical evaluation of a product to foster copy, change and improvement.

SYNOPSIS

The first part of this module is teacher oriented. The teacher is to direct the student's thinking about the products of our environment. The intent is to develop the student's observation skills to a level of understanding and analysis of how things are made. The teacher must delimit the scope and the time for experimentation and help students select experiments within the reasonable range of time and facilities.

All the suggested experiments will not be an absolute mimic of the real thing. The assistance of the teacher may be required to synthesize and make relevant comparisons of the process and material to the industrial counterpart.

Some of the experiments may be done by the student at home, such as experiments which require hot water, oven heat curing time and drying. After the completion of the experiment, the results are to be shared with the class.

Encourage honest and objective reporting. Point out to the students, that even when the experiment does not end with the anticipated results, the true results of the experiment gives the best learning.

Whenever applicable, have the students rotate around the experiment stations to experience the process first hand.

Note Book:

A good notebook is an essential part of a designer's equipment. A loose-leaf book is suggested as it allows the addition of new material. A fool-proof organization system is by topic, alphabetical.

REFERENCE

MECHANICAL DETAILS FOR PRODUCT DESIGN, Greenwood, McGraw Hill, 1964.

MANUFACTURING PROCESSES, H. W. Yankee, Prentice Hall, 1979.

NONTRADITIONAL MANUFACTURING PROCESSES, G. F. Benedict, Marcell Dekker, Inc., N.Y.

MANUFACTURING METHODS AND PROCESSES, A. Ansley, Chilton Books, N.Y., 1968.

ENCYCLOPEDIA OF HOW IT'S MADE, Donald Clarke, A. W. Publishers, 95 Madison Ave., N.Y., N.Y. 10016.

WOOD HANDBOOK, U.S. Printing Office, Washington, D. C., 20402.

INDUSTRIAL PLASTICS, Baird Goodheart, Willcox, South Holland, Ill.

TECHNICAL METALS, Johnson, Chas. A. Bennett, Peoria, Ill, 61614.

METALWORK, Ludwig & McCarthy, McKnight & McKnight, Bloomington, Ill.

PLASTIC TECHNOLOGY, Swanson McKnight & McKnight, Bloomington, Ill.

The suggested laboratory setting is a general shop facility.

Supplies:

- scrap wood
- plaster of paris
- glass cutter
- sand
- casting resin (IASCO E-Z Cast)
- plastisol
- clay
- candles and wax
- band iron
- acetone
- gallon can
- empty soda cans
- toy balloons
- inner tube rubber bands
- copper tubing and cap
- aluminum foil
- sheet plastic
- silicon mold release
- scrap window glass
- casting foam
- eye dropper
- tube cutter
- solder and propane torch

NOTE: Small experimental amounts of materials may be ordered from IASCO.

DAY	ACTIVITY
1	Complete administrative details. Orient the class to the purpose of the module, the nature of the class activity, student participation, how they will be evaluated, and the role of the teacher.
	Use the objects in the classroom to alert the student to the type of inquiry expected. Discuss:
	Switch plates: are they plastic or metal?; were they stamped or molded?
	The light covers: are they plastic or glass, extruded, cast?
	The chairs or stools: are they molded plastic, turned wood, laminated or steam bent?
	The table tops: are they particle board, was it cast, cut or extruded?
	The chalk holder: is it wood or aluminum, extruded or cut?
2	Bring in an item and analyze the shape, material, method of manufacturing, color, etc.
	NOTE: **A suggested item to be used by the teacher is a plastic milk jug. See Appendix A. If the milk jug is used, have students look at home and report at the next class, blow molded items they observed.**
3	Student report: blow molded items observed. (Previous class assignment.) Help students select an item or a process for investigation, hand out inquiry form, Appendix B. Write list shown in Appendix C or develop a class list. Have student select or assign topics.
4	Student reports and class discussion.
5	Student reports and class discussion.
	Introduce the idea of the next 7 days of experimentation. Explain the purpose of the experiments. Go over some of the suggested experiments in Appendix C and E. Have students invent their own experiments. Explain to the student that while the mock-up may not be exactly like the industrial counterpart, the intention is the production of a visual aid for learning. Hand out demonstration report form, Appendix D.

6 Help students with their experiments. Set deadline for class demonstrations. Help students locate materials for their experiments.

7 Canvass the class and have students who are ready give their demonstrations.

8 Help students prepare demonstrations.

9 Class discussion and demonstrations. Has the demonstrations given you ideas about things you could make and different methods of making them? Continue demonstrations and reports.

10 Announce test and review.

11 Test.

Take up or inspect notebooks.
Tell students about next module.

APPENDIX A

Manufacturing inquiry form

Item: One gallon plastic milk container

Brief Description: Plastic container, square for easy storage, light weight, inexpensive -10/15-cents, handle for pouring, see-through material, throw away. Threads for cap.

How Made: Blow molding. A machine extrudes a tube of hot plastic, "Parison." A super cooled, two-piece mold with draft, grasp the Parison as air pressure into the tube forces the plastic to conform to the inside shape of the mold. The plastic quickly becomes rigid. The mold opens, and the container is removed. A high production automatic manufacturing process.

Material Selection and Characteristics: Thermo plastic polyethylene may be easily heated, extruded, and formed. Relatively inexpensive. Disadvantage: Not as yet biodegradable.

"How-Made" Cues: Seam can be seen on the sides where the two pieces of the mold came together. "Parting Line." A [illegible]th-like shape can be seen on the bottom where the Parison was pinched.

Technical Vocabulary:

Parison	Blow molding	Extrusion
Thermo Plastic	Parting Line	Two Piece Mold
Polyethylene	Biodegradable	Draft

References

Industrial Plastics, Goodheart-Willcox, Chapter 7.

Questions:

Explain the blow-molding process.

Why was polyethylene used?

What is a Parison?

List items you have observed that were made by the blow-molding process.

How may the process be identified by looking at a blow- molded item?

APPENDIX B

Manufacturing Inquiry Form

Item:

Brief Description, Cost, Use:

"How Made":

Material Selection and Characteristics:

"How-Made" Cues:

Technical Vocabulary:

Reference:

Questions:

APPENDIX C

Suggested Items or Processes for Student Investigation

Glass - blowing, float process, tempered glass, bottle making, casting
Explosive forming - missile nose cones
Plating - auto bumper, silverware
Aluminum surface treating - anodizing
Metal spinning - pots and pans
Die casting - auto door handles and cranks
Lost wax process - art objects
Investment casting - precision parts
Sand casting - man hole covers
Aluminum extrusion - molding
Plastic extrusion - wire coating, garden hose
Forging - tools, hammers, wrenches
Slush casting - metal and plastic
Plastic coating of tools, epoxy, plastisol
Fluidized bed process
Fiber optics - communication lines
Rotational casting - toys, plastic barrels
Vacuum forming plastic - boats, canoes, blister packing
Injection molding - coat hangers, buckets, furniture
Expandable beads, ice buckets, packing
Use of RTV silicone rubber for mold making
Slip casting - ceramic objects
Computer chips - Automobiles

APPENDIX D

Demonstration Report Form

Name of demonstration:

What products are made by the process or the material:

Research information: When was process or material first used or invented? What procedure was used before the current methcd?

New technical terms:

What did you learn by your demonstration and investigation?:

Test questions based on your demonstration and presentation:

APPENDIX E

Ideas for Class Experiments

1. Steam Bending: Cut a small piece of straight grain wood, "oak," about 1/4" x 1" x 8". Cut a piece of band iron 1/8" x 1" x 8". Bend the band iron to a desirable curve, chair rocker, chair back. Boil the wood for about 15 minutes; tie the wood on the piece of metal with wire, and dry in oven overnight, 175°F. Fig. 1, Appendix F.

2. Extrusion: Obtain a short length of copper tubing and copper cap (suggested size 3/4"). With small drill and file, cut shape in the cap such as angle iron shape. Solder cap on to tubing. Place clay in the tubing and push through the cap with wood or metal rod. Allow clay shape to dry. Fig. 2, Appendix F.

3. Float Glass Process: Float glass is made by floating the glass on molten tin. The procedure can be demonstrated by placing a candle in an old pot, bringing to a boil and allowing to cool. Glass is lighter than tin, it floats. The wax is lighter than water, it floats.

4. Lost Wax or Investment Process: The lost wax process is usually done with investment material, high heat and metal; however, the process may be easily demonstrated with casting resin and plaster of paris. Carve figure from wax, or build up with melted wax. Use regular lost wax method and plaster of paris. Place in oven and allow wax shape to melt. Pour casting plastic in the mold and allow to set, and remove the plastic shape.

Note: Use Aluminum foil to catch wax, wax will melt at about 150°F.

5. Casting Foams: Foams provide excellent insulation, but due to their adhesive characteristics, molds require special treatment such as an RTV lining. A simple demonstration of pouring a small quantity into a small plastic cup will demonstrate its use and expansive characteristics. A small kit or rigid polyether may be purchased from IASCO for about $12.00.

6. Sheet Casting: Cast acrylic such as Plexiglas are cast between two sheets of polished glass. The process can be duplicated in the laboratory as follows:

   Cut two small pieces of glass, about 4" x 4". Apply mold release, "pork grease will work," to the casting sides of the glass. At three outside positions, place a spacer or shim about the thickness of a penny. Mix and pour on the glass a small amount of casting plastic, (IASCO E-Z Pour). Place the other piece of glass on the plastic resin and allow to dry. Fig. 3, Appendix F.

Note: On first try, use small amount of casting resin. Always experiment with newspaper under to protect table.

7. Safety Glass: Automobile safety glass is two sheets of glass with a plastic filler. Copy the sheet casting procedure, omitting the mold release, and you have made safety glass. Fig. 4, Appendix F.

8. Ice Explosive Forming Mold: Suspend a removable shape, "sand in a small balloon or plastic cup," in a small container of water, (cottage cheese container) and freeze. Remove the shape and the ice from the container, and you have an ice mold similar to the ones used in industry for explosive forming. Fig. 5, Appendix F.

9. Plastisol Coating: Heat one end of a metal shape, wire or metal rod, and dip into Plastisol. While this method requires controlled heat for curing, the experiment will demonstrate the general reaction of Plastisol to heat dip casting.

10. Slush Casting: Form a spoon shape with handle from double thickness of Aluminum foil. Coat spoon shape with mold release. Hold the spoon shape over a candle, and pour in small quantity of Plastisol. Rotate the spoon to spread the Plastisol. As the Plastisol heats, it will cure and become clear. Slush casting is used for making gloves and shoe protectors.

11. Wood Lamination: Cut two thin pieces of wood, veneer, or about 1/16" x 1" x 5". Place glue between the two pieces of wood and secure around a one gallon round metal container. Allow to set and remove. Fig. 6, Appendix F.

12. Bonding Plexiglas and Cast Acrylic Sheets: A substantial bond between smooth plastic surface may be achieved by the use of acetone. (Eye protection required.) Bond scrap Plexiglas with acetone applied with eye dropper.

13. Bending: The bending of plastic sheets for making containers and the like is usually done with a commercial strip heater. The principle is easily demonstrated as follows:

    Cut 6" length of aluminum wire, make a support saddle from wood, Fig. 7, Appendix F. Heat the wire at each end. A strip of Plexiglas will soften to bend in 2 - 5 minutes.

14. Stamping: Use two "nesting" shapes such as small salad bowls. Place aluminum foil between and press together.

15. Blow Molding: Place toy balloon inside bottle and blow up. The balloon will take the inside shape of the bottle as the mold.

Note: Place soda straw in the neck of the bottle to allow air to escape.

