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ABSTRACT

This guide contains information and hands-on activities to guide students through the problem-solving process needed in engineering (problem solving, presentation, and impact analysis) and information to help the instructor manage the program or courses in Virginia. Following an introduction, the guide contains a program description that supplies the following: Classification of Instructional Programs (CIP) code, suggested grade level, prerequisites, approved courses, and information on program implementation, completer options, and related postsecondary courses of study. The two courses in the program--introduction to engineering and advanced engineering--are presented separately. Each course has its own course description, task list, course outline, and instructional framework pages. Each course section includes a series of instructional framework pages divided into concept areas. Each page provides a state-validated task and competency, an assessment standard, and several objectives or activities designed to help students to achieve the competency. Each concept area concludes with a page that suggests the following instructional resources: equipment and materials, printed references, and audiovisual aids. Nine appendixes provide lists of additional resources: information and resources containing 18 general reference books, 20 magazines, 33 booklets and catalogs, 15 computer software, interfacing and applications, 18 films and videotapes, 29 math, science and technology resources, and 12 speakers, tours, and resource persons; information on organizing advisory committees; career slide and tape presentations; library book orders; engineering projects and case studies; reference materials for students; evaluation techniques; professional and technical societies and student associations; and laboratory facilities and equipment. (KC)

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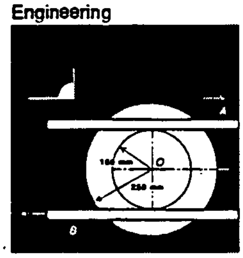
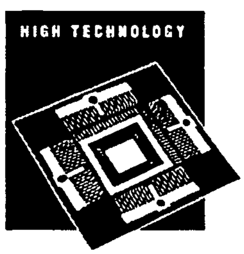
PRE-ENGINEERING PROGRAM



Introduction to Engineering



Advanced Engineering

Commonwealth of Virginia
Department of Education
Vocational, Adult, and Employment Training Services
Technology Education Service
Richmond, Virginia 23218-2120

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Rodney Fulton, Roanoke City
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Jim Rose, Fairfax County
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INTRODUCTION

Engineering education is changing in our colleges and universities for several reasons. According to Dr. J. James Benson in TIES Magazine, one of the key forces driving the change is technology. Benson compared the discipline of technology to those used in engineering. "Students learn to construct, communicate, manufacture, transport—using all the disciplines of engineering and technology. Exposure (to the study of technology) could motivate and build competencies to propel students toward engineering..."

This guide contains information and "hands-on" activities that engage students and challenge them to solve problems they will face today and tomorrow. The program task list is sequenced in order to cycle students through problem solving, presentation, and impact analysis.

Using the Guide to Support Program/Course Management

Pre-Engineering contains information to help the instructor manage the program or courses.

- Following this introduction is a program description that supplies the CIP code, suggested grade levels, prerequisites, approved courses, and information on program implementation, completer options, and related postsecondary courses of study.

- The two courses in the program—Introduction to Engineering and Advanced Engineering—are presented separately. Each carries its own course description, task list, course outline, and instructional framework pages. This arrangement allows the instructor to remove an entire section and revise, reorganize, or file pages according to local validation.

Using the Guide to Support Classroom Instruction

Each course section includes a series of instructional framework pages divided into concept areas. Each page provides a state-validated task/competency, an assessment standard (a statement that describes how well the student must perform the task), and several objectives or activities designed to help the student to achieve the competency. The task statement is written to the student, but statements outlining objectives and activities may be written to either the teacher or the student.

Each concept area concludes with a page that suggests instructional resources: equipment and materials, printed references, and audiovisual aids. Many items are keyed to a specific task/ competency; others apply to all tasks in that concept area.

Following the course frameworks is a series of appendices. These provide additional resources for both teacher and student use. Much of the material was developed and contributed by Virginia teachers. The final appendix (J), containing a collection of engineering activities, will be published separately at a later date.

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PRE-ENGINEERING PROGRAM

Description	Designed to introduce students to engineering and related careers, this program integrates mathematics and science concepts into high-tech engineering-type activities. Students explore the challenges of a career as an engineer, technologist, or technician. Students build competencies relevant to engineering principles such as problem solving, engineering graphics, and materials science. These experiences introduce and challenge students to continue study.
CIP Code	21.0101
Suggested Grade Level	11 or 12
Prerequisites	None
Approved Courses	Introduction to Engineering (8490) Advanced Engineering (8491)
Program Implementation Suggestions	This program is designed to challenge college-bound students. Usually these students have completed algebra and geometry and may be taking trigonometry and physics along with one of these courses. A basic technical drawing course is suggested for students prior to these courses.
Approved Program Completer Options	*Minimum requirements for program completion:* The two approved courses named above *Recommended for Vocational Concentration:* Minimum requirements **and** Basic Technical Drawing/Design/CAD (8435) **or** one additional approved 36-week course
Related Postsecondary Programs	*Engineering College and University Programs:* Engineering Design Engineering Technology Aeronautical Engineering Civil Engineering Electrical Engineering Geological and Mining Engineering Industrial Engineering Marine Engineering Materials and Metallurgical Engineering Nuclear Engineering

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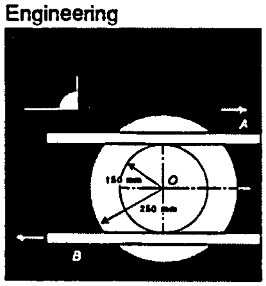
Pre-Engineering Program

Engineering



INTRODUCTION TO ENGINEERING

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PART 1
COURSE INFORMATION

The course descriptions, content outlines, and suggested task sequences contained in this section were developed using the validated tasks analyzed in part 2 of this guide. The program and courses have been approved by the Virginia Department of Education.

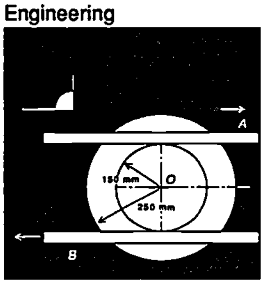
The course outline may be used by the teacher as a framework for planning instructional procedures and content. Suggested technology learning activities presented in Part 2 may be adopted or adapted for use in developing lesson plans.

Information on the long-range mission and goals and an overview of the total Technology Education curriculum are contained in *Technology Education Curriculum K-12,* Technology Education Service, 1992.

INTRODUCTION TO ENGINEERING (8490)

COURSE DESCRIPTION

Engineering



While undergoing an orientation to the careers and challenges of engineering, students are actively involved with high-tech devices, engineering graphics, and mathematics/science principles through problem-solving experiences. Activities in descriptive geometry, materials science, and technical systems challenge students as they communicate information through seminars, technical reports, and idea sharing.

PURPOSE	CODE	GRADE LEVEL	UNIT OF CREDIT	PREREQUISITES
Apply technology and engineering to life and work	8490	11 or 12	1 maximum 1 period per day 36 weeks	Higher level mathematics, science, and technical drawing courses recommended

SELECTED COURSE GOALS

- Explore engineering careers, history, practices, and concepts.
- Apply mathematical and scientific principles to technical problems.
- Assess abilities and interests as they relate to engineering and technician-level careers.
- Communicate through oral, written, or graphic means the results of solutions to problems.
- Select materials and processes appropriate to need.
- Use calculators to compute mathematical solutions.
- Use tools and machines necessary for processing materials or products.
- Use a computer to analyze data or to interface with practical applications.
- Solve problems with mechanical and electrical systems.
- Display a positive attitude toward the value of engineering practices by citing engineering contributions to the improvement of our world.
- Recognize the value of problem solving, research and development, and technical communications.
- Give examples of the value of mathematics and science to practical solutions.

INSTRUCTIONAL TASKS/COMPETENCIES

1. **Relating Objectives of the Course to Students in a Technological World**

   1.1 Describe the effects of the explosion in scientific knowledge on the development of technology.
   1.2 Explain the pressing need for engineers and technicians in the future.
   1.3 Explain the purpose and functions of the technological team.
   1.4 Participate in group work and personnel systems to manage class and laboratory activities.
   1.5 Apply safety rules to laboratory activities.

2. **Investigating the Engineering Profession and Related Careers**

   2.1 Summarize the characteristics of professional engineers.
   2.2 Describe the principal fields of specialization in engineering.
   2.3 Describe procedures for becoming a registered engineer.
   2.4 Identify benefits of study in the humanities and social sciences.
   2.5 Demonstrate a professional attitude toward classroom and laboratory activities.

3. **Applying Engineering Graphics, Descriptive Geometry, Computer Software, and Measurement Instruments**

   3.1 Distinguish among various measurement systems and their base units.
   3.2 Write a mathematical equation that is constant in units of measurement.
   3.3 Interpret drawings, using various systems of measurement.
   3.4 Use the precision measuring tools and instruments to lay out, measure, and inspect parts or products.
   3.5 Solve problems involving measurement of quantities of materials in both SI units and U.S. Customary Units.
   3.6 Use engineering design graphics and descriptive geometry in the solution of design problems.
   3.7 Sketch objects to show orthographic and pictorial views.
   3.8 Use basic technical drawing instruments to draw orthographic and isometric projections.
   3.9 Use appropriate methods to solve and report solutions of repetitive mathematical computations and observations of physical test data.
   3.10 Use graphical vector analysis in the design process.
   3.11 Build models that illustrate principal classes of physical models.
   3.12 Use computer-aided design (CAD) software to prepare drawings.
   3.13 Use computer-aided manufacturing (CAM) software to simulate a manufacturing problem.

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4. Citing the Contributions of Engineering in History

    4.1 Explore the history of engineering.
    4.2 Conduct research on an engineering achievement.
    4.3 Deliver a short oral briefing to explain a technical device or engineering achievement.

5. Working with the Fundamentals of Problem Solving

    5.1 Apply steps in the problem-solving method or process.
    5.2 Function as an engineer or technologist in group problem-solving activities.
    5.3 Apply mathematical formulas to problems and activities.
    5.4 Perform keyboard functions on a scientific, hand-held calculator.
    5.5 Use computer software and application programs to solve problems.

6. Analyzing the Science and Properties of Materials

    6.1 Describe the physical and chemical properties of engineering materials in terms of their internal structure.
    6.2 Determine the properties of materials, using tools and laboratory apparatus and equipment.
    6.3 Report test results in a written report.
    6.4 Identify causes of failure in materials and procedures used to prevent such failures.
    6.5 Explain the concept of supply and demand as it relates to materials in short supply.
    6.6 Experiment with processes used with metal, wood, polymer, ceramic, and composite materials and adhesives.

7. Working with Different Processes to Solve Problems

    7.1 Work as a team member, applying various methods to solve problems.
    7.2 Apply a variety of materials and technical processes to redesign or test a device.
    7.3 Use mathematical symbols to express a relationship between two or more variables.

8. Communicating Technical Information

    8.1 Explain the importance of communication between engineers and their clients.
    8.2 Write a proposal for an engineering project.
    8.3 Write a technical report for an engineering activity.
    8.4 Produce technical information, using a computer work processing program.
    8.5 Present technical information in an oral report.

9. Using the Design Process to Improve a Device or System

    9.1 Select a problem or project for improvement.
    9.2 Use the steps in the design process to improve a product.
    9.3 Build a model of an improved product.

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9.4 Analyze the potential impacts of the improved product.

10. Gathering Information About Problems and Solutions

10.1 Identify references found in a technical library.
10.2 Identify publications used by engineers and the sources of each.
10.3 Identify the six legal categories of patents.
10.4 Explain how patents are obtained.
10.5 Describe how patents protect the inventor.

11. Managing the Team Concept of Engineering Design

11.1 Explain the importance of teamwork in problem solving.
11.2 Describe the use of a feasibility study.
11.3 Identify the essential steps in the preliminary design phase.
11.4 Identify the essential steps in the detailed design phase.

12. Briefing Others on Results of Engineering

12.1 Pre-register for competitive events.
12.2 Participate in construction of a display of problem-solving activities.

INSTRUCTIONAL OUTLINE AND SEQUENCE

Topic	Task/ Competency	Schedule
I. Relating Objectives of the Course to Students in a Technological World Orientation to the Pre-Engineering program includes providing an overview and description of the first course, distributing course objectives or task/competency list, performing administrative details required by the school or the program, and illustrating how the course relates to the needs of both students and industry.		1 week
A. The scientific explosion		
B. Urgent need for engineers and technicians	1.1	
C. The technological team	1.2	
D. Class personnel system	1.3	
E. Safety rules	1.4	
	1.5	
II. Investigating the Engineering Profession and Related Careers Students can be introduced to careers in engineering by an audiovisual presentation. The class develops interview questions prior to a visit by an engineer or technician. Questions can include requirements for registration and specialization and professional qualities needed by engineers. Teacher forms an advisory committee.		1 week
A. Characteristics of professional engineers	2.1	
B. Fields of specialization	2.2	
C. Registration procedures	2.3	
D. Benefits of the study of humanities/social sciences	2.4	
E. Professional attitudes	2.5	
III. Applying Engineering Graphics, Computer Software, and Measurement Instruments Students are introduced to principles and skills related to mathematics, drawing, and model construction, using both manual and electronic methods.		12 weeks
A. Measurement systems		
B. Mathematical equations	3.1	
C. Use of measurement systems in drawing interpretation	3.2	
D. Use of precision measurement tools	3.3	
E. Measurement of quantities	3.4	
F. Introduction to engineering graphics/descriptive geometry	3.5	
G. Sketching techniques	3.6	
H. Drawing techniques	3.7	
I. Solutions and reporting of repetitive mathematical calculations	3.8	
and physical test data	3.9	

Topic	Task/ Competency	Schedule
III. Applying Engineering Graphics, Computer Software, and Measurement Instruments (Cont)		
J. Graphical vector analysis	3.10	
K. Principal classes of physical models	3.11	
L. Use of CAD system	3.12	
M. Use of CAM system	3.13	
IV. Citing the Contributions of Engineering in History Students select an achievement and conduct research, write an outline, produce a display or a model, and give a brief oral presentation in a class seminar.		1 week
A. History of engineering	4.1	
B. Research/presentation plan	4.2	
C. Oral briefing	4.3	
V. Working with the Fundamentals of Problem Solving Each student builds a bridge or truss of balsa wood, using the fundamentals of engineering and the design process, and tests the completed structure to compute its strength. Tool and equipment safety is incorporated in instruction.		5 weeks
A. Application of steps in problem-solving methods	5.1	
B. Library/laboratory investigation	5.2	
C. Application of mathematical formulas	5.3	
D. Use of scientific calculator	5.4	
E. Use of computer in problem solving and analysis	5.5	
VI. Analyzing the Science and Properties of Materials Students test and modify the hardness of metal and use other test equipment to evaluate materials. Additional lab safety qualifications are included. If possible, invite a guest speaker or arrange a tour of local industry.		4 weeks
A. Internal structure of materials	6.1	
B. Testing equipment	6.2	
C. Lab reports	6.3	
D. Causes and prevention of structural failure	6.4	
E. Supply of and demand for materials	6.5	
F. Processes used with various materials	6.6	
VII. Working with Different Processes to Solve Problems Students, in small groups, concentrate on redesigning and testing a second bridge or similar type of problem, using various materials and processes. They keep a log of all activities. Trigonometric and mathematical calculations are used.		4 weeks
A. Problem-solving methods	7.1	
B. Application of different materials and processes to solve problems	7.2	
C. Use of mathematical symbols	7.3	

Topic	Task/ Competency	Schedule
VIII. Communicating Technical Information Students write proposals/technical reports on problem assigned in Concept Area VII. A. Importance of engineer/client communication B. Engineering proposal C. Technical report writing D. Computer preparation and display of technical information E. Oral report	 8.1 8.2 8.3 8.4 8.5	1 week
IX. Using the Design Process to Improve a Device or System Options include assigning one problem to several groups, a different problem to each of several groups, or individual projects (contemporary or future approach). Students participate in project selection and use the design process to improve a product. A. Project selection B. Use of design process to improve a product C. Model construction D. Potential impacts of improved product	 9.1 9.2 9.3 9.4	3 weeks
X. Gathering Information about Problems and Solutions Instruction focuses on the information-gathering phase of the design process. Writing to museums and research centers; obtaining assistance of the school librarian; going on a field trip to a museum, technical library, or industry; and conducting a literature search are suggested activities. A. Technical library/on-line resources (Internet access) B. Engineering publications C. Patent information search	 10.1 10.2 10.3-10.5	1 week
At this point in the course, students may benefit from a review and further instruction in computations involving mathematical, calculator, and computer operations. Tasks/competencies 5.3, 5.4, 5.5, and 7.3 can be repeated with advanced activities to accomplish these objectives.		1 week
XI. Introducing the Team Concept of Engineering Design Activities in the area introduce the second course of the program. A. Importance of teamwork in problem solving B. Use of feasibility study C. Preliminary design phase D. Detailed design phase	 11.1 11.2 11.3 11.4	1 week
XII. Briefing Others on Results of Engineering Options include a seminar for outside observers; displays for school, class, or community; and TSA competition in bridge building, problem solving, or technical writing. A. TSA contest preregistration B. Display construction	 12.1 12.2	1 week

PART 2

TASK INVENTORY

One of the major characteristics of competency-based education (CBE) is that the course content is based upon actual jobs or tasks performed by persons living and working in the technological world. In Virginia, the Department of Education has established standards for competency-based education. According to these standards, competencies must be "role-relevant" and based upon "appropriate research." This standard states:

> Role-relevant competencies that include standards are identified and stated. The competencies with standards will be identified through V-TECS, IDECC, and other appropriate research. Advisory committees should be used to review competencies and standards. Competencies in the affective domain will be included. Role-relevant competencies for occupational preparation programs are those that specifically relate to the occupation for which the student is being prepared as well as to the personal needs of the student. Role-relevant compe-tencies are related also to orientation, exploration, or technology education experiences which have been identified for students.