16. Sand Casting: (Open mold) Make design in wet sand - pour in plaster of paris and allow to set.

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APPENDIX F

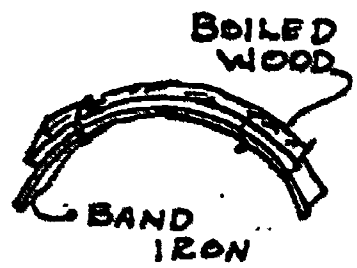


FIG-1

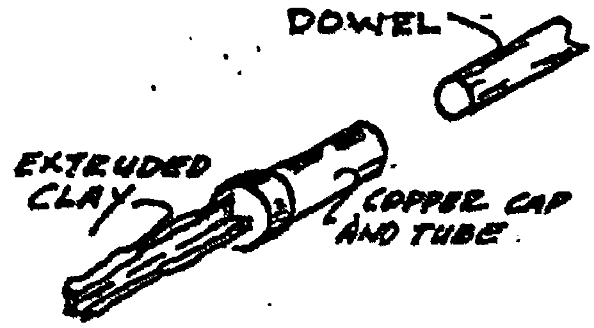


FIG-2

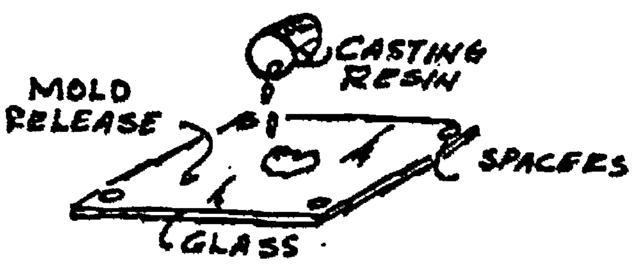


FIG 3

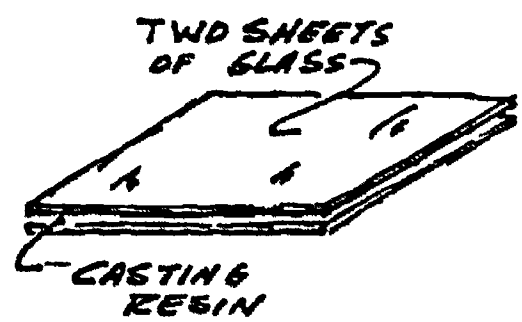


FIG 4

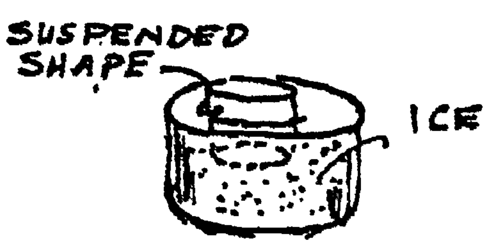


FIG-5

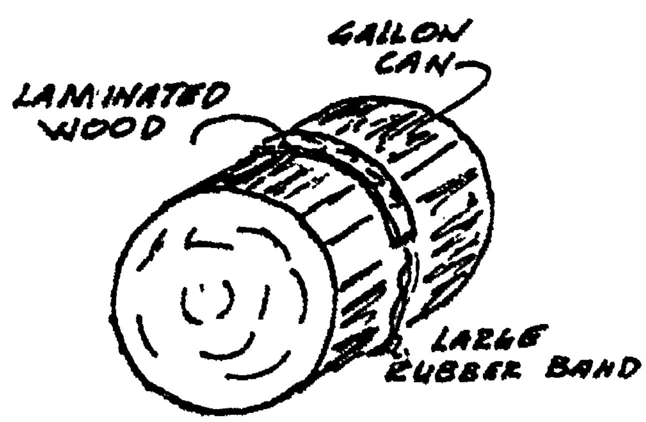


FIG-6

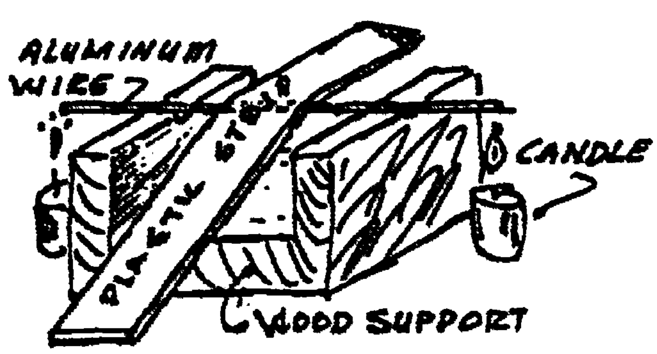


FIG-7

Module 6: Fasteners

Length 5 Days

The function of this module is:

1. To introduce the student to the common commercial fasteners, their utility, and ap[illegible]ation in products.

2. To study the specific holding power and adjusting characteristics of fasteners.

3. To learn how to identify and specify fasteners.

4. To alert the student to the learning value of continued observation and analysis of fastener applications.

OBJECTIVES

Upon completing this module each student should be able to:

1. Describe the function and explain the specific advantages of common fasteners.
2. Be able to specify common fasteners.
3. Be able to locate a source of supply for fasteners.
4. Be able to select the appropriate fastener for the intended application.
5. Explain the basic thread terminology.

SUPPLIES

This unit is designed as a survey of information about common fastening means. There is an estimated 250,000 specifiable fasteners and to cover all the fasteners is beyond the scope of this module. The intent is to give the student basic knowledge about the characteristics of fasteners that may be employed in design problems. By making the student aware of the importance of fasteners, their observation skill may be "tuned" as to promote continuous learning about fastener utilization.

A suggested method for teaching is to assign fasteners or groups of fasteners to students for study, demonstrations and the making of display units. A collection of student's work allow the teacher to build up samples for future classes.

REFERENCES

The chapters on fasteners or fastening devices found in current metal or drafting book.

Fasteners: John Deer writing service
Dept. F John Deer Rd.
Moline, Illinois 61265
1987

Technical Drafting Spence/Atkins
Chas A. Bennett Co.
1980

Metalwork-Technology Ad Practice
Ludwig/McCarthy
McKnight & McKnight
1969

Wood Handbook, Wood As An Engineering Material,
U.S. Dept. of Agriculture
Forest Products Laboratory For Sale by Sup.
of Documents
Washington, DC 20402

DAY	ACTIVITY
1	Administrative Duties.
	Explain the purpose of the module.
	Discuss the function of fasteners: adjustment, power transmission (clamps), holding power, assembly and disassembly.
	Alert students to a future assignment; the investigation of a specific fastener.
	Go over the completed investigation form, APPENDIX A, pop rivet.
	Have students select or assign fastener for investigation, APPENDIX B.
	Hand out blank investigation forms, APPENDIX C.
2	Canvass the class and record students' selection of fastener for investigation, Appendix B, and or an exercise, Appendix F.
	Go over thread terminology, Appendix B.
	Explain screw thread specification such as 1/4 - 20 NC-2.
	Discuss fasteners, Appendix B, that will not be covered by student reports.
	Explain square threads, shape and power transmission characteristic.
3	Student Reports
	After each report, ask members of the class about applications of the fastener they know about or have observed.
	Discuss wood screws, Appendix D.
	Explain the method of calculating the withdrawal resistance of wood screws, Appendix D.
	Have students copy the formula, Appendix D, and place on the board two problems to be solved for homework. See specific gravity and screw diameters, Appendix D.
4	Take up homework, give and explain answer to homework problem.

Learning game: Place the terms on Appendix B on 3 x 5 cards. Divide the class in two teams. The game is like Win, Lose or Draw on TV. One member of a team is to draw the item on the board, the other members are to guess the item. With a stop watch, time each event. The team with the lowest score wins.

Continue student reports.

Go over review questions, Appendix E.

Begin suggested activities, Appendix F.

Announce test for next class.

5 Test.

Take up, evaluate or return for their notebook investigation forms.

Deposit, store or throw away materials used for the module.

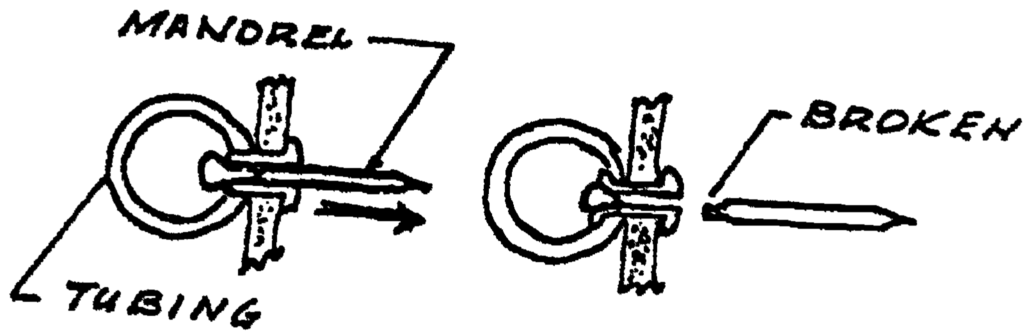
APPENDIX A

Student's Name________________

Sample Fastener Investigation Form

Fastener: Pop Rivet

Sketch or Picture:



General Description:

A Pop Rivet is classified as a blind rivet used in places where the side opposite the head is hidden. The name, "Pop" was derived from the popping noise made when the rivet is set. The rivet tool applies pressure to a small pin which expands the blind end of the rivet and breaks under the tension applied by the riveter.

Specifications:

Size: Given by diameter and length.

Example: 1/8" x 1/4"; the 1/8" is the diameter and the 1/4" is the length.

Material: Aluminum, steel or copper.

Quantity and Cost: Boxed in units such as 1/8x1/8, 40 per box $1.50

Other Information:

A riveter is required to set pop rivets at a cost of $15 to $25.

Observed Application: Aluminum furniture, metal tool boxes, repair to floor board of an old car.

APPENDIX B

Screw Thread Terminology

Thread form
Class of fit
Major diameter
Minor diameter
Lead and pitch
Single threads
Thread specification
Drill and tap

Root
Crest
Threads per inch
Thread series

Multiple threads
Left and Right hand threads
Pipe threads

Fasteners and Fastening Means for Class Discussion and Student Investigation

Sheet metal screws
Screw eyes
Eye bolts
Carriage bolts
Stove bolts
Thumb screws
Wing nuts
Lock washers
Tamper-proof fasteners
Studs
T nuts
Pipe threads
Nails
Plastic fasteners
Toggle bolts
Self-tapping threads
Velcro
Cotter pins
Nylon pellets locks
Wire nuts (electrical)
Super glue

Table top fasteners z and 8
Contact cement
Epoxy
Arc welding
Acetylene welding
Brazing
Spot welding
Soldering
Blind rivets
Hollow rivets
Solid rivets
Split rivets
Tinner's rivets
Plastic rivets
Expansive shields
Set screws
Roll pins
Lock nuts
Shoulder bolts
Turn buckles

APPENDIX C

Fastener Investigation Form

Fastener:

Sketch or Picture:

General Description:

Specifications:

Special Tools for Application:

Advantages and Special Characteristics:

Observed Application:

Other Comments:

APPENDIX D

Wood Screws

Explain: How to specify type of heads, shank, and pilot holes. Use of screwmate. Pilot holes in soft and hard wood. Hard wood pilot = 90% root diameter of threads. Soft wood pilot = 70% root diameter of threads.

Wood screw withdrawal resistance:

Wood screws properly installed have great resistance to withdrawal. The formula for calculating from forest products handbook (pp. 7-9).

Withdrawal resistance = 15,700 G^2DL

15,700 = formula constant
G = specific gravity
D = shank diameter of screw
L = thread penetration in inches

Problem:

Calculate the withdrawal resistance of a No. 14 wood screw (.242 diameter), 2" penetration in Hickory, (Specific gravity = .72)

W. R. = $15{,}700 \times (.72)^2 \times .242 \times 2 =$

$15{,}700 \times .5184 \times .242 \times 2 =$

the $8138.88 \times .484 =$ 3939 pounds.

The above calculation, 3939 pounds, is about the weight of an automobile.

Data for class problems:

Specific gravity		Screw diameter
White Ash	.60	No. 4 = .112
Basswood	.37	No. 6 = .138
Hickory	.72	No. 9 = .177
White pine	.38	No. 12 = .216
Sugar maple	.63	No. 14 = .242

APPENDIX E

Review Questions

1. Why are rivets classified as permanent fasteners?

2. What are the two most common type of wood screw heads?

3. Explain the meaning of a blind fastener.

4. If a 1/4-20 screw was turned 5 times, how far would it advance?

5. If a 1/4-32 thread was turned 8 times, how far would it advance?

6. Why are square threads used on wood clamps and jacks?

7. What is the purpose of a tamper-proof fastener?

8. What was the original purpose of a stove bolt, carriage bolt, pan head screw?

9. Where are lock washers used?

10. What is the special arrangement of screw threads on a turn buckle?

11. Which type of rivet is a blind rivet, pop or tinner's?

12. Sketch and or explain how a pop rivet works.

13. The pilot holes for hard wood should be what percent of the root diameter of screw threads, soft wood?

APPENDIX F

Suggested Laboratory Activities and Problems

1. What size wood screw, and/or what depth of penetration would be required to hold 4,000 pounds in maple? (Have student get help from their math instructor?.
2. Borrow a microscope and observe the hooks and loops on a piece of velcro. Observe through the scope the profile of a thread.
3. Drill and tap a piece4 of 1/8 angle iron for a 1/4 20 stove bolt. (Note: A No. 7 drill is recommended for a 1/4-20 tap.)
4. Threads on a stove bolt are 1/4-20. How many turns of the screw would be required to advance 1/4", 1/2"? Have student make the turns and measure.
5. Use die and cut threads on a 1/4 diameter of aluminum, steel or plastic rod.
6. Bring in pieces of bamboo. Have student design metal or plastic fastener for making a bamboo ladder.
7. Insert a small wood screw in a piece of wood and hang weights to test actual withdrawal resistance. Example white pine, No. 4 screw 1/2" penetration.

   $$P = 15{,}700 \times (.38)^2 \times .112 \times \ldots \quad 26.95^{\#}.$$

8. Drill or punch two pieces of metal and secure with sheet metal screw.

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Module 7: Patents and Inventions

Length 5 Days

The function of this module is:

1. To introduce the student to the patent system.

2. Explain the different types of patents.

3. To give survey information about patent applications.

4. A historical review of patents and inventions and their effect on society.

OBJECTIVES

Upon completing this learning module, the student should be able to:

1. Understand and discuss the U.S. Patent System.
2. List and describe the different types of patents.
3. Explain the purpose and the advantage of the patent system.
4. Describe the elements of inventions.
5. Give a historical review of an important inventor or invention.

REFERENCES

A recommended and convenient resource for this module is the Encyclopedia. Other references:

Ideas, Inventions and Patents
Robert A. Buckles, John Wiley & Sons, NY.

Inventions, Discovery and Creativity, A. D. Moore
Doubleday & Co., NY.

The Scientific Breakthrough, The impact of modern invention, Ronald W. Clark, G. P. Putnam's Sons, N.Y.

A Century of Wonders, Ernest V. Heyn, Doubleday & Co., N.Y.

The History of Invention: From Stone Axes to Silicon Chips, Trevor I. Williams, Facts on File, Inc., N.Y.

SYNOPSIS

The application and continued use of past and present inventions comprise an important facet of our environment. To list a few: the automobile, airplane, radio, television and computers. Materials such as nylon, teflon, rayon, tempered glass have become a common part of our needs.

This module is to give the student an opportunity to study and experiment leading to the appreciation for the creative minds of past and present inventors. New applications of old scientific principles resulting in new products and processes is a never-ending endeavor. The intent in this module is to help the student develop the attitude that each new material, idea, and invention opens ways for new products. That each of us are creative and the ability to think and be creative is an important educational objective.

One intent of this module is to illustrate the idea that many new ideas and inventions await the clever mind. That everything has not been invented, and that every person has creative potential. The Experiment, Appendix A and C, and News Article, Appendix D, is to give credence to the above truth.

DAY	ACTIVITY
1	Administrative details.
	Teacher led discussion.
	Elements of inventions:
	Knowledge Technical capacity Other inventions to build on Creative insight Experimentation Observation skills The role of accident The role of inspiration Need
	List and discuss inventors and what they invented, Appendix A.
	Assign or have student select an inventor or invention to investigate, Appendix A.
	Hand out investigation forms, Appendix B.
2	Canvass the class and record students selection of inventor or invention to research.
	Patent discussion:
	How patents came about, Queen Elizabeth to Sir Walter Raleigh.
	Different types of patents.
	Utility patents.
	Design patents.
	Plant patents.
	Chemical patents.
	Animal patents.
	Applying for a patent.
	What is patentable?
	How does a patent protect the inventor?
	How is a patent marked?

What value is the marking "Patent Applied for" or "Patent Pending"?

What is the length, number of years for patents?

Ask the students if they have ever known a person to whom a patent was issued.

Try to locate a patent and show it to the class.

(NOTE: By sending the patent number and $2.00, a patent may be obtained from, U. S. Patent Office, Washington, DC 20231).

3 Student oral reports about their invention or inventor.

4 Assign student the following design problem:

You are a manufacturer of telescope mirrors. A glass mirror may weigh as much as 2 tons with a diameter of 11 feet. One of the most expensive operations in making the mirror is the grinding of the large concaved faces. Develop a method of manufacturing the mirror that would decrease or eliminate the grinding cost.

Explain melting temperature of glass, about 2,000°F.

Discuss how melted glass reacts. Its goofy.

Ideas to be written and brought to the next class.

5 Take up student ideas.

Demonstrate or show the results of the experiment, Appendix A and C.

Give students a copy or read the News Article, Appendix D.

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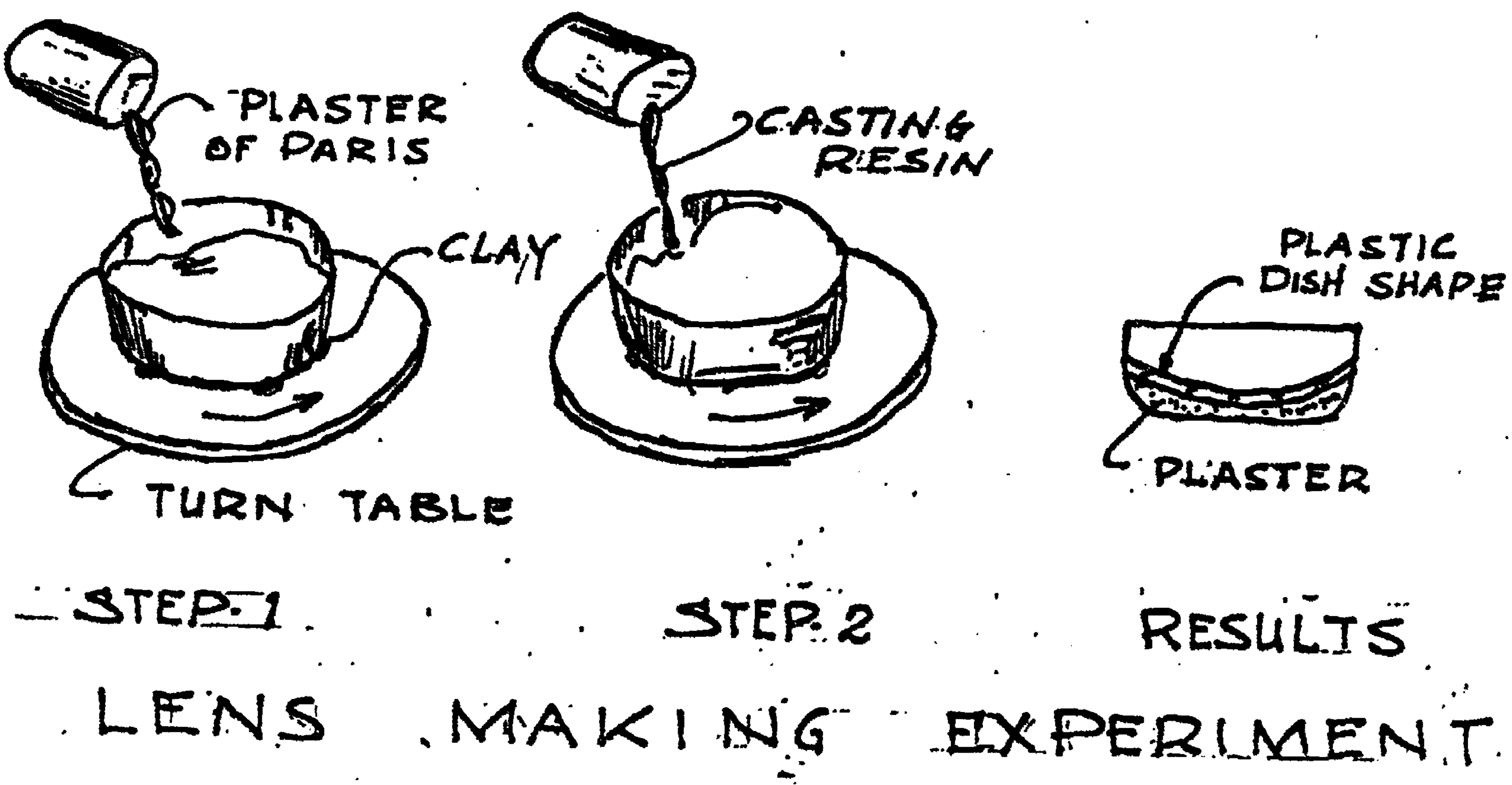
APPENDIX A

List of Inventions or Inventors for Study

- Plow
- Windmill
- Cross bow
- Safety pins (re-invented)
- Watt's steam engine
- Electricity-Edison
- Electricity-Franklin
- Automobile-Ford
- Microscope
- Telescope
- Printing Press
- Clock
- Steam engine
- Nuclear energy
- Fire arms
- Reaper
- Television
- Gasoline engine
- Float glass
- Plastics
- Nylon
- Fiber optics
- Movie camera
- Particle board
- Telephone-Bell
- Rubber-Goodyear
- Airplane-(Wright brothers)
- Polaroid camera
- Rockets
- Sewing machine
- Rayon
- Colt's revolver
- Laser
- Spectacles
- Threshing machine
- Electron microscope
- Soap
- Horseshoes



APPENDIX B

Student's Name______________

Invention Investigation Form

Name of Inventor or Item Invented:______________

____

Give historical review of the inventor, or item invented.

Impact of the invention on society.

Estimated number of people in the U.S. who use the invention each day__________.

Did you use anything this week as a result of the invention?

Source of information:

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APPENDIX C

This simple experiment is a process duplication of how the people at the University of Arizona made a mirror by a new method to save millions of dollars.

Tools and Equipment:

A turntable: an old record player or potter's wheel with 50 to 100 rpm's. Small plastic throw-away bowl about 6" in diameter.
A small amount of potter's clay.
Plaster of paris
EZ casting resin
Mold release

Experiment description:

1. Secure the plastic bowl in the center of the turntable or potter's wheel with a small amount of gooey potter's clay.

2. Make a mixture of plaster of paris and water.

   I pint of water
   1 1/2 pounds of plaster of paris

3. Coat the bowl with mold release.

4. Just before the plaster of paris begins to set up, pour into rotating bowl.

5. When the plaster sets up, the centrifugal force will produce a concaved surface. Wipe off the excess moisture from the plaster.

6. Coat the plaster shape with mold release.

7. Mix up about 4 ounces of casting resin, pour into bowl on the plaster shape and allow to rotate until set.

Results:

This experiment will produce a small plastic bowl, duplicating the lens making process. Explained in the he News Article, Appendix D. Humans have been working with glass and have observed centrifugal force when the first stone was thrown, but it was more than 2,000 years before this simple process was applied to mirror making.

Ask students about inventive ideas they may have.

Discuss problems that may be a good subject for inventive ideas.

Mirror technology promises improved telescopes

By LEE DYE
The Los Angeles Times

TUCSON, Ariz. — An imaginative new technology that could make it possible for nearly any university to have its own major telescope passed a critical stage last week when scientists created in just 24 hours what will become the 11-foot mirror for a new scope.

Not only does the new technology promise to greatly reduce the cost of telescopes, it also should lead to giant scopes — more than twice as powerful as the 200-inch Hale Telescope on Palomar Mountain — that can see almost to the edge of the universe.

The 2-ton piece of glass was cast in a spinning furnace, a process that allows molten glass to form the concave shape of a telescope mirror as it cools. That eliminates the need to grind out tons of glass, curving the reflective surface so that it will concentrate the light it collects on a single point.

Because the tedious grinding process used for centuries takes months and costs millions of dollars, representatives of many scientific institutions are very interested in the new technology and came to the University of Arizona last week to see how it works. They saw Roger Angel, who developed the concept with other university experts, guide the giant spinning furnace through a flawless and historic 24-hour marathon.

Angel's work is not done, however. During the next six weeks, the glass, called a mirror blank, must be cooled gradually for it to be strong enough to withstand the rigors demanded of a modern telescope, and then it must be ground slightly to its final shape and polished.

"There's still a long way to go, but we've got what looks like a good cast," Angel said as he monitored the process through two television cameras mounted on the side of the spinning furnace.

The furnace began slowly spinning up to 8 rpm last Monday afternoon. Scientists watching television monitors could see chunks of borosilicate glass imported from Japan inside the furnace. As day turned to night and the temperature climbed to more than 2,000 degrees Fahrenheit, the chunks slowly lost their sharp edges. By the next morning, the glass had melted into a consistency that Angel described as "like very thick honey," and it slowly worked its way into a honeycombed mold.

Gradually, the thick fluid formed a concave surface as the centrifugal force pushed it up along the edge of the circular furnace. By Tuesday, just 24 hours after the process had begun, the lid on the furnace was lifted slightly as scientists and technicians peered inside at what they had wrought, cheering wildly at what appeared to have been a total success.

The process had been tried before with smaller mirrors, but this was a test to see whether the technique could be scaled up to create giant mirrors. And although this procedure was officially billed as a test, the telescope that will house the mirror has already been built and stands waiting at the Apache Point Observatory in New Mexico.

That telescope, owned by the Astrophysical Research Consortium, will become the 14th-largest telescope in the world. The consortium includes five universities: the University of Chicago, Princeton, New Mexico State, University of Washington and Washington State.

The mirror's surface is curved much more steeply than was practical with the old technology, and that has major implications for astronomy. The steep curve allows the mirror to focus the light at a point much closer to its surface, thus reducing the focal length of the telescope. That means the telescope itself does not have to be nearly as large, greatly reducing the cost of the supporting apparatus.

And since the back of the mirror is a honeycombed structure rather than solid glass, it is much lighter and thus does not need a massive support system for it to track objects as they move across the field of view.

Don York, ARC project director, estimated that the consortium's telescope would cost a little more than $9 million — about one-third what it would have cost using prior technologies.

After this mirror is completed, the university will build another one just like it for use at Arizona's Kitt Peak by the National Optical Astronomy Observatories, a major source of funding for the project.

If both those are successful, the furnace will be enlarged to a diameter of 29.5 feet, and an even more demanding test will begin. Angel and his team expect to produce the largest mirrors ever built, giant 8-meter chunks of glass that will be used to build some of the most powerful telescopes on the planet.

The first two will be used for the Columbus Project, a binocular telescope scheduled for the top of Mount Graham in Arizona, and the third will be used in the Magellan telescope that the Carnegie Institution and Johns Hopkins University plan to build at the Las Campanas Observatory in Chile.

Each of those mirrors will require only 24 hours to cast, a remarkable achievement compared to past technologies.

"The savings should be enormous," said Peter Strittmatter, director of the University of Arizona's Steward Observatory. At least 25 tons, worth about $10 a pound, would have to be ground out of an 8-meter blank and discarded under the old technique.