Therefore, "role-relevant" jobs or tasks, called competencies in CBE, must be identified and validated before instructional materials can be developed and subsequent instruction can take place.

The task list contained in this instructional guide was based on the following:

1. Interviews with engineers and technologists at NASA and in private sectors

2. The review and selection of appropriate competency-based materials

3. Input from engineering faculty and technology teachers

4. Input from mathematics, science, and technology education supervisors.

Based on the information collected and reviewed from the available sources indicated, a task inventory was prepared.

The next major step involved in the development of the task inventory was validation of the task list. Validation is essential if the information collected is to be useful in operating CBE courses and programs. The validation process involved the following:

1. Review by writing-team members to determine completeness of the inventory

2. Review and validation by state consultants to ensure the role-relevance and completeness of the inventory

3. Pilot testing by local technology education teachers to determine the validity of the inventory

4. Final review and editing by writing team members, project directors, and state supervisors.

The task list included in this publication was based on current available resources and validated by teachers, advisory committee members, and persons employed in engineering and technology careers. The tasks are offered as guidance to teachers. Many tasks build upon others taught earlier. The methods of instruction and technology learning activities are suggested but can be varied to meet student needs.

Part 2 of this guide for Introduction to Engineering includes the following:

- A divider for each concept area that functions as a table of contents for the area
- A series of framework pages that present each task/competency in the concept area
- Transparency masters included as informational aids (Concept Areas 1, 2, 7, and 11)
- A resources page for each concept area that lists equipment and materials, references, and audiovisual aids (including software) suggested for use in the classroom or laboratory.

CONCEPT AREAS

CONCEPT AREA 1

RELATING OBJECTIVES OF THE COURSE TO STUDENTS IN A TECHNOLOGICAL WORLD

INTRODUCTION TO ENGINEERING (8490)

CONCEPT AREA

1. Relating Objectives of the Course to Students in a Technological World

TASK/COMPETENCY

1.1 Describe the effects of the explosion in scientific knowledge on the development of technology.

ASSESSMENT STANDARD

S1.1 Assigned number of examples show how mathematics, science, and computer principles are applied to new technological developments; descriptions and illustrations must be rated acceptable according to criteria included in class guidelines.

OBJECTIVES AND LEARNING ACTIVITIES

1. Explain some changes in the world that resulted from scientific discoveries.

2. Identify recent developments in technology.

3. Have students collect photos and newspaper/magazine articles about new technological advances.

4. Relate activities planned for this course to the study of mathematics, science, and computer principles responsible for technological developments.

5. Identify challenging areas of engineering.

6. Show a film such as *Challenges of Manufacturing* or Part I of the slide/tape *Engineering: An Introduction to the Field and Its Careers* to start a discussion of engineering functions.

7. Help class determine criteria for presentation of information.

CONCEPT AREA

1. Relating Objectives of the Course to Students in a Technological World

TASK/COMPETENCY

1.2 Explain the pressing need for engineers and technicians in the future.

ASSESSMENT STANDARD

S1.2 Explanation must include identification and results of recent technological advances and changes in the workforce, rated acceptable according to criteria in the assignment instructions.

OBJECTIVES AND LEARNING ACTIVITIES

1. Describe recent technological advances that affect the need for qualified engineers and technical personnel.

2. Explain how recent technological developments have eliminated certain types of manufacturing jobs.

3. Define the term *technological literacy*, and explain what this means to people who have lost their jobs because of encroaching technology.

4. Identify reasons why women have traditionally been discouraged from engineering/technical/scientific careers, and explain how the need for qualified professionals has affected this attitude.

5. Identify future needs of local employers for qualified engineers, technologists, and technicians.

6. Arrange a "fact-finding" tour of a local industry or invite a guest speaker to address this topic.

CONCEPT AREA

1. Relating Objectives of the Course to Students in a Technological World

TASK/COMPETENCY

1.3 Explain the purpose and functions of the technological team.

ASSESSMENT STANDARD

S1.3 Explanation must identify members of the team and describe the role and characteristics of each; rated acceptable according to criteria specified in instructor's guidelines.

OBJECTIVES AND LEARNING ACTIVITIES

1. Describe the role of the craftsperson, and state characteristics of his or her work.
2. Explain the type and level of work performed by the technician.
3. Have students obtain information from a community college and report on technical careers.
4. Contrast the work of the engineer and the technologist.
5. Describe how scientists are educated and the type and level of work they perform.
6. Show Part II to *Engineering: An Introduction to the Field and Its Careers,* and have students discuss the roles and qualifications needed by each member of the team.
7. Use Transparency 1.3 to show the education/training requirements of an engineering team.

INTRODUCTION TO ENGINEERING (8490)

CONCEPT AREA

1. Relating Objectives of the Course to Students in a Technological World

TASK/COMPETENCY

1.4 Participate in group work and personnel systems to manage class and laboratory activities.

ASSESSMENT STANDARD

S1.4 Participation as leader and follower must be rated acceptable during periodic observations by the instructor.

OBJECTIVES AND LEARNING ACTIVITIES

1. Identify the leadership positions needed for student activities in class or laboratory settings.
2. Provide information about other organizations and their leadership positions.
3. List and define duties of officers such as president, secretary, treasurer, and reporter used to help manage organizations and groups.
4. Identify/designate team members needed within class.
5. Have students prepare an organization chart, using a computer.
6. Organize an advisory committee for the program consisting of engineers and technical personnel from the community. Ask teachers of English, mathematics, and science to serve as consultants to the committee.

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INTRODUCTION TO ENGINEERING (8490)

CONCEPT AREA

1. Relating Objectives of the Course to Students in a Technological World

TASK/COMPETENCY

1.5 Apply safety rules to laboratory activities.

ASSESSMENT STANDARD

S1.5 Student demonstration of safe use of tools, machines, equipment, and supplies during each activity must be rated acceptable according to posted safety rules and precautions.

OBJECTIVES AND LEARNING ACTIVITIES

1. Explain the importance of safety in the laboratory and the workplace.

2. Identify hand tools, machines, equipment, and chemicals used in the laboratory, and state safety precautions for the use of each.

3. Describe safety precautions and responsibilities in regard to the following engineering areas:

Management	Construction
Industry	Production
Operation	Design
Maintenance	Development.
Research	

THE ENGINEERING TEAM EDUCATION/TRAINING REQUIREMENTS

ENGINEER

Bachelor of Science (B.S.) in Engineering
May or may not be registered
Applies theory
Leads team

TECHNOLOGIST

Baccalaureate degree after four years of study in one or more technological areas
Understands theory

TECHNICIAN

Associate degree (2 years)
Applies theory

CRAFTSPERSON

Vocational training
Possible military training
Experience and on-the-job training
Applies theory

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RESOURCES FOR

1. RELATING OBJECTIVES OF THE COURSE TO STUDENTS IN A TECHNOLOGICAL WORLD

EQUIPMENT AND MATERIALS

1.1 Film projector, slide/tape projector
Computer with graphics and word processing packages

1.2 Assignment instructions

1.3 Instructor-prepared guidelines
Slide/tape projector

1.4 Computer with graphics packages
Sample organization charts

1.5 Safety posters

REFERENCES

Careers in Engineering and Technology. Beakley. Macmillan Publications, Inc.
Disciplined Creativity for Engineers. Bailey. Ann Arbor Science, Butterworth Publishers.
"Our Designed World." *Science for All Americans.* AAAS, 1333 H Street, NW, Washington, DC 20005.

AUDIOVISUAL MATERIALS

1.1 Movie: *The Challenge of Manufacturing* (#24369, 23 min.). Society of Manufacturing Engineers. Modern, 5000 Park Street North, St. Petersburg, FL 33709.

1.2/1.3 Slide/tape: *Engineering: An Introduction to the Field and Its Careers.* Technology Education Service, Virginia Department of Education, P.O. Box 2120, Richmond, VA 23216-2120.

1.3 Transparency: *The Engineering Team Education/Training Requirements.*

1.4 Videotape: *Technology Education: A National Imperative.* ITEA, 1914 Association Drive, Reston, VA 22091.

CONCEPT AREA 2

INVESTIGATING THE ENGINEERING PROFESSION AND RELATED CAREERS

Transparency Masters

Handouts

ERIC

CONCEPT AREA

2. Investigating the Engineering Profession and Related Careers

TASK/COMPETENCY

2.1 Summarize the characteristics of professional engineers.

ASSESSMENT STANDARD

S2.1 Assigned number of characteristics must be defined and their importance explained; average rating or above is required.

OBJECTIVES AND LEARNING ACTIVITIES

1. Define the terms *profession, engineer, technician, registered engineer, engineering profession,* and *engineering technology*.

2. Describe qualifications needed by professional engineers.

3. Describe typical tasks performed by professional engineers.

4. Explain the term *certified* in *certified engineering technologist* or *certified engineering technician* according to organizations such as the Society of Manufacturing Engineers (SME), National Society of Professional Engineers (NSPE), National Institute for Certification in Engineering Technologies (NICET), or Accreditation Board for Engineering and Technologies (ABET).

5. Compare definitions of *engineer* from the following sources: Society of Professional Engineers, *Introduction to Engineering* by Blotter, and a dictionary.

6. Show Part III of *Engineering: An Introduction to the Field and Its Careers.*

CONCEPT AREA

2. Investigating the Engineering Profession and Related Careers

TASK/COMPETENCY

2.2 Describe the principal fields of specialization in engineering.

ASSESSMENT STANDARD

S2.2 Description must include list of two titles of engineers in each field, the distinguishing characteristics of their work, and two related careers outside of engineering.

OBJECTIVES AND LEARNING ACTIVITIES

1. Arrange or help students arrange interviews of engineers.
2. Use Transparency 2.2-1 and Handout 2.2A to introduce the traditional branches of engineering (chemical, civil, electrical, industrial, and mechanical).
3. Identify fields of specialization within the traditional branches.
4. Describe types of work done by engineers in the principal fields of specialization, using Handout 2.2B and Transparencies 2.2-2 and 2.2-3 as aid to discussion.
5. List careers related to various specialized engineering fields.
6. UseHandout 2.2C to introduce the educational requirements of various engineering specialties.

ERIC

INTRODUCTION TO ENGINEERING (8490)

CONCEPT AREA

2. Investigating the Engineering Profession and Related Careers

TASK/COMPETENCY

2.3 Describe procedures for becoming a registered engineer.

ASSESSMENT STANDARD

S2.3 Procedures are described accurately according to professional literature.

OBJECTIVES AND LEARNING ACTIVITIES

1. Have students write to professional engineering societies requesting information on registration requirements.

2. Explain the possible use of the word *engineer* in the name of a new construction firm.

3. Have students make a line management chart showing the firm's management personnel.

4. Compare the meanings of and requirements for licensing, registration, and certification.

CONCEPT AREA

2. Investigating the Engineering Profession and Related Careers

TASK/COMPETENCY

2.4 Identify benefits of study in the humanities and social sciences to the engineer/technologist.

ASSESSMENT STANDARD

S2.4 Benefits must include a description of the role played by the engineer/technologist in solving a variety of societal problems; description must be accurate according to references used.

OBJECTIVES AND LEARNING ACTIVITIES

1. List problems associated with major societal concerns such as health care, housing, natural resources, food production, and transportation.

2. Describe ways engineers or technologists can work to alleviate societal problems.

3. Have students discuss how engineers' work can result in a better life for the community and society.

4. Relate the study of humanities and social sciences to an engineer's ability to view the "big picture" represented by an engineering problem.

ERIC

CONCEPT AREA

2. Investigating the Engineering Profession and Related Careers

TASK/COMPETENCY

2.5 Demonstrate a professional attitude toward classroom and laboratory activities.

ASSESSMENT STANDARD

S2.5 Behaviors associated with professional attitudes toward safety, care and maintenance of equipment, work with co-workers and supervisors, and required study and problem solving must be demonstrated; acceptable rating is required during each periodic evaluation.

OBJECTIVES AND LEARNING ACTIVITIES

1. Identify behaviors associated with a professional attitude toward safety.

2. Identify behaviors associated with a professional attitude toward care and maintenance of equipment.

3. Have students make up a code of conduct, listing class rules on safety and care of equipment.

4. Identify behaviors associated with a professional attitude toward required study and problem solving.

5. Use Transparency 2.5 to initiate a discussion of traits present in professional engineers and their relationship to study habits and skills required for training in problem-solving.

6. Identify behaviors associated with a professional relationship with co-workers and supervisors.

7. Ask members of the advisory committee to speak to the class about the importance of teamwork and how professional relationships can be formed and maintained.

8. Form small groups within the class to solve short problems or exercises. Change group memberships to enable students to adapt to new, professional relationships.

TRADITIONAL BRANCHES OF ENGINEERING

CHEMICAL

CIVIL

ELECTRICAL

INDUSTRIAL

MECHANICAL

NUCLEAR

ERIC

WHERE DO ENGINEERS WORK?

60% industry

20% government

10% private practice

5% construction

5% education

ERIC

WHAT DO ENGINEERS DO?

Engineers find practical applications for abstract scientific principles.

They are

- **inventors**
- **developers of new products**
- **designers of buildings, bridges, automobiles, and airplanes**
- **creators of labor-saving devices for home, office, school, and business**
- **designers of cities and towns.**

IMPORTANT QUESTIONS FOR POTENTIAL ENGINEERS

Do I have an inquisitive, searching mind?

Do I like to solve problems and puzzles?

Do I like to create things?

Do I enjoy learning?

Can I organize my time?

Am I willing to work hard?

Prepared by Mr. Ken Anderson, Consulting Engineer, Anderson Associates, Blacksburg, VA.

ENGINEERING CAREER SPECIALTIES

Engineers apply the theories and principles of science and mathematics to the economical solution of practical technical problems. They

- design industrial machinery and equipment
- design defense and weapons systems
- design, plan, and supervise construction of buildings, highways, and rapid transit systems
- design and develop consumer products and systems for the control and automation of certain processes.

There are many branches of engineering to serve a variety of industries. Each branch requires the engineer to use specialized knowledge and training, but this knowledge and training can be applied to many fields. For example, electrical/electronics engineers work in the medical, computer, missile guidance, and power distribution fields.

Branches of Engineering

- **Aeronautical/aerospace engineers** design, develop, test, and help manufacture commercial and military aircraft, missiles, and spacecraft. They develop new technologies in commercial aviation, defense systems, and space exploration. They may specialize in structural design, guidance, navigation and control, instrumentation and communication, or production methods, or in one type of product, such as helicopters or rockets.

- **Bioengineers** combine engineering, biological sciences, and medicine to design and develop highly sophisticated medical instruments and equipment, including artificial limbs, artificial hearts, and other organ substitutes.

- **Chemical engineers** apply the principles of chemistry, physics, mathematics, and mechanical or electrical engineering to solve problems. Many work in the production of chemicals and chemical products, designing equipment and developing and testing processes for manufacturing chemicals.

- **Civil engineers** may choose from many subspecialties.
  - ❑ Structural engineers work with the design and erection of both large and small structures of concrete and steel, such as buildings, highway overpasses, bridges, and dams.
  - ❑ Geotechnical and soil mechanics engineers calculate the ability of rocks and soils to bear the load of heavy structures.
  - ❑ Environmental engineers use additional knowledge of chemistry and biology to deal with water and sewage treatment, waste disposal, and the protection of rivers and lakes.
  - ❑ Transportation engineers design highways and public transportation systems such as subways and rail systems.

- **Electrical engineers** design, develop, test, and supervise the manufacture of electrical equipment such as power generating and transmission systems, electric motors, machinery controls, and lighting and wiring systems. Electronics engineers work with equipment such as radar, computer hardware, and communications and video equipment.

- **Geotechnical and mining engineers** work with the discovery and exploration of mineral deposits and the processes to extract the minerals and convert them into useful metals or other refined products. Petroleum engineering is a subspecialty dealing with oil and gas fuels. These engineers need a knowledge of geology, rock mechanics, extraction processes, and the behavior of ores and metals.

- **Industrial engineers** determine the most effective ways to use the basic factors of production—people, machines, materials, information, and energy. They design systems to control finances, production rate and quality, distribution, and evaluation activities.

- **Materials and metallurgical engineers** develop new types of metals, ceramics, composites, and other materials to meet special requirements. Examples range from graphite shafts for golf clubs to ceramic tiles that protect spacecraft during re-entry.

- **Mechanical engineers** deal with the production, transmission, and use of mechanical power and heat. They design and develop both power-producing machines such as internal combustion engines, turbines, and jet engines and power-using machines such as air-conditioning equipment, robots, machine tools, and materials handling systems.

- **Nuclear engineers** are concerned with the safe design and operation of nuclear power plants, systems to safeguard people from harmful effects of radiation, and the safe disposal of nuclear wastes. Some specialize in the development of nuclear weapons; others develop industrial and medical uses for radioactive materials.

ENGINEERING FUNCTIONS

Engineers have a variety of responsibilities. Some engineers specialize in one or two functions; others have broader interests but limit the type of product or process involved.

RESEARCH

Research engineers use mathematics, scientific concepts, and experiments to develop new principles and processes. For example, they may develop a computer simulation to predict the behavior of an airplane in flight, thereby reducing the risks of actual flight testing. Most research engineers hold advanced degrees, usually doctorates.

DEVELOPMENT

Development of complex systems involves design, testing, and improvement of new processes, new materials, and new components, which the engineer then combines in the proper sequence to build the final engineering system. The development engineer may enlarge small-scale experiments performed by the research engineer to full-scale industrial practice. These engineers usually hold advanced degrees.