"It would take two years to remove it all," Strittmatter said.

Strittmatter noted that the greatly reduced cost would bring major facilities within the reach of "any university that is serious about astronomical research."

"You will see a lot of places with 4-meter instruments," he added.

MODULE: 8 : Products Liability

LENGTH: 3 DAYS

The function of this module is:

1. To introduce the student to the designer's responsibility for the safety of the product c eated, a responsibility for consumer safety.

2. To introduce typical examp!es of product litigation related to injury or loss of property.

3. Explore means and to develop a check list for the designing of safe products.

OBJECTIVES

Upon completing this learning module the student should be able to:

1. Describe the responsibility of the designer for the development of a reasonably safe product.

2. Exhibit a knowledge of the elementary legal terms associated with tort and product liability litigation.

3. Analyze a product and think through the probable use and misuse that may produce a hazardous situation.

REFERENCES

Product Liability and The Reasonably Safe Product - Weinstein Et Al, John Wiley & Sons, NY. *

*NOTE This book is suggested for the teachers' reference.

Products Liability, Freedman, Van Nostrand Reinhold, Co., NY - 1984.

U.S. Consumer Products Safety Commission. Washington, DC 20207.

NOTE The National Information Clearing House, A part of the Safety Commission, (Above address), could furnish national injuries that occurred associated with products such as skate board, bicycle and the like.

SYNOPSIS

Product liability, being responsible for the safety of a product, is not new. The king of Babylonia, the laws of Hammurabi, 2200 B.C. had a law about a safe house: If the house made by a builder collapsed and killed the owner, the builder was put to death. Product liability is becoming an increasing concern for designers and manufacturers. While the manufacturer and insurance companies may feel that the public has gone wild in their efforts to reap a huge liability award, the public contends, they have a right to expect a reasonably safe product.

The intent of this module is to have the student become aware of the responsibility of the designer and manufacturer for the production of a safe product. As citizens, we should temper our desire for financial recovery with ethical conduct, with the long-term objectives for safer consumer products.

While the scope of the items made in the laboratory may not allow the development of products with major product liability overtones, the designer at any level must be concerned about safety. Even the relatively simple projects made in the school shop should be scrutinized by both the student and teacher for potential hazards.

A good resource for product liability activity is the local newspaper. The teacher may be able to have a local lawyer come into the classroom to talk and answer questions about product safety. Student interest may be enhanced by giving then extra credit or recognition for a product liability case found in the local newspaper.

PRESENTING THE MODULE

DAY	ACTIVITY
1	Administrative details discuss the function and purpose of the module.
	Discuss the legal obligation of a designer or manufacturer for making a reasonably safe product.
	Go over the legal terms associated with product liability. Appendix A.
	Ask the students to talk to their parents and others about an injury they know about involving a product. (Exclude auto accidents).
2	Student reports of accidents involving products.
	Plan a mock trial to be conducted at the next class meeting. Appendix B.
	Go over foreseeable misuse and causes of product failure, Appendix C.
	Photocopy actual trials from Weinstein's book, Product Liability and A Reasonably Safe Product, and give to students to read and explain at next class.
3	Conduct mock trial.
	Have students explain their reading of actual cases from Weinstein's book.
	Go over items for consideration to insure safe product, Appendix C.
	Review and Test.

APPENDIX A

Legal Terms

<u>Tort</u>: A wrongful act or failure to exercise due care.

<u>Reasonable Care</u>: A degree of care expected of a prudent person.

<u>Liability</u>: An obligation to compensate for injury or damage.

<u>Negligence</u>: Failure to exercise reasonable care or to perform a legal duty.

<u>Contributory Negligence</u>: Negligence by the plaintiff that contributes to the injury or property loss.

<u>Express Warranty</u>: A written or oral statement of the product's performance.

<u>Implied Warranty</u>: An automatic warranty. A "common sense" expectation of the product.

<u>Proximate Cause</u>: The act that is reasonable foreseeable resulting in injury to plaintiff.

<u>Foreseeability</u>: A legal theory that a person may be held liable for action resulting in injury if the danger could be reasonable anticipated.

<u>Deposition</u>: Testimony taken out of court before a court authorized person.

<u>Discovery</u>: A procedure for gathering and exchanging facts between the litigants.

<u>Expert Witness</u>: A person classified as a professional with credentials relative to the topic that would give credence to factual testimony and opinion.

<u>Causation</u>: The events and conditions leading to an injury.

APPENDIX B

Mock Litigation: Step Ladder Accident

This is a hypothetical situation about an accident that occurred by a fall from a step ladder. The Plaintiff bought an unfinished wooden step ladder 5 years before the accident occurred. The ladder was stored under the eves of the house, where it was exposed to some rain. While the Plaintiff was painting one of the steps failed, broke on the side causing the plaintiff to fall and break his leg. As a result of the accident, the plaintiff had a hospital bill of $7,000, and was deemed by his doctors to have 5% disability.

Suggestion: Select the different court participants below and have the remaining class members act as jury.

Court People Assignments

- Judge - the teacher
- Plaintiff
- Defendant - the store that sold the ladder and/or the manufacturer
- Lawyer for Plaintiff
- Lawyer for Defendant
- Expert witness (NOTE: The expert witness could be a doctor to describe the condition of the plaintiff's injury, a technical expert about wood or design.)

Considerations

Plaintiff

The ladder was made of un-treated pine. It could have been treated or made of a wood that would not rot when exposed to weather.

Most step ladders have a metal rod under the steps, it cost very little more. Your ladder did not have the metal rod.

The ladder had no warning that said, "Store inside."

The Plaintiff weight was 280# but there was no warning on the ladder about who should use the ladder.

Defendant

You paid for a cheap ladder and that's what you got.

Had this ladder been kept inside, it would not have broken. Any consumer should know that most untreated wood will rot if exposed to the weather. You should have known that it would rot. Give examples.

This ladder is made for the average person, not for the big above average man.

Have the lawyers present their argument and allow the other students to vote as jury, possible vote ballots.

[] Designer, manufacturer and retail store Guilty of being negligent, should pay the award.

[] Not Guilty, pay no award.

[] The plaintiff is part Guilty for not taking care of the ladder, but manufacturer could have easily added the metal rod. To pay 1/2 of the requested award.

[] Others

APPENDIX C

Foreseeable Misuse and Product Failure

Using a chair as a ladder.
Faulty weld.
Lack of lock nut - loose fastener.
Poor design - a high chair with a small base.
Corrosive metal, bicycle handle bar.
Over heating - appliance.
Failure due to vibration.
Pressure explosion - boiler, hot water heater.
Insulation failure - electrical wire.
Sharp edges - furniture - sports equipment.
Shock or short circuit - electrical.
Slipperiness, tennis racket handle, tile floor.
Aging and wearing.

Check list and discussion topics to insure a safe product.

<u>Chemical</u>

corrosive damage
toxicity
flammability
explosive
oxidizing

<u>Electrical</u>

shock
short out
sparks
explosion
radiation
fire
bare wires
heating

<u>Miscellaneous</u>

skid proof, noise,
eye-light
temperature effect
acceleration
pressure-suction
emissions
air supply - ventilation
decomposition
slipperiness
moisture
aging
fatigue
lack of guards around moving parts
vapors

<u>Mechanical</u>

fastener failure
weight
balance-stability
vibration damage
rotation damage
pinch areas
sharp edges
shear
entrapment
locking device failure
material failure
stress fatigue
material selection

MODULE: 9 : Drawings & Specifications

LENGTH: 3 DAYS

The function of this module is:

1. To assist the student in the application of drawing and sketching as a desirable communication skill for the designing process.

2. To review and/or teach the fundamental system of technical drawing and sketching.

3. To introduce material and process specifications.

OBJECTIVES

Upon completing this module each student should be able to:

1. Make a readable sketch of a simplified structure by orthographic or pictorial representation.
2. Make a technical sketch with the necessary notes, dimensions and specifications.
3. Make a sectional view applicable to an orthographic or pictorial drawing.
4. Make an elementary exploded view.

REFERENCES

Current drafting or technical drawing text used by the drawing instructor.

Technical Drafting, Spence/Atkins Chas. A Bennett Co. 1980.

Drawing for Product Planning, George E. Stephenson, Chas. A. Bennett Co. 1970.

SYNOPSIS

The time schedule of this module does not allow the complete teaching/learning of drawing and sketching. The assumption is that most students have had basic instruction in technical drawing. The intent is review, practice and application of sketching used to enhance idea exchange.

Students who have had a formal course in drawing, such as instrument drawing, may have difficulty in making fast "conversational" sketches. Their previous work was likely evaluated by neatness and line weights. Technical sketching for the designer may be aptly compared to running writing.

As design and experimenting phase, designer often make sketches for each other on paper bags, cardboard boxes or even scraps of wood. The objective of this module is to give the student a method of using sketches as a means of communication, "Right Now."

DAY	ACTIVITY
1	Administrative details
	Discuss the value of sketching as an aid to designing and idea exchange.
	Review and/or explain the orthographic drawing method.
	Hand out or place on board A through H, Appendix A.
	Have students make 3 view sketches. Begin in class with Problem A. After a few minutes show the students on the board how to sketch the front view. Then extend light projection lines from front to top and front to right side. Once they have learned the procedure, they should be able to sketch Problem A in about 30 seconds.
	Continue with Problems A through H. Work to be completed at home.
2	Take up home work sketches.
	Place Problems A through H, Appendix A, on the board and have students sketch. As each student completes their sketches, write on their paper the time taken, such as 4 minutes and 30 seconds.
	Place on the board or hand out orthographic problems, Appendix A, 1 through 8. Have students study the figure and make an oblique sketch. After each student has tried, explain the suggested steps, Appendix B, and make th. sketch by the suggested method.
	After the students have worked through all the problems, have them make the sketches as fast as possible. After two or three speed tests, the students may be able to sketch all the problems in 2 to 5 minutes.
	Discuss the selection of the best pictorial view, Appendix B.
	Place on the board or give handout of orthographic views of figures A & B, Appendix C. Have students make pictorial sketches for homework.
3	Explain the fundamental of section drawings.

Cutting plane lines, sight dire.tion arrows, materials in section.

Make a sketch on board, Figure C, Appendix C, to illustrate a section of a pictorial sketch.

Specifications: Sketch Fig. A, Appendix D, without specifications. Ask the students how they would make the item:

What kind of material?
How is it made?
What size are the holes?
Where are the holes located?
What type of bolt is used, name, diameter, type head?

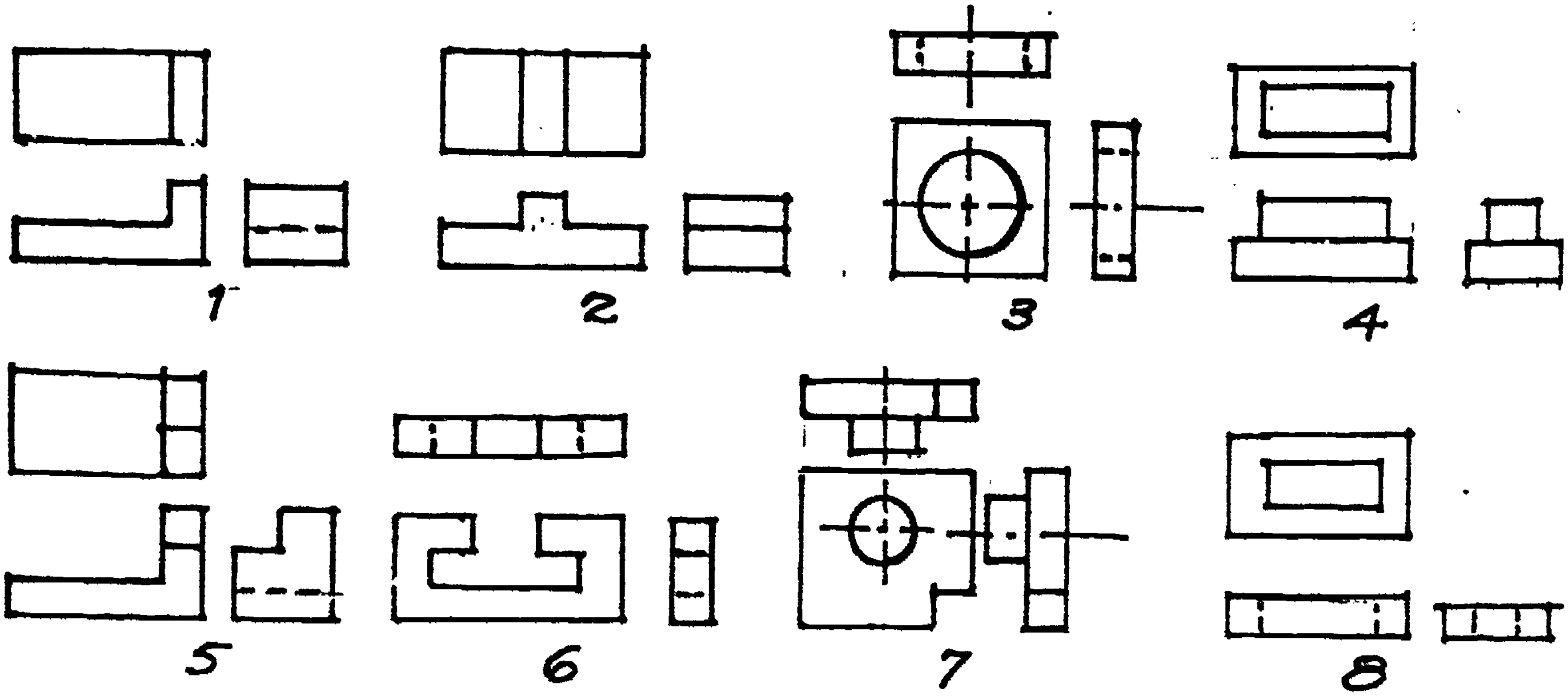
Complete the drawing with the help of the students, Figure B, Appendix D, with specifications.