DESIGN

Design goes hand-in-hand with development and ensures that a project actually works; is safe, economical, and reliable; and meets the needs of the customer.

TESTING

Products must be tested before delivery to a customer. When testing shows possible failures, a product may need to be redesigned.

MANUFACTURING/CONSTRUCTION

The manufacturing engineer selects the right tools, schedules the flow of materials and parts for the right machines, and supervises assembly of products.

QUALITY CONTROL AND INSPECTION

The quality control engineer ensures that all parts and assemblies meet all requirements.

SALES AND MARKETING

Sales engineers are responsible for interaction between the manufacturer and the customer, so they must have technical knowledge along with an understanding of customer needs. They may have to educate customers as to how their products can satisfy their needs. At other times, they may translate customer needs into special features or a redesign of product.

MAINTENANCE

Maintenance engineers are responsible for the continued safe and reliable operation of equipment and efficient repairs.

MANAGEMENT

Management of complex technical projects requires knowledge of both engineering and management techniques and thus differs from normal business management. The engineering manager may be promoted from the ranks of engineer and have an advanced degree in business management.

BECOMING AN ENGINEER

Prior to the 18th century, engineering was considered a craft, requiring experience rather than education. Civil engineering education began in France in 1747, but engineering schools did not flourish in the United States until after the Civil War. Civil, mechanical, and electrical engineering programs were the first to be implemented. They emphasized technical education, incorporating mathematics and the physical sciences into the study of practical crafts such as machine shop, surveying, drafting, and welding. Science-based engineering education did not begin until the 1950s.

EARNING A BACCALAUREATE DEGREE

Admission requirements for undergraduate engineering schools include courses in advanced high school mathematics and the physical sciences. During the first two years, students concentrate on mathematics, science, English, humanities, and social studies. The remaining years are devoted to technical courses, some of which are required for all engineering students and others which depend on a chosen branch of engineering. Many engineering students work full time as interns during the summer or for a semester for various firms to gain experience and entry into the field. This may extend a four-year program to five or even six years.

Nearly 260 colleges and universities offer engineering education. Most accredited programs focus on electrical, electronic, civil, mechanical, chemical, and industrial engineering. Fewer schools feature aeronautical, nuclear, and materials engineering, and fewer still specialize in ceramics, environmental, bioengineering, and geologic or petroleum engineering.

Approximately 66,000 students graduated from college engineering programs in 1990.

CONTINUING EDUCATION

Rapid changes in technology make it difficult to learn enough in a four-year undergraduate curriculum to be successful in some engineering specialties such as research or development. In addition, engineers may find that their knowledge quickly becomes obsolete unless they continue to study. They must keep up because their value to an employer depends on their knowledge of the latest technology.

Master's and doctoral programs stress further technical depth and independent research. Some engineers hold advanced degrees in other disciplines such as business or mathematics.

GETTING A JOB

Even with economic downturns, almost all engineering graduates get good jobs. In fact, in 1990 engineering students earned 9% of all baccalaureate degrees but 40% of all the job offers. Starting salaries, which in 1990 ranged from $28,000 to $35,000 per year, are substantially higher than in many other fields. Salaries for senior engineers may go as high as $95,000 per year.

In addition to a bachelor's degree from an accredited engineering program, employers look for new engineers who have creativity, an analytical mind, a capacity for detail, the ability to work as part of a team, and the ability to express themselves well orally and in writing.

Very few engineers leave the profession, and employers are not likely to lay off engineers when reducing their work force. Despite these factors, employment opportunities continue to grow. Employers will need more engineers as they expand plant and equipment to provide more goods and services and improve product designs. Also, more engineers will be needed to improve deteriorating roads, bridges, water and pollution control systems, and other public facilities.

Engineers whose work may affect life, health, or property or who offer their services to the public must be registered. Registration requires a degree, four years of relevant work experience, and a passing score on a state examination.

Most engineers join one or more professional engineering societies. These societies publish technical journals, encourage engineering research, hold meetings, offer continuing education courses, and look after the technical welfare of their members.

RESOURCES FOR

2. INVESTIGATING THE ENGINEERING PROFESSION AND RELATED CAREERS

EQUIPMENT AND MATERIALS

2.1 Slide/tape projector

2.2 Overhead projector

2.3 Computer with word processing package

2.5 Overhead projector

REFERENCES

Careers in Engineering and Technology. Beakley. Macmillan Publications, Inc.
Careers in Science and Technology. (EP-298). NASA, DOE, and NTA. Langley Research Center, Mail Code 400, Hampton, VA 23881.
"Engineering." *Compton's Interactive Enclyclopedia*, Compton's NewMedia, Inc., 1993.
Disciplined Creativity for Engineers. Bailey. Ann Arbor Science, Butterwork Publishers.
Occupational Outlook Handbook, 1992-93 ed. U.S. Department of Labor, Bureau of Labor Statistics.
Your Engineering Career Kit. Accreditation Board for Engineering and Technology, 345 E. 47th Street, New York, NY 10017.

AUDIOVISUAL MATERIALS

2.1 Slide/tape: *Engineering: An Introduction to the Field and Its Careers, Part III*. (See Appendix B.)

2.2 Transparency 2.2-1: *Traditional Branches of Engineering.*
Transparency 2.2-2: *Where Do They Work?*
Transparency 2.2-3: *What Do They Do?*

2.5 Transparency 2.5: *Important Questions for Potential Engineers.*

CONCEPT AREA 3

APPLYING ENGINEERING GRAPHICS, COMPUTER SOFTWARE, AND MEASUREMENT INSTRUMENTS

CONCEPT AREA

3. Applying Engineering Graphics, Computer Software, and Measurement Instruments

TASK/COMPETENCY

3.1 Distinguish among various measurement systems and their base units.

ASSESSMENT STANDARD

S3.1 Assigned number of mathematical problems involving the base units of a variety of measurement systems must be solved correctly.

OBJECTIVES AND LEARNING ACTIVITIES

1. Solve problems dealing with length, volume, and mass, using the English system.
2. Solve problems dealing with length, volume, and mass, using System International (SI) Units.
3. Demonstrate and have students use the computer software *Scientific Measurements*.

CONCEPT AREA

3. Applying Engineering Graphics, Computer Software, and Measurement Instruments

TASK/COMPETENCY

3.2 Write a mathematical equation that is constant in units of measurement.

ASSESSMENT STANDARD

S3.2 Data is converted to one unit, and problem is solved correctly.

OBJECTIVES AND LEARNING ACTIVITIES

1. Convert various measurement units to the base standard of that unit.

2. Solve problems with constant measurement units.

CONCEPT AREA

3. Applying Engineering Graphics, Computer Software, and Measurement Instruments

TASK/COMPETENCY

3.3 Interpret drawings, using various systems of measurement.

ASSESSMENT STANDARD

S3.3 Two drawings, one using U.S. Customary Units and one using SI Units, are interpreted correctly with the aid of a conversion table.

OBJECTIVES AND LEARNING ACTIVITIES

1. Explain the U.S. Customary/American Engineering Systems of Units by drawing a descriptive geometry problem.
2. Use the SI Units of Measurement by drawing a descriptive geometry problem.
3. Use conversion tables to convert from one unit to another by converting SI Units of measurement in drawings to U.S. Customary Units.

CONCEPT AREA

3. Applying Engineering Graphics, Computer Software, and Measurement Instruments

TASK/COMPETENCY

3.4 Use precision measuring tools and instruments to lay out, measure, and inspect parts or products.

ASSESSMENT STANDARD

S3.4 Assigned product parts from a product manufacturing problem are laid out, measured, and inspected to within ±1 mm accuracy.

OBJECTIVES AND LEARNING ACTIVITIES

1. Identify precision measuring tools and instruments used to lay out, measure, and inspect parts or products.

2. Explain the tolerances accepted in the manufacture of various types of parts and products.

3. Demonstrate measurements necessary to make interchangeably fitting parts such as circles and rings.

4. Have students disassemble an existing product; measure the tolerances, using a micrometer; and record the differences in the fitted parts.

ERIC

CONCEPT AREA

3. Applying Engineering Graphics, Computer Software, and Measurement Instruments

TASK/COMPETENCY

3.5 Solve problems involving measurement of quantities of materials in both SI units and U.S. Customary Units.

ASSESSMENT STANDARD

S3.5 Assigned word problems are solved correctly.

OBJECTIVES AND LEARNING ACTIVITIES

1. Express correctly the appropriate prefix and symbol of each of the following units:
   One million kilograms
   One ten-thousandth of a meter
   One million newtons.

2. Write the following numbers, using the appropriate SI notation:

   One thousand
   Ten thousand
   Ten million
   One tenth (to two decimal places).

   Repeat the above, and use appropriate U.S. Customary notation.

3. Have students compute a certain material that costs $10/lbm by expressing the cost in dollars per kilogram.

4. Have students solve the following problem:

> It costs Acme Manufacturing $2.50 to produce a particular part, which weighs 4 kilograms. Phelps Supply orders a number of these parts, resulting in a shipment weighing 792 pounds. Acme charges $1.00 per kilogram shipping and handling fee and operates with a 30% profit factor. How many parts are in the shipment? How much will Phelps pay for the total shipment?

ERIC

CONCEPT AREA

3. Applying Engineering Graphics, Computer Software, and Measurement Instruments

TASK/COMPETENCY

3.6 Use engineering graphics and descriptive geometry in the solution of design problems.

ASSESSMENT STANDARD

S3.6 Assigned design problems are solved through correct application of engineering design graphics and descriptive geometry concepts.

OBJECTIVES AND LEARNING ACTIVITIES

1. Identify planes, objects, and line types with appropriate measurements.
2. Apply proper notations to the solutions of problems.
3. Apply the principles and concepts of descriptive geometry to the solution of problems.
4. Find the true length, slope, and bearing of a line.
5. Determine the true size and shape of surfaces.
6. Prepare and show transparencies from the *Descriptive Geometry Workbook:*

   "Plane Identification"
   "Normal Objects and Surfaces"
   "Inclined Objects and Surfaces"
   "Oblique Objects and Surfaces."

ERIC

INTRODUCTION TO ENGINEERING (8490)

CONCEPT AREA

3. Applying Engineering Graphics, Computer Software, and Measurement Instruments

TASK/COMPETENCY

3.7 Sketch objects to show orthographic and pictorial views.

ASSESSMENT STANDARD

S3.7 Object is sketched to show three orthographic views and the pictorial view in proportion as measured by the eye.

OBJECTIVES AND LEARNING ACTIVITIES

1. Demonstrate the techniques of sketching straight and curved lines.
2. List several applications of freehand sketching.
3. Demonstrate the techniques of proportioning.
4. Sketch the three principal orthographic views.
5. Sketch a pictorial view of single parts or models.
6. Construct three-dimensional models from orthographic drawings.

CONCEPT AREA

3. Applying Engineering Graphics, Computer Software, and Measurement Instruments

TASK/COMPETENCY

3.8 Use basic technical drawing instruments to draw orthographic and isometric projections.

ASSESSMENT STANDARD

S3.8 Three orthographic projections and an isometric projection of one object are drawn as instructed; basic technical drawing instruments are used correctly.

OBJECTIVES AND LEARNING ACTIVITIES

1. Demonstrate the techniques of drawing straight and curved lines.
2. Demonstrate the three views of a single object.
3. Demonstrate the angle of an isometric view of a single object.
4. Construct a three-dimensional model from an orthographic drawing.

CONCEPT AREA

3. Applying Engineering Graphics, Computer Software, and Measurement Instruments

TASK/COMPETENCY

3.9 Use appropriate methods to solve and report solutions of repetitive mathematical computations and observations of physical test data.

ASSESSMENT STANDARD

S3.9 Design problem is solved and solution is reported by use of graphs, empirical equations, mechanisms (kinematic representations), graphical mathematics, and nomography.

OBJECTIVES AND LEARNING ACTIVITIES

1. Describe the methods used prior to the computer age for expeditiously approximating the solution of repetitive mathematical computations (graphical mathematics and nomography).

2. Derive and use empirical equations to expand test data beyond that observable in the lab.

3. Select scales for graphs that will yield the best representation of the data to be communicated.

4. Program a computer to solve repetitive mathematical computations.

5. Use computer graphics to communicate test results.

ERIC

CONCEPT AREA

3. Applying Engineering Graphics, Computer Software, and Measurement Instruments

TASK/COMPETENCY

3.10 Use graphical vector analysis in the design process.

ASSESSMENT STANDARD

S3.10 Assigned vector analysis problem is solved correctly by use of both manual and computer graphics analyses.

OBJECTIVES AND LEARNING ACTIVITIES

1. Use engineering graphics to construct a space diagram accurately representing a system of forces.
2. Use computer graphics to construct a free body diagram accurately representing a system of forces.
3. Use an accurately constructed free body diagram to estimate unknown quantities in a system of forces.

INTRODUCTION TO ENGINEERING (8490)

CONCEPT AREA

3. Applying Engineering Graphics, Computer Software, and Measurement Instruments

TASK/COMPETENCY

3.11 Build models that illustrate the principal classes of physical models.

ASSESSMENT STANDARD

S3.11 Assigned design problem is solved; solution is illustrated by proof of principle, scale, experimental, and prototype models constructed according to standards provided.

OBJECTIVES AND LEARNING ACTIVITIES

1. Illustrate the "proof of principle model" by designing and constructing a minimally operative model.
2. Illustrate the "scale model" by designing and constructing dimensionally enlarged and shrunken models.
3. Illustrate the "experimental model" by designing and constructing a functioning model to be tested.
4. Illustrate the "prototype model" by designing and constructing a full scale working model in a complete form.
5. Refer to p. 244 in Bailey for further information.

ERIC

CONCEPT AREA

3. Applying Engineering Graphics, Computer Software, and Measurement Instruments

TASK/COMPETENCY

3.12 Use computer-aided design (CAD) software to prepare drawings.

ASSESSMENT STANDARD

S3.12 Assigned drawings are produced accurately by correct use of software.

OBJECTIVES AND LEARNING ACTIVITIES

1. Follow the computer commands to prepare a drawing by using the menu to change functions.

2. Demonstrate the following functions:

   - Enlarge or reduce a drawing by zooming in and out.
   - Pan a drawing by moving it across the screen in any direction.
   - Locate and draw a circle by placing the pointer to the circle's center.
   - Draw lines.
   - Dimension drawings.

CONCEPT AREA

3. Applying Engineering Graphics, Computer Software, and Measurement Instruments

TASK/COMPETENCY

3.13 Use computer-aided manufacturing (CAM) software to simulate a manufacturing problem.

ASSESSMENT STANDARD

S3.13 Assigned manufacturing problem is solved correctly by correct use of CAM software.

OBJECTIVES AND LEARNING ACTIVITIES

1. Introduce students to CAM with computer software or video.
   - Demonstrate the mathematical concept of rotation by explaining what it means to rotate an object 45°, 90°, and 135° in order to use *The Factory* software.
   - Assign individual students to work on computer at different times. Suggest all start on Test A.
   - Have students use *The Factory* Product Sheet to design their own product on paper, then try to produce it with *The Factory* program.
   - Investigate other computer programs and simulations.
2. Load software into the computer.
3. Input data or information where appropriate.
4. Observe and check results/output of computer program.
5. Identify uses and benefits of CAM.
6. Arrange for students to visit new industries that use CAM systems.

ERIC

RESOURCES FOR

3. APPLYING ENGINEERING GRAPHICS, COMPUTER SOFTWARE, AND MEASUREMENT INSTRUMENTS

EQUIPMENT AND MATERIALS

3.1 Math problems
Computer with applicable software
Scientific calculator

3.2 Math problems
Scientific calculator

3.3 Drawings using different systems of measurement
Conversion tables

3.4 Precision measuring tools and instruments
Product to disassemble

3.5 Word problems
Scientific calculator

3.6 Design problems
Overhead projector

3.7 Drawing instruments and supplies
Modeling materials

3.8 Drawing instruments and supplies

3.9 Design problems
Computer with applicable software
Scientific calculator

3.10 Vector analysis problems
Computer with applicable software
Scientific calculator

3.11 Design problems
Computer with applicable software
Modeling materials

3.12 Computer with applicable CAD software

ERIC

3.13 Manufacturing problems
Computer with applicable manufacturing simulation package

REFERENCES

Descriptive Geometry Workbook. Alkazin. Prakken Publications, Inc.
Disciplined Creativity for Engineering. Bailey. Ann Arbor Science, Butterwork Publishers.
Physics for Technology. Betts. Prentice-Hall.
"Fundamentals of Spatial Relationships," *Engineering Design Graphics.* Earle. Addison-Wesley.
"Basic Descriptive Geometry," *Mechanical Drawing.* French, et al. McGraw-Hill.
"Practical Descriptive Geometry," *Engineering Technical Drafting.*
"Points and Lines and Plane Surfaces," *Technical Descriptive Geometry.* Wellman.

AUDIOVISUAL MATERIALS

3.1 Software: *Scientific Measurements.* Micro Learningware, Highway 66 S., Box 307, Mankato, MN 56002-0307.

3.6 Instructor-prepared transparencies from *Descriptive Geometry Workbook:*
"Plane Identification," p. 3
"Normal Objects and Surfaces," p. 7
"Inclined Objects and Surfaces," p. 8
"Oblique Objects and Surfaces," p. 9.

CONCEPT AREA

4. CITING THE CONTRIBUTIONS OF ENGINEERING IN HISTORY

ERIC

CONCEPT AREA

4. Citing the Contributions of Engineering in History

TASK/COMPETENCY

4.1 Explore the history of engineering.

ASSESSMENT STANDARD

S4.1 Major engineering accomplishments from the beginning of civilization to the present day are cited accurately according to printed or multimedia resources used.