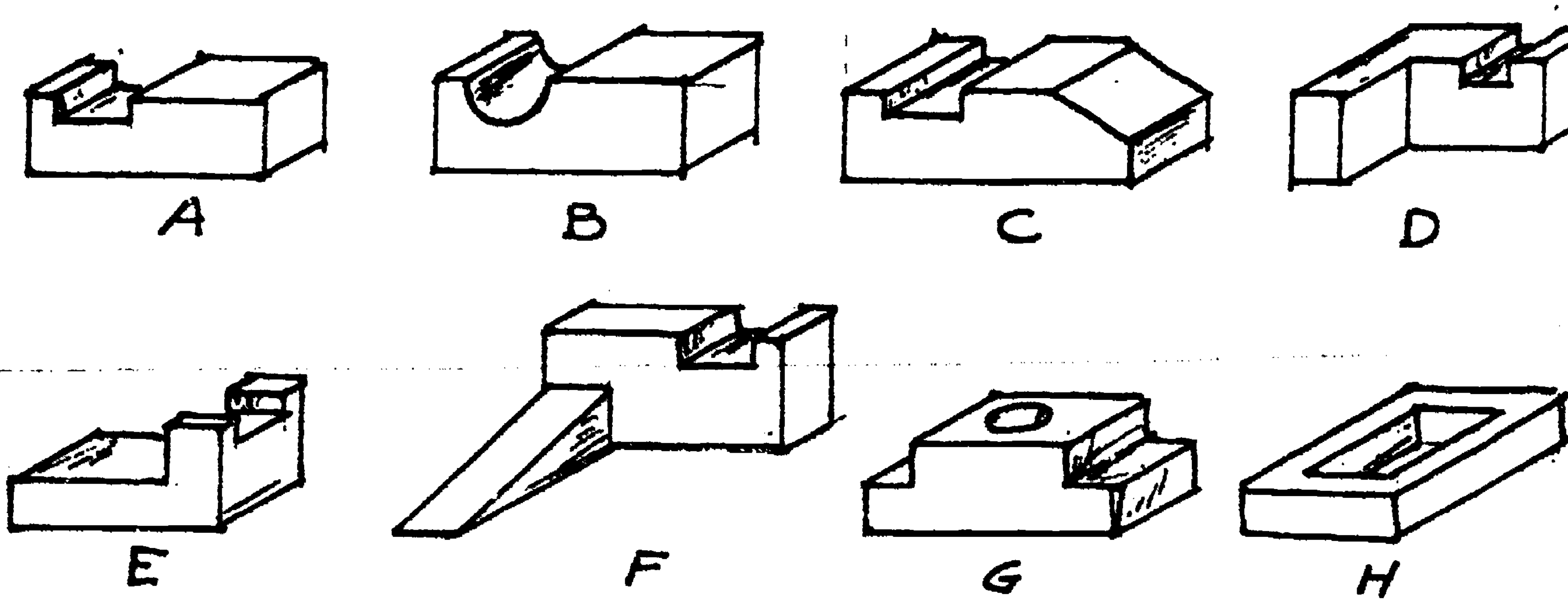
Explain the exploded view - Fig. D, Appendix C.

* Conduct the communication problem, Appendix D.

* This is an exercise to illustrate the communication value of sketching. Show Fig. C, Appendix D, to two students. The two students are to describe the shape to two other members of the class. One student is allowed to use sketches, the other must describe the shape by words. have the class observe the speed by which the object can be described with and without sketching.