OBJECTIVES AND LEARNING ACTIVITIES

1. Identify examples of engineering feats.
2. Show a variety of movies, slides, and videos (refer to Appendix A) such as *Out of the Fiery Furnace* and *It Couldn't Be Done.*
3. Prepare a timeline, using cards or computer software, that shows technological advances through the ages.
4. Place early devices in the timeline by using photocopied pictures from magazines and books.

ERIC

CONCEPT AREA

4. Citing the Contributions of Engineering in History

TASK/COMPETENCY

4.2 Conduct research on an engineering achievement.

ASSESSMENT STANDARD

S4.2 Research on an engineering achievement from a selected historical time range is contained in a written presentation report, which must be rated acceptable according to instructor-prepared specifications.

OBJECTIVES AND LEARNING ACTIVITIES

1. Select an engineering achievement from the assigned historical time range.
2. Use library references, textbooks, and electronic resources for research.
3. Make a sketch of a model to illustrate the selected achievement, and list materials needed for construction of the model. Review Task/Competency 3.11 on model building.
4. Identify tools and machines needed for model construction, and list applicable safety rules. See Task/Competency 3.11 on model building.
5. Make an outline for a brief written report.
6. Write a brief report on the research.
7. Combine the written report, sketch(es), and lists of tools and materials into a presentation report.
8. Review written communication skills with students whose reports do not meet specifications.

ERIC

CONCEPT AREA

4. Citing the Contributions of Engineering in History

TASK/COMPETENCY

4.3 Deliver a short oral briefing to explain a technical device or engineering achievement.

ASSESSMENT STANDARD

S4.3 Briefing, accompanied by model or display, delivered, cites problem(s) solved by a device or achievement; it must be rated acceptable according to seminar specifications.

OBJECTIVES AND LEARNING ACTIVITIES

1. Report the topic selected for presentation in an early class seminar.
2. Construct a model or display of the device or achievement.
3. Prepare oral report and practice delivery with another student or a family member.
4. Have students illustrate with posters and other display elements the contributions or impact of a technical/engineering achievement.
5. Describe some planned and unplanned effects of the engineering achievement.

RESOURCES FOR

4. CITING THE CONTRIBUTIONS OF ENGINEERING IN HISTORY

EQUIPMENT AND MATERIALS

4.1 Videotape player, film projector
Computer with applicable software

4.2 Report specifications
Sketching supplies
Modeling materials
Computer with word processing and graphics software

4.3 Seminar specifications
Modeling or display materials
Computer for multimedia presentations

REFERENCES

Disciplined Creativity for Engineers. Bailey. Ann Arbor Science, Butterwork Publishers.
Careers in Engineering and Technology. Beakley. Macmillan Publications, Inc.

AUDIOVISUAL MATERIALS

4.1 Films: *It Couldn't Be Done.* University of Illinois Film Library, 1325 S. Oak Street, Champaign, IL 61820.
Out of the Fiery Furnace. University of Illinois Film Library, 1325 S. Oak Street, Champaign, IL 61820.

CONCEPT AREA

5. WORKING WITH THE FUNDAMENTALS OF PROBLEM SOLVING

CONCEPT AREA

5. Working with the Fundamentals of Problem Solving

TASK/COMPETENCY

5.1 Apply steps in the problem-solving method or process (individual activity).

ASSESSMENT STANDARD

S5.1 Steps in the problem-solving method are applied to construction of a model bridge that tests to a load efficiency of .49, using the formula

$$E = \frac{FW \text{ (failure weight)}}{L \text{ (length of wood used)}}.$$

OBJECTIVES AND LEARNING ACTIVITIES

1. Provide illustrations of different types of bridge from photographs, slides, and magazines in order to create interest in bridge design and engineering. Show film *They Said It Couldn't Be Done*. Introduce students to state and national TSA Structural Engineering (Bridge Building) Contest, and provide entry forms.

2. Describe different bridge types: covered, arch, truss, and suspended.

3. Define stress, shear strength, span, load, elastic, and fracture, and lead a discussion on the reasons for bridge failure.

4. Design a bridge to withstand a given weight, and sketch the design.

5. Construct and test bridge designs; use computer software to analyze bridge design and efficiency.

6. Refine design, and construct a model bridge.

7. Test model bridge, and record data.

8. Calculate efficiency, using formula $E = \frac{\text{Failure Weight}}{\text{Length}}$.

9. Compare designs and models with those of others.

10. Demonstrate readiness to revise conclusions in light of research.

ERIC

CONCEPT AREA

5. Working with the Fundamentals of Problem Solving

TASK/COMPETENCY

5.2 Function as an engineer or technologist in group problem-solving activities.

ASSESSMENT STANDARD

S5.2 Functions of an engineer or technologist, including library and laboratory investigation, recordkeeping, and reporting, are performed during problem-solving assignment and recorded in a log.

OBJECTIVES AND LEARNING ACTIVITIES

1. Investigate the work of civil engineers by using libraries and research techniques (see Concept Area 10).
2. Cite engineering standards, codes, and graphic techniques.
3. Record data obtained from investigations and tests.
4. Use spoken, graphic, and written communications to report results of problem solving.
5. Enter activities in a log as they are performed (see Appendix F for form).
6. Show videotapes from the *Search for Solutions* series: "Adaptation," "Trial and Error," and "Context."

ERIC

CONCEPT AREA

5. Working with the Fundamentals of Problem Solving

TASK/COMPETENCY

5.3 Apply mathematical formulas to problems and activities.

ASSESSMENT STANDARD

S5.3 Word problems are solved correctly, using appropriate mathematical formulas.

OBJECTIVES AND LEARNING ACTIVITIES

1. Describe the modeling process used by engineers to conceptualize a system.
2. Identify a mathematical model as used to analyze and revise a particular system design.
3. Illustrate the concept of system input and output with sketches and equations.

ERIC

CONCEPT AREA

5. Working with the Fundamentals of Problem Solving

TASK/COMPETENCY

5.4 Perform keyboard functions on a scientific, hand-held calculator.

ASSESSMENT STANDARD

S5.4 Problems are solved by use of correct keyboard functions.

OBJECTIVES AND LEARNING ACTIVITIES

1. Apply basic logic systems used in calculators to press keys in order.
2. Use special keys on calculator to perform arithmetic functions.
3. Show students how to perform calculations that result in a word, upside down, on the calculator readout.
4. Use special functions such as roots and powers, reciprocals, factorials, percentages, trig functions, degrees, and radical conversions.
5. Use memory function.
6. Estimate answers to calculations.

CONCEPT AREA

5. Working with the Fundamentals of Problem Solving

TASK/COMPETENCY

5.5 Use computer application programs to solve problems.

ASSESSMENT STANDARD

S5.5 Assigned problems are solved correctly by use of appropriate application program, resulting in a printout of accurate data for each problem.

OBJECTIVES AND LEARNING ACTIVITIES

1. Identify the components of a computer system such as the processor, monitor, keyboard, disk drives, and printer.
2. Follow procedures to turn on, boot up software, and make menu selection.
3. Describe computer and software commands.
4. Use computer for numerical calculations.
5. Select commands to manipulate data and obtain information.
6. Program a computer to accept and analyze data for a specific/unique problem.

RESOURCES FOR

5. WORKING WITH THE FUNDAMENTALS OF PROBLEM SOLVING

EQUIPMENT AND MATERIALS

5.1 Bridge design and construction materials
- Graph paper
- 1/8″ x 1/8″ balsa
- Model glue
- Ruler(12″)
- Testing apparatus
- Illustrations of bridges of various types
- Calculators
- Straight pins
- Cutting board
- Utility knife or single-edge razor blades

5.2 Recordkeeping or log forms
Videotape player

5.3, 5.4 Scientific calculator and related materials
Instructor-provided problems

5.5 Computer hardware and software for bridge/truss analysis
Instructor-provided problems

REFERENCES

Structural Engineering (Bridge Building) Contest Rules. TSA Competitive Events Handbook.
Calculator Activities. National Council of Teachers of Mathematics.
Careers in Engineering and Technology. Beakley. Macmillan Publications, Inc.
Disciplined Creativity for Engineers. Bailey. Ann Arbor Science, Butterwork Publishers.
Problems in Search of a Calculator. National Coordinating Center for Curriculum Development, College of Engineering and Applied Sciences, SUNY at Stony Brook, Stony Brook, NY 11794.
Computer Interfaces and Software. Vernier Sóftware, 2920 S. W. 89th Street, Portland, Oregon, 97220.

AUDIOVISUAL MATERIALS

5.1 Film: *They Said It Couldn't Be Done*. ($27 rental fee) University of Illinois Film Library, 1325 S. Oak Street, Champaign, IL 61820.

5.2 Videotape: *The Search for Solutions* series. Phillips Petroleum Company, C-25 Philips Building, Bartlesville, OK 74004.

5.1-5.5 Software: *Bridge Builder Software* for IBM or Macintosh. #ICS200W from Modern School Supply, P.O. Box 958, Hartford, CT 06143.

CONCEPT AREA

6. ANALYZING THE SCIENCE AND PROPERTIES OF MATERIALS

INTRODUCTION TO ENGINEERING (8490)

CONCEPT AREA

6. Analyzing the Science and Properties of Materials

TASK/COMPETENCY

6.1 Describe the physical and chemical properties of engineering materials in terms of their internal structure.

ASSESSMENT STANDARD

S6.1 Description must include at least six properties with definitions.

OBJECTIVES AND LEARNING ACTIVITIES

1. Explain the atomic and molecular structure of various metals and other materials.
2. Classify samples of materials into these family groups: metallic, polymeric, ceramic, and composites.
3. Define the term *mechanical property* and give examples.
4. Define the term *chemical property* and give examples.

ERIC

CONCEPT AREA

6. Analyzing the Science and Properties of Materials

TASK/COMPETENCY

6.2 Determine the properties of materials, using tools and laboratory apparatus and equipment.

ASSESSMENT STANDARD

S6.2 Mechanical and chemical properties of each material are determined according to instructor-provided test procedures. Safety rules for use of tools and laboratory apparatus and equipment must be followed.

OBJECTIVES AND LEARNING ACTIVITIES

1. Define and explain these properties: *strength, ductility, hardness,* and *fatigue strength*.
2. Identify the types of stress that can be applied to materials.
3. Follow safety rules in use of chemicals, tools, and equipment.
4. Conduct tests to measure tensile strength, elasticity, torsional strength, hardness, and compression strength.
5. Set up chemical tests, using proper eye protection.
6. Design and build or modify testing devices needed to test safely for a specific property.
   - Make a specific gravity test device from a tall glass cylinder.
   - Construct a rebound hardness tester to determine relative hardness of different steels, aluminum, copper, or other metals.

INTRODUCTION TO ENGINEERING (8490)

CONCEPT AREA

6. Analyzing the Science and Properties of Materials

TASK/COMPETENCY

6.3 Report test results in a written report.

ASSESSMENT STANDARD

S6.3 Written report shows data collected and describes results of assigned laboratory tests; report conforms to instructor-provided guidelines for content and style.

OBJECTIVES AND LEARNING ACTIVITIES

1. Prepare charts to record data on each test to be conducted.
2. Record data in accurate manner after each material is tested.
3. Prepare charts or graphs to show data collected and results of tests.
4. Use computer software where appropriate.
5. Write reports on results of tests by showing collected data in different ways.

CONCEPT AREA

6. Analyzing the Science and Properties of Materials

TASK/COMPETENCY

6.4 Identify causes of failure in materials and procedures used to prevent such failures.

ASSESSMENT STANDARD

S6.4 Causes and preventive procedures of assigned examples of materials failure are identified.

OBJECTIVES AND LEARNING ACTIVITIES

1. Define the terms *fatigue, stress,* and *strain* by interpreting testing information.
2. Define the terms *creep, elasticity, yield,* and *tensile.*
3. Direct a discussion of the failure of sample products that have broken.
4. List the properties of materials, and describe the good and poor characteristics of each material for specific uses.
5. Explain ways to prevent corrosion and breakage and to improve strength of objects.
6. Calculate mechanical strength of materials, using problems in *Introduction to Engineering* by Blotter.

CONCEPT AREA

6. Analyzing the Science and Properties of Materials

TASK/COMPETENCY

6.5 Explain the concept of supply and demand as it relates to materials in short supply.

ASSESSMENT STANDARD

S6.5 Explanation must include examples of specific materials, the impact of their shortages, and possible solutions to the problems presented.

OBJECTIVES AND LEARNING ACTIVITIES

1. List materials used primarily in these technological systems: communications, construction, manufacturing, and production.
2. Identify reasons for the scarcity of certain materials.
3. Explain how the need to reduce weight has led to the development of new materials.
4. Describe the impact of energy supply and demand on society and individuals.
5. Explain the need for recycling of natural materials.
6. List examples of changes in technology that have come about due to shortages of various materials.
7. Describe the role of the consumer in control of shortages.

CONCEPT AREA

6. Analyzing the Science and Properties of Materials

TASK/COMPETENCY

6.6 Experiment with processes used with metal, wood, polymeric, ceramic, and composite materials and adhesives

ASSESSMENT STANDARD

S6.6 Experiments must be performed safely according to instructor-provided demonstrations or handouts.

OBJECTIVES AND LEARNING ACTIVITIES

Note: Demonstration and lecture precede each of the following laboratory activities.

1. Process metallic materials.
2. Process wood materials.
3. Process ceramic materials.
4. Process composite materials.
5. Assemble materials, using adhesives appropriate to material and process selected.
6. Demonstrate safe procedures in use of tools, equipment, and materials.

RESOURCES FOR

6. ANALYZING THE SCIENCE AND PROPERTIES OF MATERIALS

EQUIPMENT AND MATERIALS

6.1 Film projector

6.2 Mohs Hardness Test Kit
Tensile testing machine
Materials for making specific gravity and rebound hardness test devices
Materials for testing device construction or modifications

6.3 Report forms, report guidelines
Materials for graph/chart construction
Computer with spreadsheet software

6.4 Samples of broken products
Examples for processing metal, wood, polymer, ceramic, and adhesive materials
Scientific calculator

6.5 Materials, tools, and machines for processing metal, wood, polymer, ceramic, and adhesive materials

REFERENCES

Instructional Tasks/Competencies for Materials and Processes Technology. Technology Education Service, Virginia Department of Education.
Introduction to Engineering. Chapter 5. Blotter. John Wiley & Sons.
"Ceramic Materials." *The Technology Teacher*, May/June 1986.
"Developing Material Testing Equipment for Specific Needs." *The Technology Teacher*, May/June 1985.
"New Materials." *The Technology Teacher*, May/June 1986.
"Composite Materials." *The Technology Teacher*, March 1986.
"Nature and Properties of Engineering Materials." *The Technology Teacher*, December 1985.

AUDIOVISUAL MATERIALS

6.1 Film: *The Original Recyclers #24974* (10 min.). Modern Talking Pictures, 5000 Park St. North, St. Petersburg, FL 33709.

Videotape: *Metals and Alloys* (11 min.). Lucerne Media, 37 Ground Pine Rd., Morris Plains, NJ 07950.

CONCEPT AREA

7. WORKING WITH DIFFERENT PROCESSES TO SOLVE PROBLEMS

Transparency Master

CONCEPT AREA

7. Working with Different Processes to Solve Problems

TASK/COMPETENCY

7.1 Work as a team member, applying various methods to solve problems.

ASSESSMENT STANDARD

S7.1 Scientific, engineering design, and other generalized problem-solving method must be applied to the assigned problem; problem solution must meet the instructor's criteria for creativity or degree of change in design.

OBJECTIVES AND LEARNING ACTIVITIES

1. Divide class into small teams, and assign each team a problem involving the redesign or testing of a technical device (bridge, mousetrap car, glider, beam compass, etc.)
2. Identify sources of information for problem solving.
3. Review steps of various problem-solving methods, and compare the engineering design method to other procedures. Use Transparency 7.1 to review problem-solving steps.
4. Invite an engineer to discuss and demonstrate the engineering design process.
5. Decide on each team member's responsibilities and activities.
6. Select the best method for solving a problem or for redesigning and testing the device.
7. Maintain a log of activities.

CONCEPT AREA

7. Working with Different Processes to Solve Problems

TASK/COMPETENCY

7.2 Apply a variety of materials and technical processes to solve an assigned problem to redesign or test a device.

ASSESSMENT STANDARD

S7.2 A variety of materials and technical processes must be applied to the redesign or testing of a device; redesign must result in an increased use of the device and must meet testing specifications provided by the instructor.

OBJECTIVES AND LEARNING ACTIVITIES

1. Divide the class into small teams, and assign each team a problem involving redesign of a technical device, using different materials or modeling packages.
2. List the essential steps in the problem-solving process.
3. Review physical properties of various available materials.
4. Show the movie *The Flight of the Gossamer Condor* to stimulate creativity and demonstrate the value of perseverance.
5. Construct a model of a redesigned device, or use a CAD program.
6. Test solution to problem.
7. Analyze factors affecting performance of device, and recommend alternate solutions to the problem, if necessary.
8. Maintain a log of activities.

CONCEPT AREA

7. Working with Different Processes to Solve Problems

TASK/COMPETENCY

7.3 Use mathematical symbols to express a relationship between two or more variables.

ASSESSMENT STANDARD

S7.3 Mathematical symbols must be used correctly.

OBJECTIVES AND LEARNING ACTIVITIES

1. Apply mathematical formulas to problems and activities. (See Task 5.3.)
2. Perform the keyboard functions on a scientific hand-held calculator. (See Task 5.4.)
3. Input data into computers and applications programs for problem solving. (See Task 5.5.)
4. Use data to estimate costs to finance a project or contract related to a design problem.
5. Use computer software to access information about technology.

PROBLEM-SOLVING PROCESS

1. Accept the situation.
2. Analyze what is involved.
3. Define the problem.
4. Ideate solutions.
5. Select best design.
6. Implement decision.
7. Evaluate results.
8. Recycle if required.

RESOURCES FOR

7. WORKING WITH DIFFERENT PROCESSES TO SOLVE PROBLEMS

EQUIPMENT AND MATERIALS

7.1 Problems and criteria for solutions
Scientific calculator
Computer and applicable software

7.2 Testing specifications
Scientific calculator
Computer, applicable software, and control interfaces
Model construction materials such as Fischertechnik
Drafting equipment
Film projector

7.3 Scientific calculator
Computer and applicable software

REFERENCES

Disciplined Creativity for Engineers. Bailey. Ann Arbor Science, Butterworth Publishers.
Engineering Materials Technology. Jacobs and Kilduff. Prentice-Hall.
Introduction to Engineering, Chapter 5. Blotter. John Wiley & Sons.
Programmable Controllers. U. S. Automation, Inc., P.O. Box 14874, Lenexa, KS 66215-2410.

AUDIOVISUAL MATERIALS

7.1 Transparency 7.1: *Problem-Solving Process.*

7.2 Movie: *The Flight of the Gossamer Condor*. ($19 rental fee) University of Illinois Film Library, 1325 S. Oak Street, Champaign, IL 61820.

7.3 Software: *Rapid Access Technology Software*. Shopware Education Systems, 101 Hill Road, Aberdeen, WA 98520.

ERIC

CONCEPT AREA

8. COMMUNICATING TECHNICAL INFORMATION

CONCEPT AREA

8. Communicating Technical Information

TASK/COMPETENCY

8.1 Explain the importance of communication between engineers and their clients.

ASSESSMENT STANDARD

S8.1 Explanation must identify ways that engineering data can be communicated and possible effects of a lack of communication on the quality and completion of a project.

OBJECTIVES AND LEARNING ACTIVITIES

1. List times when communication is extremely important to engineering work.
2. Explain some of the ways communication takes place.
3. Invite an engineer to discuss effective communication among engineers and between engineers and their clients.
4. Explain the different ways an engineer must be able to communicate with both technical and nontechnical people. Have students examine their bridge-building logs and discuss ways that this information can be presented to classmates and to a nontechnical audience.
5. Deliver a short oral briefing which explains a technical device. (See Task 4.3.)
6. Use mathematical symbols to express a relationship between two or more variables. (See Task 7.3.)
7. Describe types of drawings used by engineers.
8. List computer applications used by engineers to communicate.
9. Have students write letters to request technical information for problem-solving and design teams.
10. Have students contact engineers on the Internet and request information related to a design problem.

ERIC

CONCEPT AREA

8. Communicating Technical Information

TASK/COMPETENCY

8.2 Write a proposal for an engineering project.

ASSESSMENT STANDARD

S8.2 Proposal includes all components identified in instructor-provided guidelines and must be rated acceptable according to the five Cs of effective technical writing.

OBJECTIVES AND LEARNING ACTIVITIES

1. Define *engineering proposal.*
2. State the components of a proposal, and review proposals written by others.
3. Identify and explain the five Cs of effective technical writing: completeness, correctness, conciseness, clarity, and consideration (of the intended audience).
4. Identify specifications to be taken in the engineering project.
5. Identify expected results.
6. State who will use the results and when.

CONCEPT AREA

8. Communicating Technical Information

TASK/COMPETENCY

8.3 Write a technical report for an engineering activity.

ASSESSMENT STANDARD

S8.3 Written technical report meets all criteria for TSA Research and Technical Report Writing Contest.

OBJECTIVES AND LEARNING ACTIVITIES

1. Show film *Reporting and Briefing* to introduce or reinforce technical writing standards.
2. Explain proper writing style for an engineering report.
3. Identify the elements required for an effective engineering report.
4. Display samples of effective technical reports, and have students point out both content and style elements.
5. Interpret rules of the TSA Research and Technical Report Writing Contest.
6. Construct outlines that illustrate content and chronology of reports in the proper form.
7. Ask students' English teachers to evaluate outlines and reports in terms of style and construction.

ERIC

CONCEPT AREA

8. Communicating Technical Information

TASK/COMPETENCY

8.4 Produce technical information, using a computer word processing package.

ASSESSMENT STANDARD

S8.4 Printout must be rated acceptable according to instructor's specifications, with maximum of two errors per page.

OBJECTIVES AND LEARNING ACTIVITIES

1. Explain steps to boot the computer.
2. Select menu commands for the type of page to be keyed and standards to be followed.
3. Enter all written information.
4. Enter all engineering data.
5. Use commands to modify file and information.
6. Print out information.
7. Proofread and revise information in the computer.

CONCEPT AREA

8. Communicating Technical Information

TASK/COMPETENCY

8.5 Present technical information in an oral report.

ASSESSMENT STANDARD

S8.5 Presentation includes use of visual aids and meets all criteria specified in class-developed guidelines.

OBJECTIVES AND LEARNING ACTIVITIES

1. List techniques that contribute to an effective oral presentation of technical information.
2. Identify factors that detract from the effectiveness of an oral presentation.
3. List examples of visual aids that illustrate technical information, such as models and engineering graphics.
4. Explain the importance of visual aids in an oral presentation.
5. Describe techniques for presenting information using computers and multimedia technologies.
6. Identify content components of an oral report on engineering problem solution.
7. Help students develop criteria for rating oral reports.

RESOURCES FOR

8. COMMUNICATING TECHNICAL INFORMATION

EQUIPMENT AND MATERIALS

8.1 Students' bridge-building logs
Telecomputing hardware and software

8.2 Instructor-prepared guidelines and checklist

8.3 TSA Research and Technical Report Writing Contest rules
Sample technical reports
Film projector

8.4 Computer with word-processing software
Report specifications

8.5 Materials for development and presentation of visual aids
Class-developed guidelines for oral reports

REFERENCES

Rules and Criteria for Virginia's Competitive Events. Technology Education Service, Virginia Department of Education.
Curricular Resources Guide. TSA National Office, Reston, VA, 1994.

CONCEPT AREA

9. USING THE DESIGN PROCESS TO IMPROVE A DEVICE OR SYSTEM

ERIC

CONCEPT AREA

9. Using the Design Process to Improve a Device or System

TASK/COMPETENCY

9.1 Select a problem or project for improvement.

ASSESSMENT STANDARD

S9.1 One to five ideas are submitted to modify a project in quality, performance, or appearance; final selection must be approved by the instructor.

OBJECTIVES AND LEARNING ACTIVITIES

1. Examine the problem and determine other applications of the idea.
2. Examine the problem and determine whether it can be combined with another idea.
3. List the disadvantages of the problem.
4. List the advantages of the problem.
    - Have students brainstorm, then list five "highly desirable" alterations that would encourage personal travel by rail.
    - Have students describe some design that, according to personal opinion, defies improvement.
    - Show videotape "Trial and Error" from *The Search for Solutions* series.
5. Describe the effects of a technological development on people, society, and the environment.
6. Demonstrate software related to product testing, such as "Guilty or Innocent?"

CONCEPT AREA

9. Using the Design Process to Improve a Device or System

TASK/COMPETENCY

9.2 Use the steps in the design process to improve a product.

ASSESSMENT STANDARD

S9.2 Product is improved according to instructor-provided criteria; steps in the design process are recorded as each is completed.

OBJECTIVES AND LEARNING ACTIVITIES

1. List in order the essential steps in the design process.
2. Formulate the problem statement.
3. Conduct systematic research (including library references, interviews, and written requests for information) to collect information on the problem.
4. Use a method such as "brainstorming" to generate ideas.
5. Explain the different ways that a solution can be modeled.
6. Use a systematic approach to evaluate possible problem solutions.
7. Design and conduct experiments to test problem solutions.
8. Communicate the solution of a problem effectively.
9. Schedule report/demonstration days for students to brief class and visitors on problems and solutions.

CONCEPT AREA

9. Using the Design Process to Improve a Device or System

TASK/COMPETENCY

9.3 Build a model of the improved product.

ASSESSMENT STANDARD

S9.3 Model must be rated acceptable according to a checklist based on class-developed standards.

OBJECTIVES AND LEARNING ACTIVITIES

1. Review the principal classes of physical models (Task 3.11).

2. Help students develop standards of acceptability for models.

3. Select and gather materials and supplies, or use modeling kits/packages for model construction.

4. Apply safety rules to use of lab equipment and materials.

5. Test the model as necessary.

ERIC

CONCEPT AREA

9. Using the Design Process to Improve a Device or System

TASK/COMPETENCY

9.4 Analyze the potential impact of the improved product.

ASSESSMENT STANDARD

S9.4 Predicted effects of improvement are defined and explained as benefits or liabilities for individuals or groups who use the product, for the environment, and for society.

OBJECTIVES AND LEARNING ACTIVITIES

1. Use a technology assessment process to prepare an impact study.
2. Create a relevance tree to study the effects of a new product.
3. Chart the "desired" and "undesired" outcomes in a list for comparison.
4. Predict future impacts of the product.
5. Interview people to learn their predictions regarding a new product.

ERIC

RESOURCES FOR

9. USING THE DESIGN PROCESS TO IMPROVE A DEVICE OR SYSTEM

EQUIPMENT AND MATERIALS

9.1 Videotape player

9.2 Products for improvement
Materials for experiments
Log or recording form

9.3 Model construction materials

9.4 Case examples of impact studies or technology assessments

REFERENCES

Careers in Engineering and Technology. Beakley. Macmillan Publications, Inc.
Disciplined Creativity for Engineers. Bailey. Ann Arbor Science, Butterwork Publishers.

AUDIOVISUAL MATERIALS

9.1 Videotape: "Trial and Error." *The Search for Solutions* series. Phillips Petroleum Company, C-25 Phillips Building, Bartlesville, OK 74004.

9.1 Software: "Guilty or Innocent?" *You Be a Car Crash Expert* (Hypercard Stack). AAPT, 5112 Berwyn Road, College Park, MD 20740-4100.

9.3 Electronics Kit: Unilab, Inc., 1604 Walker Lake Road, Mansfield, OH 44906.

CONCEPT AREA

10. GATHERING INFORMATION ABOUT PROBLEMS AND SOLUTIONS

CONCEPT AREA

10. Gathering Information About Problems and Solutions

TASK/COMPETENCY

10.1 Identify references found in a technical library.

ASSESSMENT STANDARD

S10.1 Three appropriate resources from a local, school, or on-line library are named for an assigned topic.

OBJECTIVES AND LEARNING ACTIVITIES

1. Identify the three basic sections of a typical library.
2. List the categories of technical references.
3. List three technical or scientific journals held in the library.
4. Synthesize information from multiple sources to prepare a resource paper.
5. Demonstrate proficiency in information-gathering skills.
6. Access information on a CD-ROM database, videodisk, or on-line database.
7. Identify alternative systems for organizing and gaining access to information.
8. Develop guidelines for evaluating sources of information.

ERIC

CONCEPT AREA

10. Gathering Information About Problems and Solutions

TASK/COMPETENCY

10.2 Identify publications used by engineers and the source of each.

ASSESSMENT STANDARD

S10.2 At least three publications appropriate for research of an assigned topic are identified, along with information on how to obtain each publication.

OBJECTIVES AND LEARNING ACTIVITIES

1. Name two engineering societies from which publications may be obtained.
2. Locate and interpret information given in manufacturers' catalogs.
3. Identify local libraries, institutions, and engineering firms as possible sources of information.
4. Compile lists of engineering periodicals, reference books, and dictionaries.
5. Assign various topics for practice in gathering scientific or technical information. Examples:
    - Find an article on the subject of "composite materials" published in an engineering journal within the last six months.
    - Find the manufacturer's catalog for a company that produces ball bearings, and list the source.
    - Find the definition and an illustration of a *magnetohydrodynamic generator*, and list the source.
6. Explain the use of computer databases to locate information for research.

CONCEPT AREA

10. Gathering Information About Problems and Solutions

TASK/COMPETENCY

10.3 List and define the six legal categories of patents.

ASSESSMENT STANDARD

S10.3 *Process patent, machine patent, method of manufacturing patent, composition patent, living plant patent,* and *design patent* are listed and defined accurately according to references used.

OBJECTIVES AND LEARNING ACTIVITIES

1. Define *patent, invention, trademark,* and *copyright,* and identify the types of products or processes to which each applies.

2. Explain how a manufacturing process may be modified to qualify for a new patent.

3. Cite an example of an innovation to an existing machine that was or could be patented by its inventor.

4. Identify computer databases that provide information on the current status of U. S. patents.

5. Have students visit or write to the following for information on databases dealing with government sponsored research, development, and engineering reports: National Technical Information Service, U. S. Department of Commerce, Operations Division, Springfield, VA 22151.

ERIC

CONCEPT AREA

10. Gathering Information About Problems and Solutions

TASK/COMPETENCY

10.4 Explain how patents are obtained.

ASSESSMENT STANDARD

S10.4 Explanation consists of making a working model of a device in one patent category, simulating the patent process, and documenting each step in the process.

OBJECTIVES AND LEARNING ACTIVITIES

1. List the steps in a patent search.
2. Explain the requirements of a patent search.
3. Identify sources of information for a patent search, including summaries, drawings, abstracts, microfilms, encyclopedias, and databases.
4. Determine the procedure for applying for a patent, and explain any attendant costs.
5. Contact a patent counsel through a NASA research center or private corporation for information.
6. Identify the nine components of a patent.
7. Obtain a copy of a patent from U. S. Patent Office, local library, or corporation for student review.
8. Determine whether patents can be transferred or inherited.
9. Describe the difference between a patent lawyer and a patent agent.
10. Complete filing application procedures.
11. Ask engineers on the advisory committee to validate the uniqueness of the device or process that would qualify it for a patent.
12. Read or review literature or videos about inventors and their inventions.

CONCEPT AREA

10. Gathering Information About Problems and Solutions

TASK/COMPETENCY

10.5 Describe how patents protect the inventor.

ASSESSMENT STANDARD

S10.5 Description presents a patent and explains its grant for sole manufacture, use, or sale of the invention.

OBJECTIVES AND LEARNING ACTIVITIES

1. Determine the rights of inventors who work for corporations and compare them with the rights of authors who write work for hire.

2. Describe how copyrights protect authors and publishers.

3. Explain the unique features of an invention that qualified it for patent.

4. Explain the time period granted by a patent for protecting an invention.

ERIC

RESOURCES FOR

10. USING THE DESIGN PROCESS TO IMPROVE A DEVICE OR SYSTEM

EQUIPMENT AND MATERIALS

10.1 Computer with CD-ROM

10.4 Sample patent
Patent application documents
Model construction materials

REFERENCES

Eddings, J. *How the Internet Works.* Emeryville, CA: Ziff-Davis Press, 1994.
SME directories, Virginia Department of Highways and Transportation offices, and U. S. Patent office publications. See Appendix A, Part VII.
Case studies. See Appendix E, Parts I and II.

AUDIOVISUAL MATERIALS

10.1 Film: *Effective Writing, Research Skills,* or *Your Study Skills—Using Reference Materials.* Division of Instructional Media and Technology, Virginia Department of Education.

10.4 Video: *Technology's Price* (25 min.). National Geographic Society, Education Services, P. O. Box 98019, Washington, D. C. 20090-8019.

CONCEPT AREA

11. MANAGING THE TEAM CONCEPT OF ENGINEERING DESIGN

Transparency Master

CONCEPT AREA

11. Managing the Team Concept of Engineering Design

TASK/COMPETENCY

11.1 Explain the importance of teamwork in problem solving.

ASSESSMENT STANDARD

S11.1 Explanation includes the following:
- a description of the functions of each team member
- definitions of at least two strategies for group problem solving and the benefits and disadvantages of each
- at least two noted examples of successful team problem solving.

OBJECTIVES AND LEARNING ACTIVITIES

1. Recall the members of the technological team, and review the responsibilities of each member.
2. List the essential steps in organizing and managing the group method of problem solving.
3. Recall the steps in problem solving. Use Transparency 11.1 to elaborate on the basic problem-solving process.
4. Identify strategies, such as brainstorming or sub-grouping (task force approach) and individual task assignments, which groups can use for problem solving.
5. Compare the benefits and disadvantages of various group strategies for problem solving.
6. Define *seminar* and discuss benefits they offer.
7. Explain the importance of a personnel system in the solution of engineering problems.
8. List ways the group method encourages teamwork.

CONCEPT AREA

11. Managing the Team Concept of Engineering Design

TASK/COMPETENCY

11.2 Describe the use of a feasibility study.

ASSESSMENT STANDARD

S11.2 Description includes the following:
- definition of the term
- reasons for the study
- list and explanation of each step of the process.

OBJECTIVES AND LEARNING ACTIVITIES

1. Define *feasibility study.*
2. List and explain the objectives of a feasibility study.
3. Explain the role of the feasibility study in the design phases.
4. Invite an engineer to discuss the importance of feasibility studies.
5. Introduce the process of brainstorming as a group problem-solving strategy by having the class list possible problems for a feasibility study.
6. Use the democratic process to select one or more problems for feasibility study.
7. Conduct a feasibility study of a selected problem solution.

CONCEPT AREA

11. Managing the Team Concept of Engineering Design

TASK/COMPETENCY

11.3 List and define the essential steps in the preliminary design phase.

ASSESSMENT STANDARD

S11.3 Steps are listed and defined with 100% accuracy.

OBJECTIVES AND LEARNING ACTIVITIES

1. Define preliminary design.

2. Identify the components of the preliminary phase.

3. Explain the importance of a preliminary design. Have an engineer discuss and demonstrate the importance of this design phase.