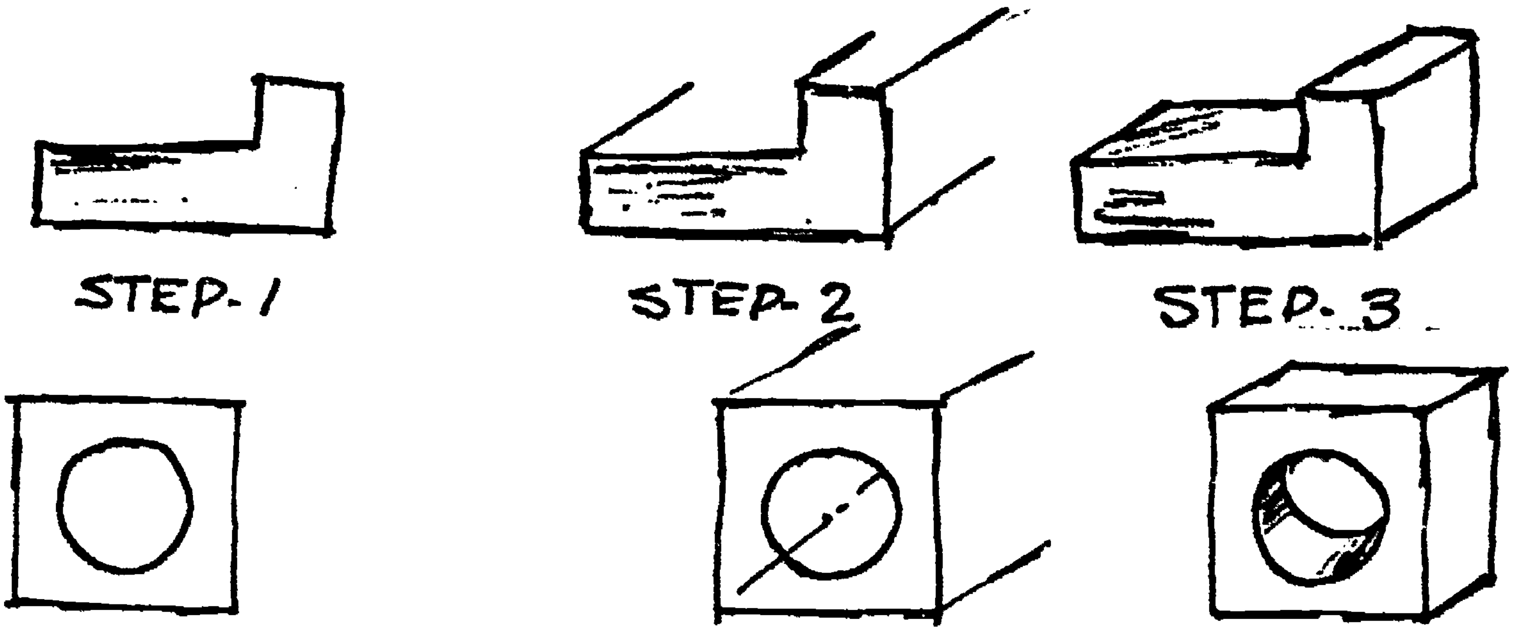
APPENDIX A



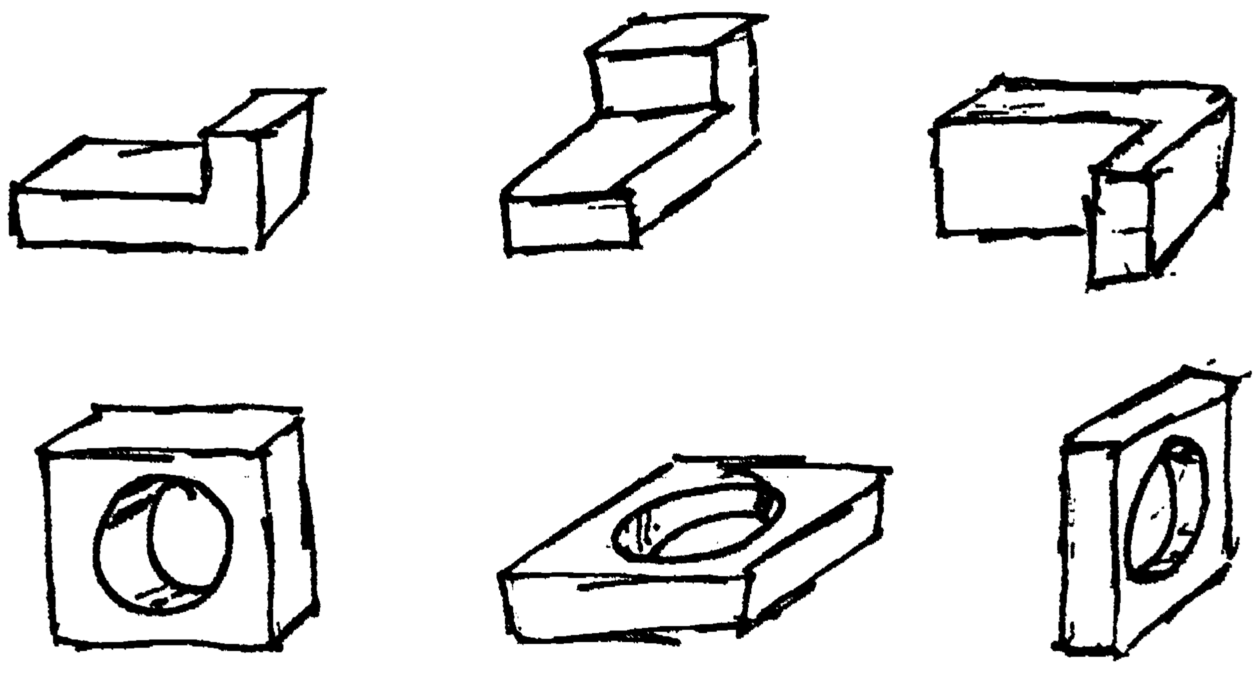


APPENDIX B

SUGGESTED STEPS FOR MAKING PICTORIAL SKETCHES



SKETCHING THE SAME FIGURE IN DIFFERENT POSITIONS



APPENDIX C

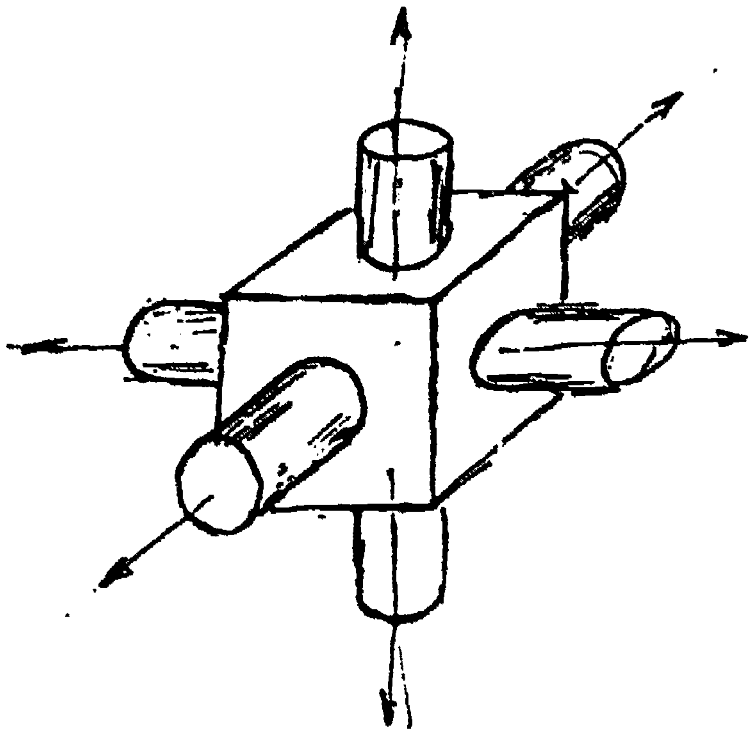


FIG. A

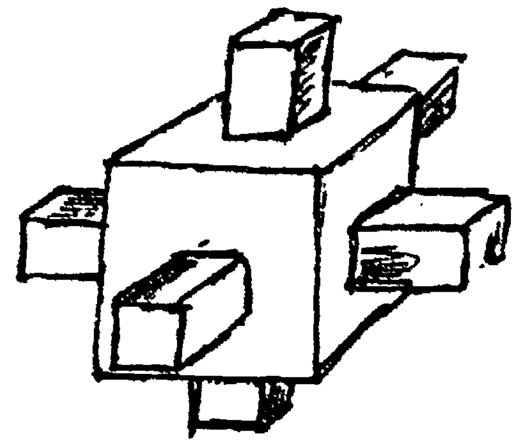
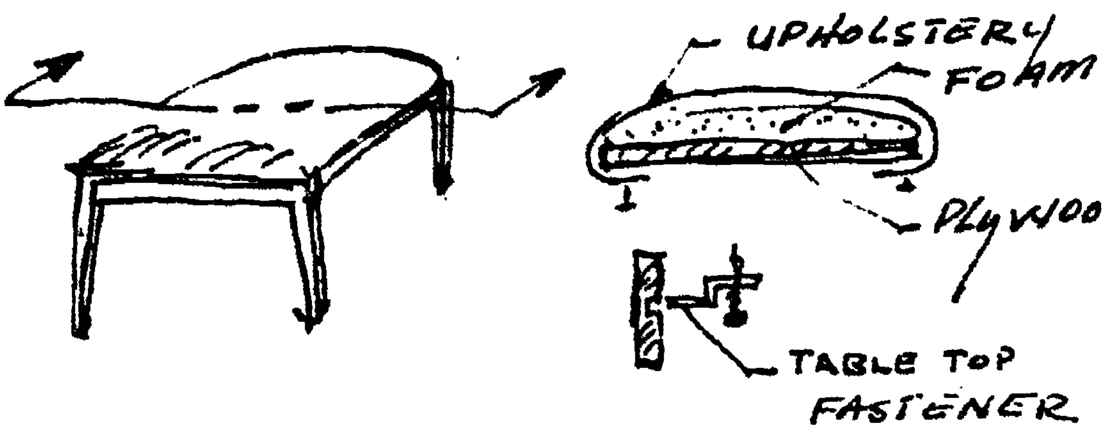
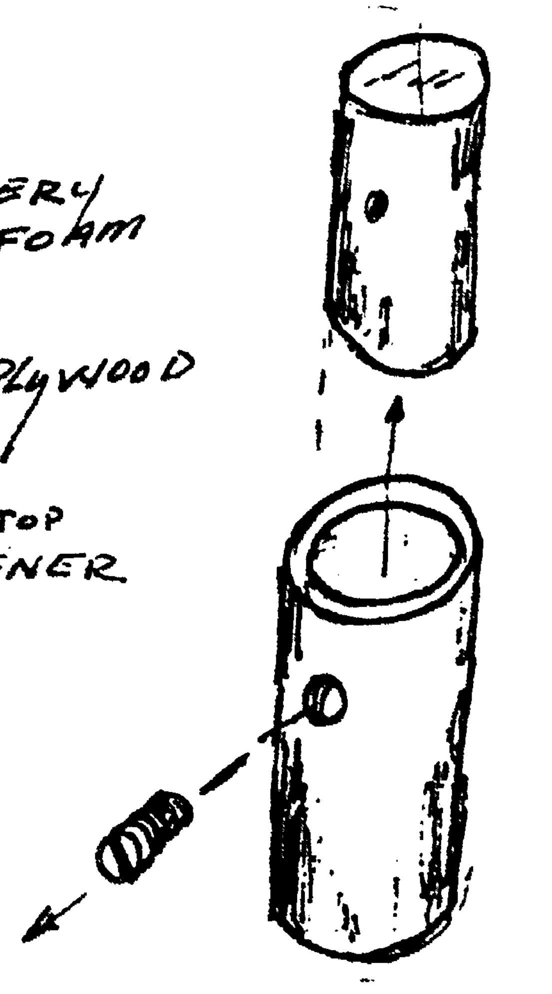


FIG B



SECTION APPLIED TO PICTORIAL

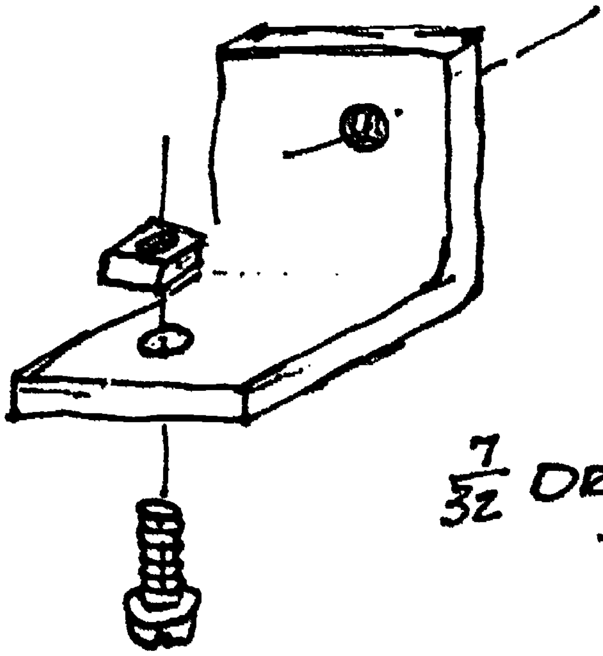
FIG C



EXPLOADED VIEW

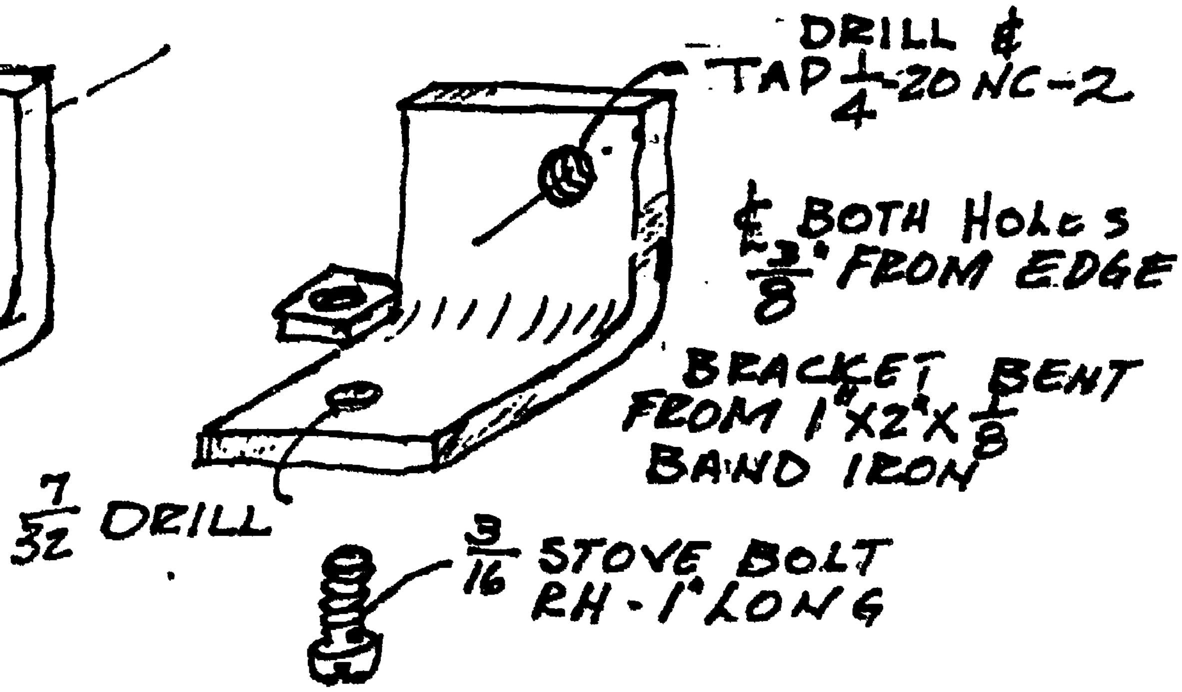
FIG D

APPENDIX D



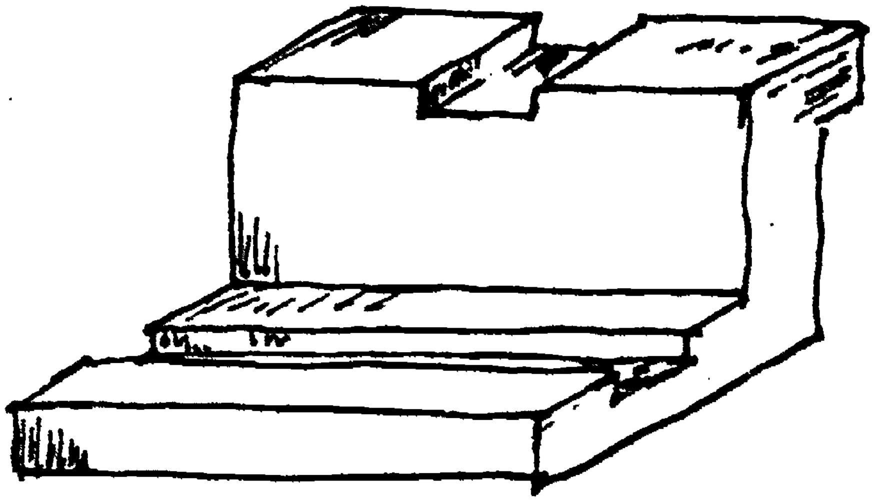
SKETCH WITHOUT SPECIFICATIONS

FIG-A



SKETCH WITH SPECIFICATIONS

FIG B



COMMUNICATION SKETCH

FIG-C

MODULE: 10 : Developing A Design

LENGTH: 30 DAYS

The function of this module is:

1. To field test and synthesize the knowledge gained in the preceding modules.

2. To have the student begin with an idea and develop a working prototype.

3. To have the students apply their creativity and problem solving skills with materials and processes.

OBJECTIVES

Upon completing this module each student should be able to:

1. Explain the designing process.
2. Have basic information about material characteristics, cost, and source of supply.
3. Have an understanding of the designing procedure as it relates to improving discarding, charging, and redesigning.
4. Gain knowledge and experience in independent and team problem solving and experimentation.

RESOURCES AND LIBRARY LIST

Architectural Residential Drawing and Design, Kuklighter, Goodheart-Willcock (insulation section).

Introduction to Creative Design, Henry Edel, Jr. Printice Hall.

Focus on Designing, Hubel & Lussow, McGraw Hill, 1984.

Objects of Desire, Adrian Forty, Pantheon Books, NY, 1986.

Industrial Plastics, Baird, Goodheart-Willcock, 1976.

Plastics Technology, Swanson, McKnight & McKnight, 1965.

Experimental Supplies

IASCO
5724 W. 36th Street
Minneapolis, MN 55416

The somewhat crude unit explained in Appendix A, when properly constructed is quite impressive. The unit will hold about 6 hot dogs in rolls, and after an hour or so, sun exposure are ready to eat. The unit will get hot enough to steam a cooked potato and will fry an egg (250° - 275°F).

TEACHER SUGGESTION:

Keep the "Ace" design to be completed the latter part of the module. Hopefully the student's creative efforts and experimentation will lead to such a design or a successful alternate.

GOOD LUCK!

SYNOPSIS

One of the dilemmas for the design teacher is the selection of a problem which promotes creativity, requires testing and experimentation and is in keeping with the student's abilities and the allocated time. A suggested approach is to choose a product not currently produced by industry, thereby forcing creativity. Another problem confronting the teacher is the laboratory equipment and process limitations. An item designed for blowmolding, injection molding or stamping would be beyond the range of the typical laboratory.

The designing phase of this module is built around a solar lunch box. The teacher may wish to substitute another problem and use this cook-book outline as a guide. This design project was selected because of the tests and experiments applied there to. The intent was to focus on the designing process and experience gained.

SUGGESTED CLASS ORGANIZATION:

This designing phase is intended to give the student experience working independently as well as a team member. Whenever possible, break the designing into small problems and allow each student to develop a solution independently. Encourage students to work alone, a process that will allow for more ideas in the development pool. Once the best ideas are selected from the "pool," the team work of refining and utilization can take place.

After each student has submitted his/her ideas, the teacher may wish to:

1. Act as the leader, share the ideas with all the students, and decide on the best scheme.

2. Divide the class into groups and have each group pool their ideas and come up with their best design.

3. Have each student or teams make a crude model or mock-up of their idea.

NOTE: Constant reorganization of team members may be necessary due to problem extension and completion.

SAFETY EMPHASIS:

Designing products, experimentation and making prototypes requires a wide range of materials and processes. Students are often experimenting and working in locations that defy constant instructor observation. The safe operation of all machines within the laboratory should be demonstrated. Eye protection should be stressed, with special emphasis around the machine area, and when working with toxic material, such as Acetone. When working with polyether foam, breathing the fumes during the reaction stage is to be avoided. Care should be taken to avoid skin contact with resins and plastic bonding liquids. Emphasis on safety is recommended at the beginning of each class period. Questionable new and different experiments are to be approved by the instructor.

SUPPLIES FOR THE SOLAR BOX

For best results, it is advisable for the teacher to order the basic supplies in advance. Finding materials, sources of supply and technical data is an important phase of the designing experience. Encourage students to use the Yellow pages, the Thomas Register, technical journals and local stores, but have back-up supplies if their efforts fail. During the design development, unforeseen needs are likely to occur to challenge the students and the teacher.

If the school system does not have an allocation of funds for supplies, a class organization with a treasurer may be advisable. Parents may volunteer funds, or a fee could be collected from each student. Since many of the supplies are purchased at local stores, a petty cash system may prove convenient.