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CONCEPT AREA

11. Managing the Team Concept of Engineering Design

TASK/COMPETENCY

11.4 List and define the essential steps in the detailed design phase.

ASSESSMENT STANDARD

S11.4 Steps are listed and defined with 100% accuracy.

OBJECTIVES AND LEARNING ACTIVITIES

1. Define a *detailed design*.
2. Identify the components of a detailed design.
3. Explain the importance of a detailed design. Have an engineer discuss and demonstrate the importance of this design phase.

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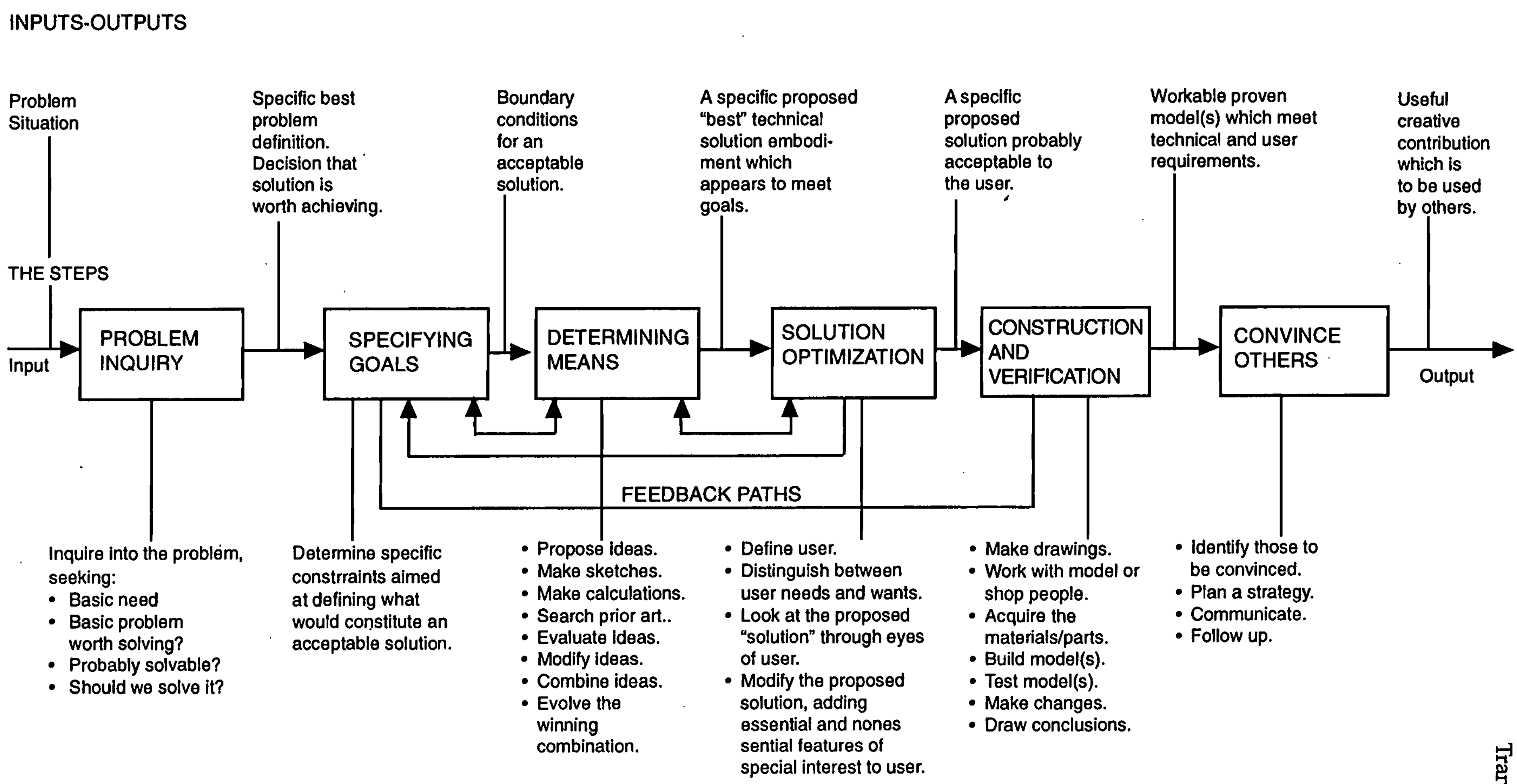
PROBLEM SOLVING



The six-step system approach to solving in a mature, disciplined manner an engineering problem requiring a creative soltuion. The figure gives an overview of the approach.

113 114

Reproduced from Robert L. Bailey, Disciplined Creativity for Engineers (Stoneham MA: Butterworth Publishers, 1978), p. 69. With permission from the publisher.

RESOURCES FOR

11. USING THE DESIGN PROCESS TO IMPROVE A DEVICE OR SYSTEM

EQUIPMENT AND MATERIALS

11.1 Overhead projector

REFERENCES

Careers in Engineering and Technology. Beakley. Macmillan Publications, Inc.
Careers in Science and Technology (EP - 298). NASA, DOE, & NTA. NASA Langley Research Center, Mail Stop 400, Hampton, VA 23681-0001.
Disciplined Creativity for Engineers. Bailey. Ann Arbor Science, Butterwork Publishers.

AUDIOVISUAL MATERIALS

11.1 Transparency: *Problem Solving*.

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CONCEPT AREA

12. BRIEFING OTHERS ON RESULTS OF ENGINEERING

ERIC

CONCEPT AREA

12. Briefing Others on Results of Engineering

TASK/COMPETENCY

12.1 Pre-register for competitive events.

ASSESSMENT STANDARD

S12.1 Pre-registration for a competitive event related to engineering problems must be completed according to TSA rules and standards.

OBJECTIVES AND LEARNING ACTIVITIES

1. Interpret the rules and criteria for competitive events involving appropriate engineering problems.
2. Complete pre-registration forms for appropriate competitive events.
3. Prepare materials and problems solved for entry according to the standards of the event.
4. Add teachers and school name to mailing list for TSA, JETS, and various contests, and colleges, museums, or associations.
5. Help students understand the value of competition and the benefits of cooperation.

ERIC

CONCEPT AREA

12. Briefing Others on Results of Engineering

TASK/COMPETENCY

12.2 Participate in construction of a display of problem-solving activities.

ASSESSMENT STANDARD

S12.2 Individual assignment for group construction of display must be completed according to directions.

OBJECTIVES AND LEARNING ACTIVITIES

1. List ways for effective display of problem-solving activities completed in the course.
2. Design and organize display.
3. Select materials needed for display.
4. Design graphics and text for signs and posters, using computer graphics, CAD software, and photographs.
5. Suggest possible display sites, such as malls, school board office, bank buildings, engineering firm offices, etc.
6. Obtain permission from proper authorities for date and location.
7. Write news release for local papers to announce the display, and list all students and their projects.
8. Prepare display for competition in regional, state, and national events according to contest criteria.

RESOURCES FOR

12. BRIEFING OTHERS ON RESULTS OF ENGINEERING

EQUIPMENT AND MATERIALS

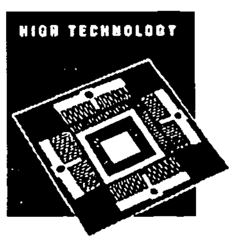
12.1 TSA contest rules and standards
Pre-registration forms
JETS - TEAMS Competition and Rules

12.2 Instructor-prepared directions for individual assignments
Materials and equipment for display construction

REFERENCES

TSA Chapter Handbook. TSA National Office.
TSA Member Guide. TSA National Office.
Curriculum Resources Guide. TSA National Office, 1994.
TSA Rules and Criteria for Virginia and National Contests. Technology Education Service.

Pre-Engineering Program



ADVANCED ENGINEERING

TECHNOLOGY EDUCATION • VIRGINIA DEPARTMENT OF EDUCATION • RICHMOND, VIRGINIA 23218

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PART 1
COURSE INFORMATION

The course descriptions, content outlines, and suggested task sequences contained in this section were developed using the validated tasks analyzed in part 2 of this guide. The program and courses have been approved by the Virginia Department of Education.

The course outline may be used by the teacher as a framework for planning instructional procedures and content. Suggested learning activities presented in Part 2 may be adopted or adapted for use in developing lesson plans.

Information on the long-range mission and goals and an overview of the total Technology Education curriculum are contained in *Technology Education Curriculum K-12,* Technology Education Service, 1992.

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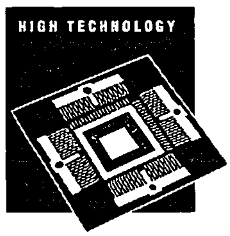
ADVANCED ENGINEERING (8491)

COURSE DESCRIPTION



To learn the applications and design process of engineering, students form engineering teams and select a group design project. Each team uses communications, graphics, mathematics, and community resources to solve problems as team members gather appropriate information in order to complete a project. Projects may be models, systems, or products that creatively solve an engineering problem.

PURPOSE	CODE	GRADE LEVEL	UNIT OF CREDIT	PREREQUISITES
Apply technology and engineering to life and work	8491	11 or 12	1 maximum 1 period per day 36 weeks	Introduction to Engineering (8490) College preparatory mathematics and science courses

SELECTED COURSE GOALS

- Recognize the impact of engineering on society and the environment.
- Appraise the importance of continuing education and community involvement by engineers.
- Apply the professional characteristics and management responsibilities of engineers to class and laboratory activities.
- Present technical information by a variety of electronic and graphic means.
- Apply mathematics, scientific principles, and technology to problems and their solutions.
- Observe designs in nature for adaptation to engineering design.
- Implement engineering design phases.
- Work as a member of a team to solve engineering design problems.

INSTRUCTIONAL TASKS/COMPETENCIES

1. **Relating Objectives of the Course to Students in a Technological World**

   1.1 List courses that help an engineer work with and for people.
   1.2 Describe methods of continuing education for engineers.
   1.3 Describe the impact of engineering on society, human safety, and the environment.
   1.4 Identify community activities for engineers.
   1.5 Participate in group work and personnel system to manage class and laboratory activities.

2. **Investigating the Engineering Profession and Related Careers**

   2.1 Explain the purpose and functions of the technological team.
   2.2 Describe education needed for specialty fields in engineering and technology.
   2.3 Summarize the characteristics of professional engineers.
   2.4 Demonstrate a professional attitude toward classroom and laboratory activities.
   2.5 Describe the management responsibilities of engineers.

3. **Preparing a Formal Seminar on an Engineering Case Study**

   3.1 Identify engineering problems and their solutions.
   3.2 Apply mathematical formulas to problems and activities.
   3.3 Describe the application of mathematics in the solution of engineering problems.
   3.4 Describe the application of scientific principles in the solution of engineering problems.
   3.5 Use appropriate computer software and application programs to solve problems.
   3.6 Describe the application of technology in the solution of engineering problems.
   3.7 Apply safety rules to laboratory activities.
   3.8 Build models that illustrate the principal classes of physical models.
   3.9 Prepare a model demonstrating an engineering problem and its solution.
   3.10 Use graphical vector analysis in the design process.
   3.11 Use engineering graphics to describe the solution of an engineering problem.
   3.12 Describe the social, cultural, economic, and environmental impact of an engineering project.
   3.13 Present technical information in an oral report.

4. **Observing Designs in Nature**

   4.1 Describe characteristics of natural materials used in selected products.

4.2 Identify plant structures on which engineering designs may be based.
4.3 Illustrate the design of human and animal bones.
4.4 List examples of functional design in birds and reptiles.
4.5 Identify examples of the honeycomb structure in nature and in engineering designs.

5. **Reviewing Engineering Design Phases**

5.1 Describe steps in the engineering design process.
5.2 Explain why an optimum design rarely exists.
5.3 Identify the three phases used in most engineering designs.
5.4 Identify the essential steps in the preliminary design phase.
5.5 Identify the essential steps in the detailed design phase.
5.6 Describe the use of a feasibility study.
5.7 Explain the use of the evaluation table during the preliminary design phase.

6. **Using the Design Process as a Group Study**

6.1 Explain the importance of teamwork in problem solving.
6.2 Use brainstorming as a strategy for problem solving.
6.3 Write a proposal for an engineering project.
6.4 Determine sources of information available for problem solving.
6.5 Write a business letter requesting information or materials.
6.6 Conduct an interview to gather information.
6.7 Describe the use of sketches and detail and assembly drawings in the design process.
6.8 Use anthropometric tables.
6.9 Select appropriate materials and processes for producing the design project.
6.10 Determine objectives for an engineering test.
6.11 Conduct a technology assessment.
6.12 Formulate an alternate design solution to a problem.

7. **Managing the Team Concept of Engineering Design**

7.1 Present technical information with charts, graphics, and symbols.
7.2 Use computer-aided design (CAD) software to prepare drawings.
7.3 Present technical information through computer-aided design and drafting.
7.4 Program computer-aided manufacturing (CAM) software to simulate a manufacturing problem.
7.5 Program computer-aided machines and numerical controls.
7.6 Write a technical report for an engineering activity.

8. **Briefing Others on Results of Engineering**

8.1 Pre-register for competitive events.
8.2 Participate in construction of a display of problem-solving activities.

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INSTRUCTIONAL OUTLINE AND SEQUENCE

Topic	Task/ Competency	Schedule
I. Relating Objectives of the Course to Students in a Technological World Orientation to the second course includes a course overview and description, administrative details, emphasis on the importance of engineering and its professional responsibilities, and current events related to the field.		2 days
A. Secondary courses	1.1	
B. Continuing education	1.2	
C. Impact of engineering on society and the environment	1.3	
D. Community activities	1.4	
E. Group work and personnel system (review)	1.5	
II. Investigating the Engineering Profession and Related Careers Students review career aspects of first course and explore the role of the engineer in management.		4 days
A. Purpose and function of the technological team (review)	2.1	
B. Specialty fields (review)	2.2	
C. Characteristics of professional engineers (review)	2.3, 2.4	
D. Management responsibilities of engineers	2.5	
III. Preparing a Formal Seminar on an Engineering Case Study Individual students can be assigned an engineering project with numerous existing references such as the Brooklyn Bridge, Panama Canal, or Hoover Dam, or follow a project underway near the school, such as construction of a sewer line, water treatment plant, bridge, road, or building. Skills instruction is an important aspect of this unit. The class or instructor may select three outstanding projects to be presented in a formal seminar to which outside guests are invited; the remaining projects are displayed.		8 weeks
A. Identification of engineering problems and their solutions	3.1	
B. Application of mathematics to the problem	3.2, 3.3	
C. Application of scientific principles to the problem	3.4	
D. Application of technology to the problem	3.5, 3.6	
E. Safety instruction	3.7	
F. Model construction	3.8, 3.9	
G. Engineering graphics	3.10, 3.11	
H. Social, cultural, and environmental impact of the solution	3.12	
I. Oral report	3.13	

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Topic	Task/ Competency	Schedule
IV. Observing Designs in Nature Students explore designs in nature adaptable to engineering design. A. Characteristics of natural materials used in manufactured products B. Plant structures C. Human and animal bones D. Birds and reptiles E. Honeycomb design	 4.1 4.2 4.3 4.4 4.5	2 days
V. Reviewing the Engineering Design Phases Students review the process of design prior to beginning a major group project. A. Steps in the engineering design process B. Optimum design C. Design phases D. Feasibility study E. Evaluation table	 5.1 5.2 5.3, 5.4, 5.5 5.6 5.7	2 days
VI. Using the Design Process as a Group Study Students form one or more engineering teams to select and solve a problem. Brainstorming is used as a strategy to select a problem and to generate ideas for solution. Suggested problems include an elevator, wind tunnel, mass transit system, and nuclear safety. Teams perform a feasibility study to select one of three possible problems. Students form a Personnel Management Team to coordinate the steps of the design process: (1) problem statement, (2) individual research, (3) generation of ideas for solution, (4) model or graphic simulation (subgroups), and (5) testing of solution. A. Importance of teamwork (review) B. Brainstorming activities C. Engineering proposal D. Sources of information E. Information-gathering activities F. Sketches, drawings G. Anthropometric tables H. Selection of materials and processes I. Test objectives J. Technology assessment K. Alternate solution	6.1 6.2 6.3 6.4 6.5, 6.6 6.7 6.8 6.9 6.10 6.11 6.12	18 weeks
VII. Communicating Technical Information After review of appropriate aspects of the first course, students (as a team) produce an engineering report on the problem and solution just completed. A. Ways to present technical information B. CAD system C. CAM system D. Written report	 7.1 7.2, 7.3 7.4, 7.5 7.6	2 weeks

Topic	Task/ Competency	Schedule
VIII. Briefing Others on Results of Engineering This culminating activity involves displaying project results and dissemination of the engineering report to both invited guests and the public. A. Competitive event registration B. Display construction	 8.1 8.2	2 days

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PART 2

TASK INVENTORY

One of the major characteristics of competency-based education (CBE) is that the course content is based upon actual jobs or tasks performed by persons living and working in the technological world. In Virginia, the Department of Education has established standards for competency-based education. According to these standards, competencies must be "role-relevant" and based upon "appropriate research." This standard states:

> Role-relevant competencies that include standards are identified and stated. The competencies with standards will be identified through V-TECS, IDECC, and other appropriate research. Advisory committees should be used to review competencies and standards. Competencies in the affective domain will be included. Role-relevant competencies for occupational preparation programs are those that specifically relate to the occupation for which the student is being prepared as well as to the personal needs of the student. Role-relevant competencies are related also to orientation, exploration, or technology education experiences which have been identified for students.

Therefore, "role-relevant" jobs or tasks, called competencies in CBE, must be identified and validated before instructional materials can be developed and subsequent instruction can take place.

The task list contained in this instructional guide was based on the following:

1. Interviews with engineers and technologists at NASA and in private sectors
2. The review and selection of appropriate competency-based materials
3. Input from engineering faculty and technology teacher
4. Input from mathematics, science, and technology education supervisors.

Based on the information collected and reviewed from the available sources indicated, a task inventory was prepared.

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The next major step involved in the development of the task inventory was validation of the task list. Validation is essential if the information collected is to be useful in operating CBE courses and programs. The validation process involved the following:

1. Review by writing-team members to determine completeness of the inventory

2. Review and validation by state consultants to ensure the role-relevance and completeness of the inventory

3. Pilot testing by local technology education teachers to determine the validity of the inventory

4. Final review and editing by writing team members, project directors, and state staff.

The task list included in this publication was based on current available resources and validated by teachers, advisory committee members, and persons employed in industrial technology. The tasks are offered as guidance to teachers. Many tasks build upon others taught earlier. The methods of instruction and technology learning activities are suggested but can be varied to meet student needs.

Part 2 of this guide for Advanced Engineering includes the following:

- A divider for each concept area that functions as a table of contents for the area
- A series of framework pages that present each task/competency in the concept area
- Transparency masters included as informational aids
- A resources page for each concept area that lists equipment and materials, references, and audiovisual aids(including software) suggested for use in the classroom or laboratory.

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CONCEPT AREAS

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CONCEPT AREA

1. RELATING OBJECTIVES OF THE COURSE TO STUDENTS IN A TECHNOLOGICAL WORLD

ADVANCED ENGINEERING (8491)

CONCEPT AREA

1. Relating Objectives of the Course to Students in a Technological World

TASK/COMPETENCY

1.1 List courses that help an engineer work with and for people.

ASSESSMENT STANDARD

S1.1 List includes courses in communication, social sciences, physical sciences, and mathematics.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. Explain the nature of an engineer's work.
2. Describe the importance of effective communication skills to an engineer.
3. Explain the impact of the engineer's work on society.
4. List courses that contain activities similar to those of an engineer.
5. Identify course requirements for admission to engineering programs at two- and four-year colleges.
6. Help students set up interviews to determine engineers' background and training. (Refer to Task 6.6.)

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CONCEPT AREA

1. Relating Objectives of the Course to Students in a Technological World

TASK/COMPETENCY

1.2 Describe methods of continuing education for engineers.

ASSESSMENT STANDARD

S1.2 Description must identify and evaluate (by giving benefits and disadvantages) three of the following methods of continuing education: periodicals, classes, seminars, and visitation.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. Explain the effects of rapid expansion of technology on an engineer's performance ability.
2. Explain the dangers of obsolete skills and knowledge to an engineer.
3. Identify benefits and responsibilities of membership in engineering societies or other professional organizations.
4. Write to the American Society of Professional Engineers to obtain information on opportunities for continuing education. (Refer to Task 6.5.)
5. Ask engineers to speak to the class and describe continuing education requirements.

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CONCEPT AREA

1. Relating Objectives of the Course to Students in a Technological World

TASK/COMPETENCY

1.3 Describe the impact of engineering on society, human safety, and the environment.

ASSESSMENT STANDARD

S1.3 Description must include short-term and long-term benefits and disadvantages of an assigned engineering project in terms of social change, human safety, and the environment.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. Assign each student a local engineering project to observe, such as highway construction, industrial/community facility construction, residential renovation, or urban renewal.
2. Compare the short-term effects of an engineering project on individuals and on the community as a whole in terms of human safety.
3. Describe the concerns of environmentalists confronted with industrial or population expansion.
4. Describe long-term benefits and disadvantages of industrial expansion for the community as a whole.
5. Identify contributions of engineers in the fields of, for example, biomedical or product engineering to a better life for individuals.
6. Arrange an invitation for students to a meeting of a local engineering society and have them report on chapter activities and interests.
7. Arrange a visit to a public hearing on a new project or zoning change.
8. Show the video *Pre-Engineering*, and discuss.

CONCEPT AREA

1. Relating Objectives of the Course to Students in a Technological World

TASK/COMPETENCY

1.4 Identify community activities for engineers.

ASSESSMENT STANDARD

S1.4 Assigned number of examples of appropriate community activities are identified according to the Engineering Profession's Code of Ethics.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. Identify the elements contained in the Code of Ethics.
2. Explain the value of community activities to a professional engineer.
3. List ways the community benefits from the contribution of time, skills, and knowledge by engineers.
4. Arrange for students to interview an engineer about the Code of Ethics and the role played by community activities in the profession.

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CONCEPT AREA

1. Relating Objectives of the Course to Students in a Technological World

TASK/COMPETENCY

1.5 Participate in group work and personnel system to manage class and laboratory activities.

CRITERION-REFERENCED MEASURE

S1.5 Participation as leader and follower must be rated acceptable during periodic observations by the instructor.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. Identify the leadership positions needed for technology student activities.
2. Provide information about other organizations and their leadership positions.
3. List duties of president, secretary, treasurer, and reporter and explain how these officers help manage organizations and groups.
4. Identify/designate team members needed within class.
5. Have students prepare an organization chart, using a computer.
6. Organize an advisory committee for the program consisting of engineers and technical personnel from the community. Ask teachers of English, math, and science to serve as consultants to the committee.

RESOURCES FOR

1. RELATING OBJECTIVES OF THE COURSE TO STUDENTS IN A TECHNOLOGICAL WORLD

EQUIPMENT AND MATERIALS

1.1 Course information for high school/college offerings

1.2 Information on professional engineering organizations and publications

1.3 TV/VCR

1.4 Engineering Profession's Code of Ethics

1.5 Computer with applicable software

REFERENCES

Careers in Engineering and Technology. Beakley. Macmillan Publications, Inc.
Disciplined Creativity for Engineers. Bailey. Ann Arbor Science, Butterworth Publishers.
"Our Designed World." *Science for All Americans*. AAAS, 1333 H. Street, NW, Washington, DC 20005.

AUDIOVISUAL MATERIALS

1.3 Videotape: *Pre-Engineering* (#154, 26 min.). Modern Talking Picture Service, 500 Park Street North, St. Petersburg, FL 33709.

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CONCEPT AREA

2. INVESTIGATING THE ENGINEERING PROFESSION AND RELATED CAREERS

Transparency Masters

ERIC

CONCEPT AREA

2. Investigating the Engineering Profession and Related Careers

TASK/COMPETENCY

2.1 Explain the purpose and functions of the technological team.

ASSESSMENT STANDARD

S2.1 Explanation must identify members of the team and describe the role and characteristics of each; rated acceptable according to criteria specified in instructor's guidelines.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. Describe the role of the craftsperson, and state characteristics of his or her work.
2. Explain the kind of work performed by the technician.
3. Have students obtain information from a community college and report on technician careers.
4. Contrast the work of the engineer and the technologist.
5. Describe how scientists are educated and the work they do.
6. Show Part II of *Engineering: An Introduction to the Field and Its Careers*, and have students discuss the role and qualifications needed by each member of the team.
7. Use Transparency 2.1 to show the education/training requirements of an engineering team.

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CONCEPT AREA

2. Investigating the Engineering Profession and Related Careers

TASK/COMPETENCY

2.2 Describe education needed for specialty fields in engineering and technology.

ASSESSMENT STANDARD

S2.2 Description must cover two specialty fields and be rated complete and correct according to references used.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. List engineering and technology programs offered in Virginia universities and community colleges.
2. State the entrance requirements for selected engineering schools and community college engineering technology programs.
3. Compare and contrast the degree requirements for selected engineering and technology programs.
4. Have students review university and community college catalogs and write to the admission offices for information.

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ADVANCED ENGINEERING (8491)

CONCEPT AREA

2. Investigating the Engineering Profession and Related Careers

TASK/COMPETENCY

2.3 Summarize the characteristics of professional engineers.

ASSESSMENT STANDARD

S2.3 Assigned number of characteristics must be defined and their importance explained; average rating or above is required.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. Define the terms *profession, engineer, technician, registered engineer, engineering profession,* and *engineering technology.*

2. Describe qualifications needed by professional engineers.

3. Describe typical tasks performed by professional engineers.

4. Explain the term *certified* in *certified engineering technologist* or *certified engineering technician* according to organizations such as the Society of Manufacturing Engineers (SME), National Society of Professional Engineers (NSPE), or National Institute for Certification in Engineering Technologies (NICET).

5. Compare definitions of *engineer* from the following sources: Society of Professional Engineers, *Introduction to Engineering* by Blotter, and a dictionary.

6. Show Part III of *Engineering: An Introduction to the Field and Its Careers.*

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CONCEPT AREA

2. Investigating the Engineering Profession and Related Careers

TASK/COMPETENCY

2.4 Demonstrate a professional attitude toward classroom and laboratory activities.

ASSESSMENT STANDARD

S2.4 Behaviors associated with professional attitudes toward safety, care and maintenance of equipment, work with co-workers and supervisors, and required study and problem solving must be demonstrated; acceptable rating is required during each periodic evaluation.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. Identify behaviors associated with a professional attitude toward safety.

2. Identify behaviors associated with a professional attitude toward care and maintenance of equipment.

3. Have students make up a code of ethics listing class rules on safety and care of equipment.

4. Identify behaviors associated with a professional attitude toward required study and problem solving.

5. Use Transparency 2.4 to initiate a discussion of traits present in professional engineers and their relationship to study habits and skills required for training in problem-solving.

6. Identify behaviors associated with a professional relationship with co-workers and supervisors.

7. Ask members of the advisory committee to speak to the class about the importance of teamwork and ways that professional relationships can be formed and maintained.

8. Form small groups within the class to solve short problems or exercises. Change group memberships to enable students to adapt to new, professional relationships.

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CONCEPT AREA

2. Investigating the Engineering Profession and Related Careers

TASK/COMPETENCY

2.5 Describe the management responsibilities of engineers.

ASSESSMENT STANDARD

S2.5 Description must cover levels of management in two engineering fields and five specific management responsibilities; information must be accurate according to references used.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. List aspects of work that can be managed, such as people, time, projects, information, money, and equipment.

2. List the engineering fields recognized by the state registration board for licensing as professional engineers.

3. List the levels of engineering that require a licensed professional engineer.

4. Relate the management roles of officers in the student organization to similar management roles of an engineer.

5. Assign officer(s) the task of preparing an organizational chart for managers in the class and laboratory.

6. Recall the responsibilities of each member of the technological team (Task 2.1).

THE ENGINEERING TEAM EDUCATION/TRAINING REQUIREMENTS

ENGINEER

Bachelor of Science (B.S.) in Engineering
May or may not be registered
Applies theory
Leads team

TECHNOLOGIST

Baccalaureate degree after four years of study
Understands theory

TECHNICIAN

Associate degree (2 years)

CRAFTSPERSON

Vocational training
Possible military training
Experience and on-the-job training

ERIC

IMPORTANT QUESTIONS FOR POTENTIAL ENGINEERS

Do I have an inquisitive, searching mind?

Do I like to solve problems and puzzles?

Do I like to create things?

Do I enjoy learning?

Can I organize my time?

Am I willing to work hard?

Prepared by Mr. Ken Anderson, Consulting Engineer, Anderson Associates, Blacksburg, VA.

RESOURCES FOR

2. INVESTIGATING THE ENGINEERING PROFESSION AND RELATED CAREERS

EQUIPMENT AND MATERIALS

2.1 Slide/tape projector, overhead projector
Instructor's guidelines

2.2 College catalogs

2.3 Slide/tape projector

2.4 Overhead projector

2.5 Chart-making materials

REFERENCES

Careers in Engineering and Technology. Beakley. Macmillan Publications, Inc.
Careers in Science and Technology (EP-298). NASA, DOE, and NTA.
Disciplined Creativity for Engineers. Bailey. Ann Arbor Science, Butterworth Publishers.
Your Engineering Career Kit. Accreditation Board for Engineering and Technology, 345 E. 47th Street, New York, NY 10017.

AUDIOVISUAL MATERIALS

2.1 Slide/tape: *Engineering: An Introduction to the Field and Its Careers.* Technology Education Service, Virginia Department of Education.
2.1 Transparency: *The Engineering Team Education/Training Requirements.*
2.3 Slide/tape: *Engineering: An Introduction to the Field and Its Careers,* Part III. (See Appendix B.)
2.4 Transparency: *Important Questions for Potential Engineers.*

CONCEPT AREA

3. PREPARING A FORMAL SEMINAR ON AN ENGINEERING CASE STUDY

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CONCEPT AREA

3. Preparing a Formal Seminar on an Engineering Case Study

TASK/COMPETENCY

3.1 Identify engineering problems and their solutions.

ASSESSMENT STANDARD

S3.1 A case study is analyzed, and at least three associated problems are identified and solved correctly.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. List types of problems that may be encountered in engineering design, such as size, weight, load capacity, durability, flexibility, utility, strength, environmental effects, safety factors, and manufacturing process.

2. Recall steps in the problem-solving process.

3. Identify appropriate ways to solve problems, including the application of mathematics, scientific principles, and technology.

4. Have students select a problem identified in their case studies and discuss an alternate solution.

CONCEPT AREA

3. Preparing a Formal Seminar on an Engineering Case Study

TASK/COMPETENCY

3.2 Apply mathematical formulas to problems and activities.

ASSESSMENT STANDARD

S3.2 Word problems are solved correctly, using appropriate mathematical formulas.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. Describe the modeling process used by engineers to conceptualize a system.
2. Identify a mathematical model as used to analyze and revise a particular system design.
3. Illustrate the concept of system input and output with sketches and equations.

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CONCEPT AREA

3. Preparing a Formal Seminar on an Engineering Case Study

TASK/COMPETENCY

3.3 Describe the application of mathematics in the solution of engineering problems.

ASSESSMENT STANDARD

S3.3 The mathematics used to solve an engineering problem is described, including equations or specific principles involved.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. Recall mathematical operations and formulas used in engineering problem solutions.
2. Apply mathematical formulas to problems.
3. Use a scientific calculator to solve numerical problems.
4. Use a computer to perform repetitive mathematical operations.
5. Use spreadsheet software such as *Excel.*
6. Use data analysis software such as *D-Base I, Lotus 1-2-3,* or *Access.*

ERIC

CONCEPT AREA

3. Preparing a Formal Seminar on an Engineering Case Study

TASK/COMPETENCY

3.4 Describe the application of scientific principles in the solution of engineering problems.

ASSESSMENT STANDARD

S3.4 The scientific principles used to solve an engineering problem are described, including equations or specific laws involved.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. Identify examples of laws and principles of physics that can be applied to engineering design.
2. State formulas or equations derived from these laws.
3. Use reference books and textbooks from science classes to look up principles that apply to the problem.
4. Access videodisk technologies such as *Windows on Science* or *Technology*.

ADVANCED ENGINEERING (8491)

CONCEPT AREA

3. Preparing a Formal Seminar on an Engineering Case Study

TASK/COMPETENCY

3.5 Use computer application programs to solve problems.

ASSESSMENT STANDARD

S3.5 Assigned problems are solved correctly by use of appropriate software or application program, resulting in a printout of accurate data for each problem.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. Identify the components of a computer system such as the processor, monitor, keyboard, disk drives, modem, and printer.
2. Follow procedures to turn on computer, boot up software, and make menu selection.
3. Describe computer and software commands.
4. Use computer for numerical calculations.
5. Select commands to manipulate data and obtain information.
6. Program a computer to accept and analyze data for a specific/unique problem.

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CONCEPT AREA

3. Preparing a Formal Seminar on an Engineering Case Study

TASK/COMPETENCY

3.6 Describe the application of technology in the solution of engineering problems.

ASSESSMENT STANDARD

S3.6 The technology used to solve an engineering problem is described, including specific processes and materials involved.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. Identify physical and chemical properties of various materials.
2. Explain various processes applied to metallic, polymeric, ceramic, and composite materials.
3. Use reference materials in the library, such as *How Things Work*.
4. Review technical magazines in local and school libraries, such as *Popular Science* and *Architectural Review*.
5. Identify hydraulic, mechanical, electrical, and thermal systems that are fundamental to technology devices.

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ADVANCED ENGINEERING (8491)

CONCEPT AREA

3. Preparing a Formal Seminar on an Engineering Case Study

TASK/COMPETENCY

3.7 Apply safety rules to laboratory activities.

ASSESSMENT STANDARD

S3.7 Student demonstration of safe use of tools, machines, equipment, and supplies during each activity must be rated acceptable according to posted safety rules and precautions.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. Explain the importance of safety in the laboratory and the workplace.

2. Identify hand tools, machines, equipment, and chemicals used in the laboratory, and state safety precautions for the use of each.

3. Describe safety precautions and responsibilities in regard to the following engineering areas:

Management	Construction
Industry	Production
Operation	Design
Maintenance	Development
Research	

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CONCEPT AREA

3. Preparing a Formal Seminar on an Engineering Case Study

TASK/COMPETENCY

3.8 Build models that illustrate the principal classes of physical models.

ASSESSMENT STANDARD

S3.8 Assigned design problem is solved; solution is illustrated by proof of principle, scale, experimental, and prototype models constructed according to standards provided.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. Illustrate the "proof of principle model" by designing and constructing a minimally operative model.

2. Illustrate the "scale model" by designing and constructing dimensionally enlarged and shrunken models.

3. Illustrate the "experimental model" by designing and constructing a functioning model to be tested.

4. Illustrate the "prototype model" by designing and constructing a full scale working model in a complete form.

5. Refer to p. 244 in Bailey for further information.

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CONCEPT AREA

3. Preparing a Formal Seminar on an Engineering Case Study

TASK/COMPETENCY

3.9 Produce a model demonstrating an engineering problem and its solution.

ASSESSMENT STANDARD

S3.9 Model may be a physical construction, a computer simulation, or demonstration of principles, using scientific apparatus, but it must be prepared according to instructor-prepared guidelines.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. Describe at least four different ways that an object or a system can be modeled.
2. Identify models used daily by society, and explain why they are used.
3. Follow safety rules for laboratory activities.
4. Demonstrate CAD and 3-D modeling software such as AutoCAD or CADKey.
5. Invite personnel from local computer store to show modeling software, plotters, and visualization tools.