SUGGESTED SUPPLY LIST

ITEM	SOURCE OF SUPPLY	APPROXIMATE COST
2 oven thermometers	grocery store	$2.00 ea.
tube thermometer range to 300°F	Fisher Scientific borrow from Science department	3.00
1 pkg. strong zip-lock bags	grocery store	2.00 pkg.
small cans of spray paint of assorted colors - non-toxic. Flat black, white	local stores	2.00 ea.
1 pkg. large foam cups	local store	2.00 pkg.
lexan sheets 1/16 - 4 sheets 12"x14", 1/8" Plexiglas for 14" strip	IASCO or local plastic store	2.00 sq. ft.
1 pt. Acetone	IASCO	2.00 pt.
syringe or eye dropper	drug store	.25 ea.
1/8" cork gasket sheet	auto supply	3.50
2 linear feet gutter aluminum	hardware store	.75 ft.
1 Qt. kit rigid foam	IASCO	13.00

assorted collection of insulating materials, sawdust, pine bark, fiber glass, expanded polystyrene	scrap, Building Supply Co.	?
2 - 11 3/4 x 9 1/4 x 2 1/2 foil bake pans	grocery store	2 for .99

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PRESENTING THE MODULE

DAY	ACTIVITY
1	Administrative details.
	Discuss the process of designing a product.
	Explain the course structure and the expected outcome.
	Discuss the team concept as well as the expected individual effort. Each student is expected to work independently, bringing in a problem solution. The individual solutions will be "pooled," changed, combined and refined toward a final prototype.
2	Discuss or have students develop a list of characteristics that make a good design team member:
	1. willingness to share. 2. one who does not "Hog the Show." 3. patience and consideration for ideas not their own. 4. one who can laugh and accept their own mistakes, and keep trying. 5. a person who will make a good effort. 6. a non-judgmental team mate. 7. others-have students add to the list.
3	Announce, choose and explain the design problem selected.
	Discuss how new products come about; by accident, need obtained from surveys, the desires of a changing society, professional inventors and enterprising thinkers.
	THE SOLAR LUNCH BOX POSSIBLE USE
	campers, scouts — tourist back packers — scientific explorers fishermen — baby food hunters — army
	Discuss the problem selection as:
	Being within the range of allocated time and expense.
	A problem with many facets, a variety of materials, processes, testing, and construction.
	<u>Homework problem</u>: Design a solar lunch box, a unit when exposed to the sun will heat or warm a lunch

for one or two people. A design sketch to be turned in at the next class on 8 1/2 x 11" paper, one side only.

NOTE: The students will most likely look at each other and say "We don't understand what you want. Can you give us more directions." <u>Give them no more</u>.

4 Take up homework. Compliment the students on their ideas. Give them assistance if needed on sketching. Discuss the type questions that need to be answered:

What food do you like served warm?
How much space would the food require?
What are some specific foods, such as: Hot dogs, sandwiches, hamburgers, potatoes, soup or hot drinks?

Assign students or ask for volunteers to measure and make mock foods to be combined as a class as an aid in determining the size of the solar box. The foods could be the actual item such as potatoes, or be made the correct size from materials such as wood or plastic foam.

5 Collect the mock food. With the aid of the students, make food combination and decide on preliminary box size. With the new information, a standard size. Have students work on a second design. begin the design in class to be completed at home.

6 Take up the student's second solutions.

Discussion:

What is the most desirable shape, flat, round, deep or shallow?
What shapes are easiest made from the various materials, metal, wood, plastic?
Did the students include insulation in their first or second designs?
If insulation was used, what type and what thickness was selected?
What type of glass or plastic was selected for the solar panel?
What type of door or lid would allow the placement of the food?
What type of device was made for tilting the box toward the sun?

Have students make a 3rd design based on the above requirements. This design to have specifications, materials, notes and dimensions.

7 Hand back the first two designs and have the students make comparisons between their three designs.

Discuss the desirability of change. Even the most experienced designers must go through the same steps: Design, refine, ask new questions, throw away, improve and change.

Anytime a solution is replaced with a better design, progress is made.

To criticize one's own design is difficult, but it's a requirement for making progress. Sometimes people such as parents and members of other classes may give some good suggestions.

8 ATTENTION TO DETAILS:

This is the beginning of research and development. Whenever possible make decisions based on technical data and experiment results. By discussing the many questions about the total design, the students may better understand how their individual research and experimentation fits with the total.

DEPTH OF COMPARTMENT:

The sun exposure ratio to box depth is a consideration. A solar panel, 9"x12" one inch deep would be one inch exposure to each cubic inch of box volume. If the depth of the food compartment was made 3 inches deep, the ratio would go from 1 to 1, to 1 to 3.

A shallow box will have a faster build-up of heat, but it must have sufficient depth to hold the food. What is the best depth?

Of what material should the food compartment be made? It should be washable, of a color to absorb the sun's rays, easy to make.

9 INSULATION:

To promote heat build-up, the food compartment must be well-insulated. What insulation would be best? What thickness would be practical? What is the R value of the different insulation materials?

OUTSIDE BOX:

The insulation may require a protective shell. What is the best material for the outside box? Aluminum, fiber glass, plywood, paper and resin, galvanized iron?

10 THE SOLAR PANEL:

The panel must be an effective insulator. What materials are available and how should they be fabricated? Should the solar panel be made of window glass, Plexiglas, lexan? How can a good seal be made between the food compartment and the solar panel? The food compartment may get as hot as 250^{o}F. What will happen to the panel materials at that temperature? Could tempered glass be used?

Hand out or explain the solar radiation chart, Appendix E.

Problems:

1. The average BTU's per hour per square foot for Nov. at 45^{o} = 326. How many minutes would be required to boil one pound of water to 60^{o}F? to 212^{o}F?

2. On an average day in Nov., a sq. ft. at 45^{o} yields 1818 BTU per day. Compare that amount of heat with the BTU's (converted to calories) required for a day for an average person.

11 Should the box have a carrying handle or an over-the-shoulder strap?

What means will the box have to tilt it toward the sun? At this point, many unanswered questions have been raised.

Divide the class into teams of about 5 students each and have them discuss and come up with some answers for a new design, size of food container, type and thickness of insulation, inside box material, outside box material, means of tilting, construction of the solar panel.

12 Take up and/or evaluate and discuss the students' group designs. Have students compare their team design with their individual ideas.

Establish an "investigating atmosphere" within the class room. Establish desirable material characteristics for each part:

<u>Solar panel</u>, easy to make, withstand the design temperature, have maximum heat loss, size and shape, easy to cut, maximum exposure, inexpensive, unbreakable.

<u>Insulation</u>, least thickness with most effective, resistance value, light weight, inexpensive, availability.

<u>Inside container</u>, sealable, washable, desirable color, water tight, easy to make, withstand design temperature,

<u>Outside container</u>, light weight, tough, easy to make, weather resistant.

What is the best method of providing a heat seal for loading? Would the design be best loaded from the end, the bottom?

Divide the class into 4 teams for work and experimentation.

Team A - overall design team, see Appendix A.
Team B - insulation, Appendix B.
Team C - the solar panel, Appendix C.
Team D - special test team, Appendix D.

REVIEW SAFETY RULES

Designing and experimentation require a variety of tools, machines and materials. Students will be engaged in a wide range of activity. Before the laboratory work begins, review the standard safety rules. In addition to the standard safety rules, EMPHASIZE:

Eye protection.

Take special precaution when working with plastics to avoid toxic fumes or Acetone splash.

Demonstrate and give safety rules of hand power tools.

Any questionable operation to be checked-out with the instructor.

Develop a standard procedure to be followed if an accident should occur.

Work on team assignments Set aside specific stations for each team Each day or each week, allow time for progress reports.

Have each group explain the results of their experimentation.

Discuss and develop ideas and changes for mass production of the designed unit.

Plan an open house. Invite parents and/or the school to visit the laboratory to hear student reports and see the product.

Review the designing experience. Go over the objectives and the attainment thereof.

Throw out, store or return all materials.

Tests.

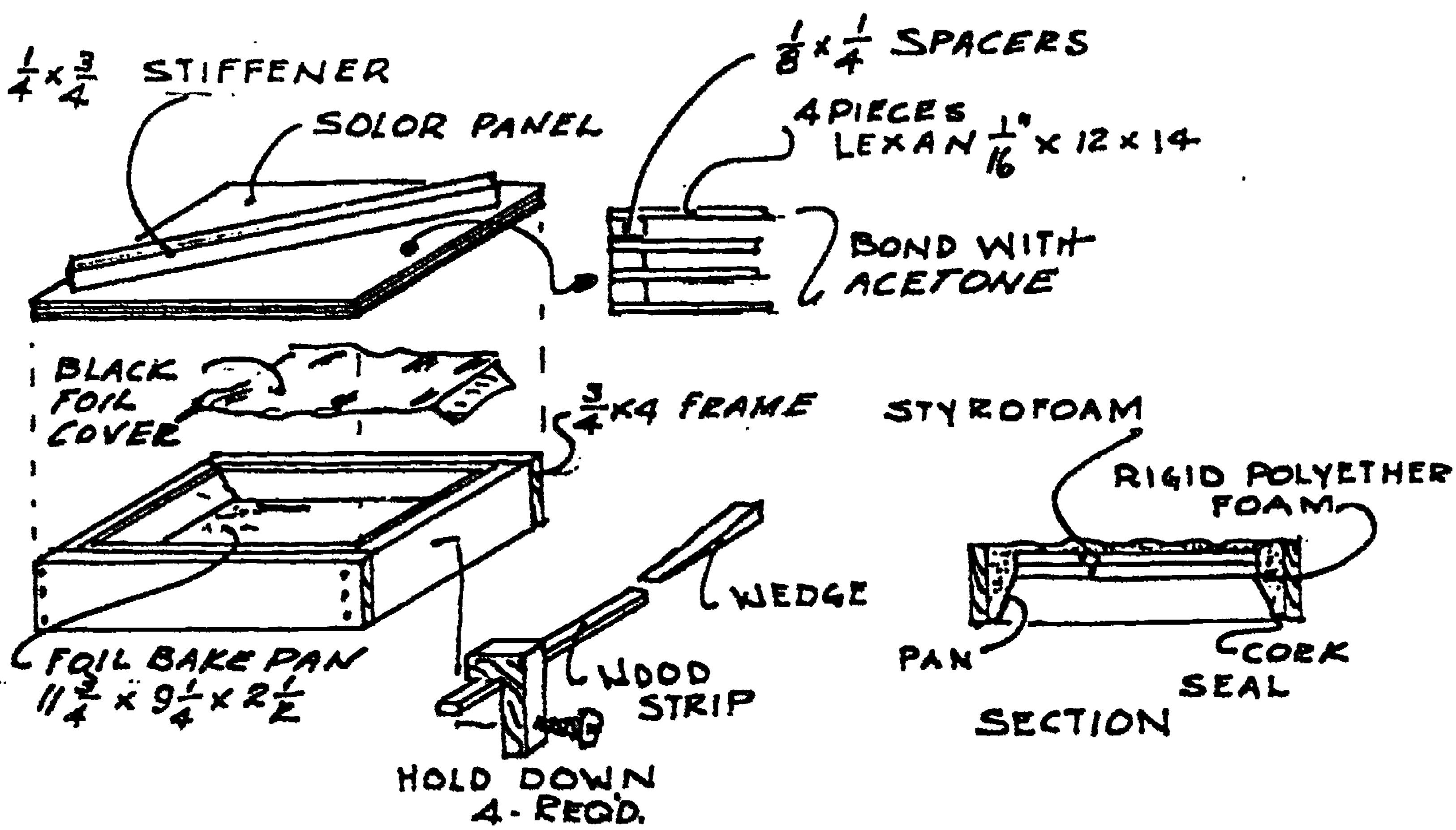
APPENDIX A

Team A. Overall design

This team is charged with making the overall design. The design may be changed as feedback information is given by the other teams. The specific tasks are:

Establish basic dimensions.
Make the outside shell and food compartment.
A method of loading and sealing.
Handle and means of tilting.

TEACHER: Make every effort to have students follow their own design. The unit described is to insure hot solar-food to be sampled by the class.



Team B. Insulation investigation

Possible materials for experimentation:

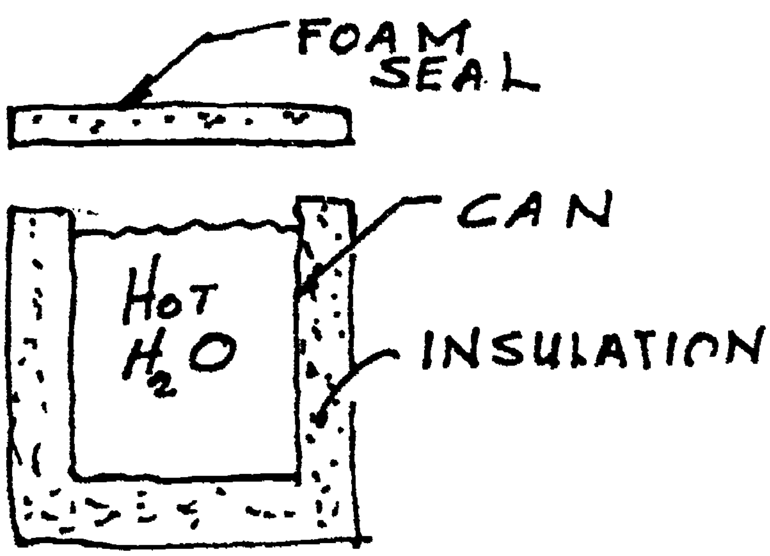
rock wool	cellylostic fiber	fiber glass
sawdust	pine bark	urethane
crumpled paper	vermiculite	polystyrene beads

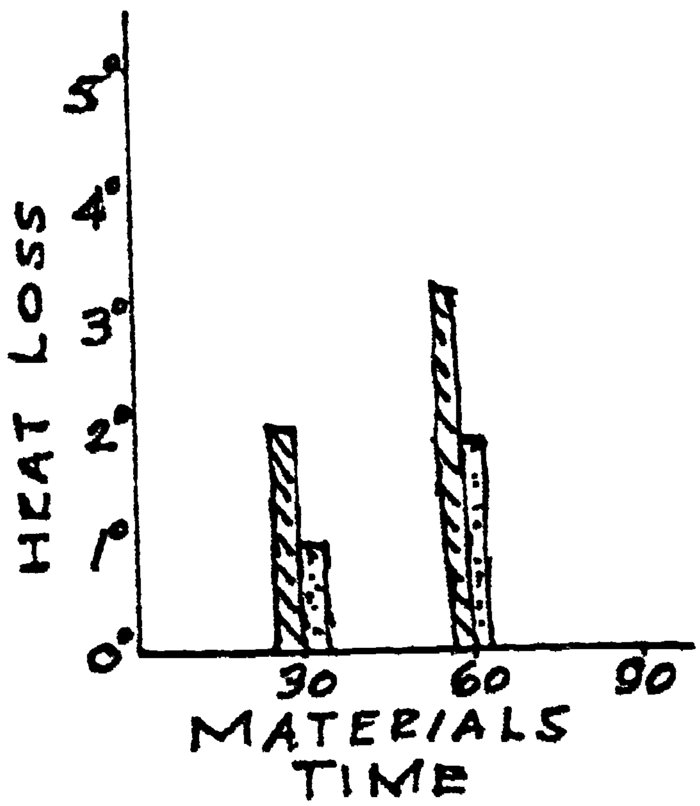
Activity:

Study and report R value of materials.
Search literature for technical data.
Design test equipment for testing and comparing insulating materials.
Encourage students to develop their own method of testing, here is a suggested way.

Select a metal container such as a coffee can. Make an outside shell with an allowance for 1" insulation. Cut blocks of foam for the top seal, three units suggested. Use different type of insulation in each can. Fill all three cans with hot water of same temperature. Check with thermometer the decrease in temperature every 30 minutes.

Have students make a bar chart to show the differences and comparisons.





TESTING

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BAR CHART

APPENDIX C

Team C. Solar panel

This team is charged with the development of a solar panel with min. heat loss. The first activity is to design small and inexpensive test.

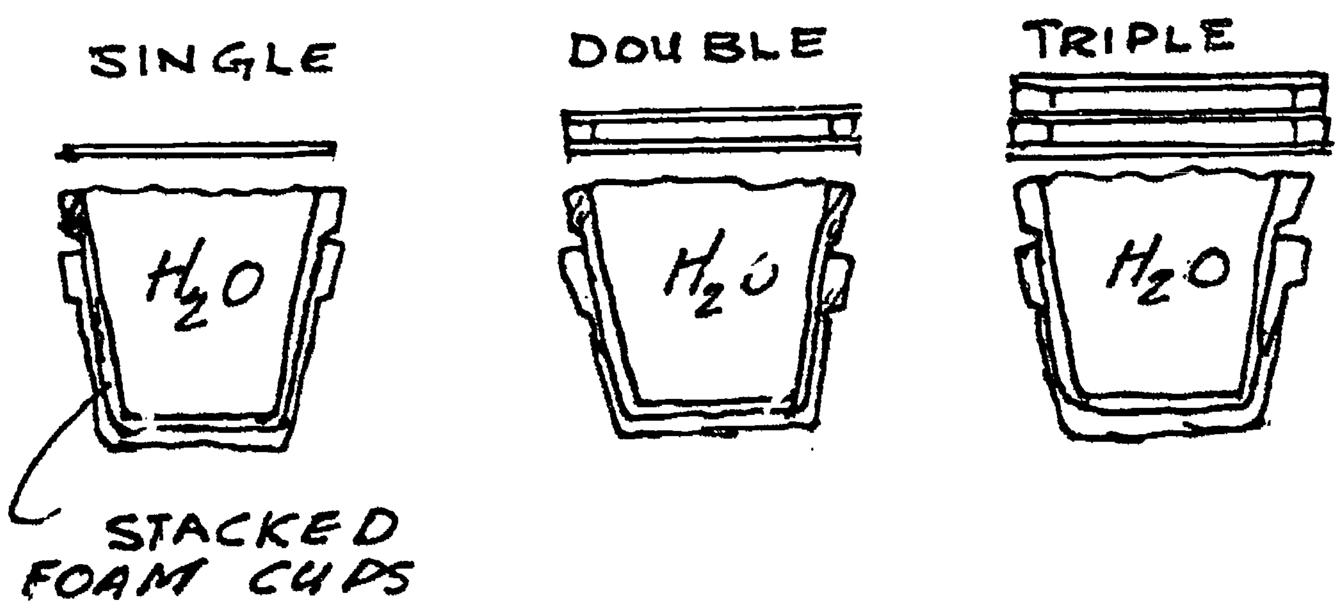
Desirable characteristics:

maximum heat loss	easy to make
min. thickness approx. 1/2"	withstand 300° temp.

Suggested materials for testing: ss window glass, 1/16" plexiglas, 1/16" lexan

Encourage students to develop their own testing procedure. Since it may not be convenient to expose the panels to the sun, below is a suggested back-up. Three test units may be used for comparison between single and multiple panel units. Fill the test cups with hot water and measure the decrease in water temperature every 30 minutes.

Have students make bar charts to show and exaggerate the differences. The kitchen oven could be used to check for the slump temperature of plastic units.



Special Team D

This team is charged with making a variety of test, heat build-up, and color choice.

Design and test problem:

Test and record heat build-up for different depths.
Test and record the best color for heat absorption.
Research for data on heat and color.

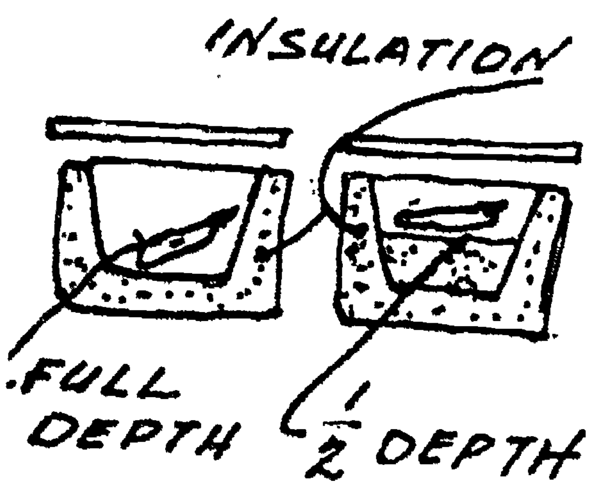
After the students are given an opportunity to design for the above, here are back-up suggestions.

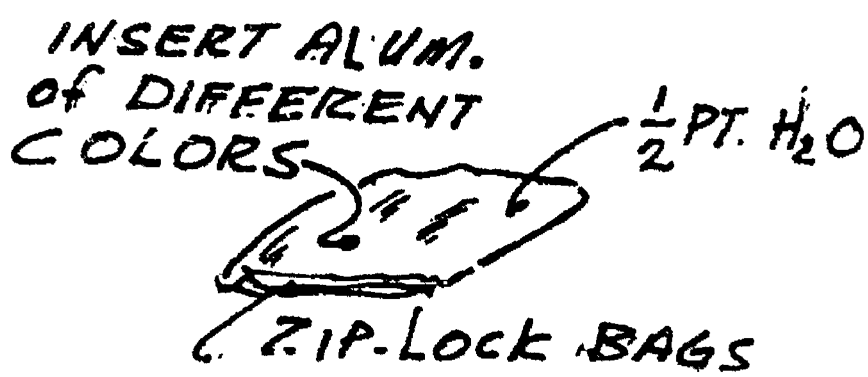
Heat build-up

Secure 2 aluminum foil bake pans, 9 1/2" x 5 1/4" x 2 1/2". Spray inside flat black. Use same type insulation, and same type solar panel on both pans. Leave on pan full depth, fill other pan to one-half its depth with rigid foam. Place 1/2 pt. water in zip-lock bags in the test pans. Place in the sun and measure the water temperature every 30 minutes.

Color tests:

Cut small pieces of aluminum to fit inside zip-lock bags. Spray aluminum with test colors such as, gloss black, flat black, red, green or white. Place 1/2 pt. water in the bags and expose colors to sun. Measure water temperature every 30 minutes. Make bar charts to show the differences.





SOLAR RADIATION DATA FOR RALEIGH, NC LATITUDE 35.8 DEGREES NORTH
DATA IN BTU PER SQUARE FOOT OF SOUTH FACING SURFACE
RADIATION PROGRAM DEVELOPED AT THE SCHOOL OF DESIGN, N.C.S.U., BY PROF. DON BARNES

MONTH		0	15	30	45	60	75	90	AVERAGE DAYTIME TEMPERATURE
		DEGREES TILT FROM HORIZONTAL							
JAN	MAXIMUM HOURLY	199.	260.	303.	327.	328.	308.	275.	45.3
	AVERAGE DAY	794.	1173.	1488.	1708.	1807.	1799.	1651.	
	AVERAGE MONTH	24304.	36366.	46113.	52832.	56027.	55460.	51174.	
FEB	MAXIMUM HOURLY	245.	296.	328.	333.	329.	308.	274.	45.2
	AVERAGE DAY	1039.	1450.	1768.	1970.	2040.	1973.	1774.	
	AVERAGE MONTH	29071.	40599.	49513.	55158.	57116.	55242.	49675.	
MAR	MAXIMUM HOURLY	287.	323.	337.	338.	325.	301.	268.	52.7
	AVERAGE DAY	1426.	1854.	2162.	2327.	2337.	2191.	1900.	
	AVERAGE MONTH	44217.	57485.	67033.	72152.	72458.	67926.	58901.	
APR	MAXIMUM HOURLY	310.	330.	337.	329.	312.	293.	253.	62.0
	AVERAGE DAY	1741.	2143.	2406.	2511.	2450.	2227.	1860.	
	AVERAGE MONTH	52242.	64287.	72187.	75337.	73497.	66809.	55788.	
MAY	MAXIMUM HOURLY	320.	331.	329.	318.	301.	274.	243.	70.1
	AVERAGE DAY	1927.	2297.	2521.	2580.	2469.	2198.	1788.	
	AVERAGE MONTH	59727.	71221.	78150.	79975.	76552.	68153.	55434.	
JUN	MAXIMUM HOURLY	321.	329.	322.	310.	294.	270.	234.	77.5
	AVERAGE DAY	1974.	2320.	2517.	2551.	2419.	2131.	1710.	
	AVERAGE MONTH	59223.	69592.	75522.	76543.	72574.	63933.	51305.	
JUL	MAXIMUM HOURLY	320.	328.	321.	310.	293.	267.	234.	80.0
	AVERAGE DAY	1996.	2354.	2563.	2606.	2478.	2191.	1767.	
	AVERAGE MONTH	61870.	72989.	79463.	80776.	76824.	67926.	54790.	
AUG	MAXIMUM HOURLY	312.	326.	327.	315.	297.	273.	240.	79.1
	AVERAGE DAY	1794.	2167.	2402.	2481.	2397.	2156.	1779.	
	AVERAGE MONTH	55620.	67186.	74475.	76909.	74298.	66850.	55155.	
SEP	MAXIMUM HOURLY	291.	319.	328.	327.	318.	288.	252.	74.0
	AVERAGE DAY	1487.	1876.	2144.	2272.	2250.	2079.	1772.	
	AVERAGE MONTH	44620.	56269.	64324.	68164.	67490.	62357.	53164.	
OCT	MAXIMUM HOURLY	257.	301.	325.	329.	322.	298.	264.	64.0
	AVERAGE DAY	1206.	1630.	1950.	2142.	2192.	2095.	1859.	
	AVERAGE MONTH	37398.	50543.	60460.	66408.	67937.	64930.	57618.	
NOV	MAXIMUM HOURLY	212.	268.	307.	326.	322.	305.	271.	54.0
	AVERAGE DAY	887.	1287.	1605.	1818.	1910.	1874.	1712.	
	AVERAGE MONTH	26604.	38608.	48155.	54542.	57295.	56206.	51357.	
DEC	MAXIMUM HOURLY	175.	238.	284.	312.	319.	306.	274.	45.6
	AVERAGE DAY	709.	1087.	1395.	1613.	1723.	1717.	1596.	
	AVERAGE MONTH	21991.	33688.	43254.	49991.	53399.	53224.	49480.	

APPENDIX E

BEST COPY AVAILABLE