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CONCEPT AREA

3. Preparing a Formal Seminar on an Engineering Case Study

TASK/COMPETENCY

3.10 Use graphical vector analysis in the design process.

ASSESSMENT STANDARD

S3.10 Assigned vector analysis problem is solved correctly by use of both manual and computer graphics analyses.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. Use engineering graphics to construct a space diagram accurately representing a system of forces.
2. Use computer graphics to construct a free body diagram accurately representing a system of forces.
3. Use an accurately constructed free body diagram to estimate unknown quantities in a system of forces.

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CONCEPT AREA

3. Preparing a Formal Seminar on an Engineering Case Study

TASK/COMPETENCY

3.11 Use engineering graphics to describe the solution of an engineering problem.

ASSESSMENT STANDARD

S3.11 Description of the problem and its solution must include at least one orthographic projection and one pictorial view produced by either manual or computer-aided drafting.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. Draw and interpret objects in orthographic projection.
2. Draw and interpret objects in isometric or oblique projection.
3. Use graphs and empirical equations to describe physical phenomenon.
4. Use a computer-aided drafting system to produce engineering graphics.

ERIC

CONCEPT AREA

3. Preparing a Formal Seminar on an Engineering Case Study

TASK/COMPETENCY

3.12 Describe the social, cultural, economic, and environmental impact of an engineering project.

ASSESSMENT STANDARD

S3.12 Description must include (1) ways in which the project affects the social, cultural, economic, and environmental elements of the community involved, and (2) ways in which social, cultural, economic, and environmental interests affect the design of the project.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. Analyze engineering problems and solutions described in case study resources to identify social, cultural, economic, and environmental impacts.

2. Explain how engineering design is affected by projected social, cultural, economic, and environmental factors.

3. Have students bring in newspaper clippings and discuss impacts related to technology projects in the news.

4. Discuss how the addition or loss of a new business or industry can affect a community's labor force and economy.

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ADVANCED ENGINEERING (8491)

CONCEPT AREA

3. Preparing a Formal Seminar on an Engineering Case Study

TASK/COMPETENCY

3.13 Present technical information in an oral report.

ASSESSMENT STANDARD

S3.13 Presentation includes use of visual aids and meets all criteria specified in class-developed guidelines.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. List techniques that contribute to an effective oral presentation of technical information.
2. Identify factors that detract from the effectiveness of an oral presentation.
3. List examples of visual aids that illustrate technical information, such as models and engineering graphics.
4. Explain the importance of visual aids in an oral presentation.
5. Describe techniques for presenting visual aids.
6. Identify content components of an oral report on engineering problem solution.
7. Help students develop criteria for rating oral reports.

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RESOURCES FOR

3. PREPARING A FORMAL SEMINAR ON AN ENGINEERING CASE STUDY

EQUIPMENT AND MATERIALS

3.1 - 3.13	Engineering case studies
3.2	Scientific calculator and related materials Instructor-provided problems
3.3, 3.4, 3.6	CD-ROM or videodisk players
3.5	Computer hardware and software Instructor-provided problems
3.7	Safety posters
3.8	Design problems Computer with applicable software Modeling materials
3.9	Instructor-prepared guidelines Computer and software Model construction materials Scientific apparatus
3.10	Vector analysis problems Computer with applicable software
3.11	Technical drawing equipment and supplies CAD system, modeling software
3.13	Materials for development and presentation of visual aids Class-developed guidelines for oral reports

REFERENCES

Careers in Engineering and Technology. Beakley. Macmillan Publications, Inc.
Disciplined Creativity for Engineers. Bailey. Ann Arbor Science, Butterworth Publishers.
Physics for Technology. Betts. Prentice Hall.
School-approved chemistry, biology, math, and technical drawing texts
"Documenting the Design Process." *Supplemental Instructional Resource Guide for High School Technology Education Programs*. Technology Education Service, Virginia Department of Education.
Unified Technical Concepts—Physics for Technicians. The Center for Occupational Research and Development, 601C Lake Air Drive, Waco, TX 76710.
Structural Engineering (Bridge Building) Contest Rules. TSA Competitive Events Handbook.
Calculator Activities. National Council of Teachers of Mathematics.
Problems in Search of a Calculator. National Coordinating Center for Curriculum Development, College of Engineering and Applied Sciences, SUNY at Stony Brook, Stony Brook, NY 11794.
Computer Interfaces and Software. Vernier Company, 8565 S.W. Beaverton, Hillsdale Highway, Portland, OR 97225-2429.

AUDIOVISUAL MATERIALS

3.12 Videotapes:*You, Me, & Technology*. Delmar, Two Computer Drive, Albany, NY 12212.

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CONCEPT AREA

4. OBSERVING DESIGNS IN NATURE

CONCEPT AREA

4. Observing Designs in Nature

TASK/COMPETENCY

4.1 Describe characteristics of natural materials used in selected products.

ASSESSMENT STANDARD

S4.1 Description includes the characteristics of the natural material that justifies its use in the selected product; 4 of 5 products must be described correctly.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. List examples of common products made from natural materials.

2. Have students select a product category (such as cotton clothing, wooden furniture, jewelry with precious gems, or fine crystal) and compare examples of these products with those made from synthetic materials in terms of utility, aesthetic quality, and environmental concerns.

3. Identify physical properties of various natural materials.

4. Identify chemical properties of various natural materials.

ERIC

CONCEPT AREA

4. Observing Designs in Nature

TASK/COMPETENCY

4.2 Identify plant structures on which engineering designs may be based.

ASSESSMENT STANDARD

S4.2 4 of 5 plant structures are identified correctly.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. Illustrate various plant structures such as dandelion and bamboo.
2. Identify the characteristics of plant structures that justify their duplication in engineering design.
3. List examples of engineering designs that attempt to duplicate the structure of plants.

ADVANCED ENGINEERING (8491)

CONCEPT AREA

4. Observing Designs in Nature

TASK/COMPETENCY

4.3 Illustrate the design of human and animal bones.

ASSESSMENT STANDARD

S4.3 Illustration includes physical activities to show torsion and resistance and laboratory tests to show compression and tension strengths, all performed according to directions.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. Examine human and animal skeletons and relate to engineering design principles.
2. Use CD-ROM materials to see "inside" animal structure.
3. Evaluate, through examination of medical records, strengths and weaknesses of bones that have been injured.
4. Compare characteristics of human and animal bones to those of various other materials.
5. Identify examples of engineering designs based on designs of human and animal bone structures.

CONCEPT AREA

4. Observing Designs in Nature

TASK/COMPETENCY

4.4 List examples of functional design in birds and reptiles.

ASSESSMENT STANDARD

S4.4 Four examples of functional design in birds and reptiles must be listed correctly.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. Identify animals in the reptile class, and describe their common characteristics.

2. Explain the following characteristics of snakes in terms of function: scales, retractable fangs, and hinged jaws.

3. Explain the role of the following characteristics of birds that enable them to fly: wing shape, wing speed, wing span, hollow bones, feathers, and high metabolism.

4. Describe differences in body design in aquatic birds and land-inhabiting birds.

5. Ask a biology teacher to explain the functional designs of birds and reptiles to the class.

6. Use CD-ROM or videodisk materials to examine birds and reptiles.

ERIC

CONCEPT AREA

4. Observing Designs in Nature

TASK/COMPETENCY

4.5 Identify examples of the honeycomb structure in nature and in engineering design.

ASSESSMENT STANDARD

S4.5 Three examples must be listed correctly, along with characteristics of the honeycomb structure that make it suitable for duplication in engineering design.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. Identify characteristics of the honeycomb structure that make it suitable for duplication in engineering design.
2. List examples of the honeycomb structure in nature.
3. Explain how the honeycomb structure can be used in engineering design by describing its use on the Surveyor spacecraft.
4. Examine crystalline structures of natural materials such as ice or metals.

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RESOURCES FOR

4. OBSERVING DESIGNS IN NATURE

EQUIPMENT AND MATERIALS

4.1 Samples of natural materials for testing

4.2 Samples or illustrations of plants

4.3 Animal bones, skeleton parts

4.3, 4.4 Computer with CD-ROM drive and speakers

REFERENCES

Careers in Engineering and Technology. Beakley. Macmillan Publications, Inc.
Various publications on the Surveyor spacecraft project. Educational Programs Officer, NASA Administration, Washington, DC 20546.

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CONCEPT AREA

5. REVIEWING THE ENGINEERING DESIGN PHASES

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CONCEPT AREA

5. Reviewing the Engineering Design Phases

TASK/COMPETENCY

5.1 Describe steps in the engineering design process.

ASSESSMENT STANDARD

S5.1 Description includes written definition and example of each step, accurate according to references used.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. Define the *engineering design process.*
2. Compare engineering design with scientific method and other problem-solving methods.
3. Ask an engineer who is working in industrial design/development to visit the class for student interview. Have the class develop a list of questions prior to the visit.
4. Have students use computer software *The Scientific Method.*

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CONCEPT AREA

5. Reviewing the Engineering Design Phases

TASK/COMPETENCY

5.2 Explain why an optimum design rarely exists.

ASSESSMENT STANDARD

S5.2 Explanation must include descriptions of three designs of a product and possible limitations of each.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. Identify and describe the elements of good design.
2. Identify the possible limitations in designing products.
3. Define *optimum design*.
4. Explain why the optimum design is difficult to achieve.
5. Use reference materials in the library to find out about classic designs in history and architecture.

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CONCEPT AREA

5. Reviewing the Engineering Design Phases

TASK/COMPETENCY

5.3 Identify the three phases used in most engineering designs.

ASSESSMENT STANDARD

S5.3 Identification must include the accurate listing and defining of the three phases.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. List the three engineering design phases.
2. Define each of the design phases.
3. Explain the necessity for each of the phases.
4. Describe the relationship among the three phases.
5. Explain why the feasibility study is conducted first in the design phase.
6. Show the filmstrip *Product Design* to introduce or review the three phases of engineering design.

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CONCEPT AREA

5. Reviewing the Engineering Design Phases

TASK/COMPETENCY

5.4 Identify the essential steps in the preliminary design phase.

ASSESSMENT STANDARD

S5.4 Steps are listed and defined with 100% accuracy.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. Define *preliminary design.*

2. Identify the components of the preliminary phase.

3. Explain the importance of a preliminary design. Have an engineer discuss and demonstrate the importance of this design phase.

CONCEPT AREA

5. Reviewing the Engineering Design Phases

TASK/COMPETENCY

5.5 Identify the essential steps in the detailed design phase.

ASSESSMENT STANDARD

S5.5 Steps are listed and defined with 100% accuracy.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. Define a *detailed design.*
2. Identify the components of a detailed design.
3. Explain the importance of a detailed design. Have an engineer discuss and demonstrate the importance of this design phase.

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CONCEPT AREA

5. Reviewing the Engineering Design Phases

TASK/COMPETENCY

5.6 Describe the use of a feasibility study.

ASSESSMENT STANDARD

S5.6 Description includes the following:
- definition of the term
- reasons for the study
- list and explanation of each step of the process.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. Define *feasibility study.*
2. List and explain the objectives of a feasibility study.
3. Explain the role of the feasibility study in the design phases.
4. Invite an engineer to discuss the importance of feasibility studies.
5. Introduce the process of brainstorming as a group problem-solving strategy by having the class list possible problems for a feasibility study.
6. Use the democratic process to select one or more problems for feasibility study.
7. Conduct a feasibility study of a selected problem solution.

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CONCEPT AREA

5. Reviewing the Engineering Design Phases

TASK/COMPETENCY

5.7 Explain the use of the evaluation table during the preliminary design phase.

STANDARD OF TASK MASTERY

S5.7 Explanation includes a review of sample tables and a description of how the tables would be used for selected designs.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. Explain the purpose of an evaluation table.
2. Compare various evaluation tables for content and layout.
3. Determine the extent that evaluation tables are used in industry.
4. Arrange for students to talk to a design engineer about the need and use of evaluation tables. (Combine this activity with the one for Task 5.1.)
5. Demonstrate spreadsheet software such as *Excel*.

RESOURCES FOR

5. REVIEWING THE ENGINEERING DESIGN PHASES

EQUIPMENT AND MATERIALS

5.1 Overhead projector
Computer with applicable software

5.5 Filmstrip projector

5.7 Evaluation tables
Computer with applicable software

REFERENCES

Careers in Engineering and Technology. Beakley. Macmillan Publications, Inc.
Disciplined Creativity for Engineers. Bailey. Ann Arbor Science, Butterworth Publishers.
Careers in Science and Technology (EP-298). NASA, DOE, and NTA, Washington, DC.

AUDIOVISUAL MATERIALS

5.1 Software: *Scientific Method.* Micro Learningware, Highway 66 S., Box 307, Mankato, MN 56002-0307.

5.5 Filmstrip: *Product Design.* Manufacturing Forum, Ball State University, Muncie, IN 47306.

CONCEPT AREA

6. USING THE DESIGN PROCESS AS A GROUP STUDY

CONCEPT AREA

6. Using the Design Process as a Group Study

TASK/COMPETENCY

6.1 Explain the importance of teamwork in problem solving.

ASSESSMENT STANDARD

S6.1 Explanation includes the following:
- a description of the functions of each team member
- definitions of at least two strategies for group problem solving and the benefits and disadvantages of each
- at least two noted examples of successful team problem solving.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. Recall the members of the technological team, and review the responsibilities of each member.
2. List the essential steps in organizing and managing the group method of problem solving.
3. Recall the steps in problem solving. Use Transparency 6.1 to elaborate on the basic problem-solving process.
4. Identify strategies, such as brainstorming or sub-grouping (task force approach) and individual task assignments, which groups can use for problem solving.
5. Compare the benefits and disadvantages of various group strategies for problem solving.
6. Define *seminar*, and discuss benefits offered by seminars.
7. Explain the importance of a personnel system in the solution of engineering problems.
8. List ways the group method encourages teamwork.

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ADVANCED ENGINEERING (8491)

CONCEPT AREA

6. Using the Design Process as a Group Study

TASK/COMPETENCY

6.2 Use brainstorming as a strategy for problem solving.

ASSESSMENT STANDARD

S6.2 Active participation according to established rules of brainstorming is recorded.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. Define *brainstorming* and explain its value as a strategy for problem solving.
2. Explain why brainstorming is used by engineering teams.
3. Follow established rules for brainstorming:
   a. Keep a record of all ideas for future discussion.
   b. Avoid criticizing or evaluating suggested ideas.
   c. Build on (combine, modify, and add to) ideas as they are suggested.
   d. Concentrate on quantity, not quality, of ideas by suggesting as many ideas as possible.

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CONCEPT AREA

6. Using the Design Process as a Group Study

TASK/COMPETENCY

6.3 Write a proposal for an engineering project.

ASSESSMENT STANDARD

S6.3 Proposal includes all components identified in instructor-provided guidelines and must be rated acceptable according to the five Cs of effective technical writing.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. Define *engineering proposal.*
2. State the components of a proposal.
3. Identify and explain the five Cs of effective technical writing: completeness, correctness, conciseness, clarity, and consideration (of the intended audience).
4. Identify specifications to be taken in the engineering project.
5. Identify expected results.
6. State who will use the results and when.

CONCEPT AREA

6. Using the Design Process as a Group Study

TASK/COMPETENCY

6.4 Determine sources of information available for problem solving.

ASSESSMENT STANDARD

S6.4 At least one possible source of information is listed for each problem on a diversified list.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. List the sources of information available in a technical library.
2. Identify types of information that would possibly be available from museums, research centers, colleges, product testing laboratories, manufacturers, consultants, engineering firms, government agencies, and professional engineering societies.
3. Identify examples of computer databases with information applicable to engineers.
4. List examples of publications useful for engineering problem solving.
5. Demonstrate techniques for effective interviewing as a means of gathering information.
6. Demonstrate how to take interview notes.
7. Ask the librarian to demonstrate CD-ROM materials for reference and research.
8. Use on-line programs to access information through Internet.

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CONCEPT AREA

6. Using the Design Process as a Group Study

TASK/COMPETENCY

6.5 Write a business letter to request information or materials.

ASSESSMENT STANDARD

S6.5 Letter is in appropriate format, is grammatically correct, and includes all necessary elements.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. Identify the elements of a business letter.
2. Examine samples of appropriate formats for business letters.
3. State appropriate ways to word requests for information or materials.
4. Proofread letters for and correct errors in grammar, spelling, vocabulary, and sentence structure.
5. State the importance of courteous expression in business correspondence to promote good will.
6. Use a computer and word-processing software to produce letters.
7. Discuss other methods of contacting information sources, such as electronic networking.

CONCEPT AREA

6. Using the Design Process as a Group Study

TASK/COMPETENCY

6.6 Conduct an interview to gather information.

ASSESSMENT STANDARD

S6.6 Interview with professional engineer, technologist, or technical librarian is documented by notes that include the following:
- Name, address, and position of person interviewed
- Type of interview (face-to-face or telephone)
- Answers to a minimum of three questions designed to gather information for problem solving.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. Explain how to prepare for an interview.
2. Design interview questions to elicit essential information (who, what, when, where, why, and how).
3. Design interview questions to encourage disclosure of detailed information or opinion.
4. Arrange for an interview by phone call, letter, or electronic (on-line) communication.
5. Demonstrate techniques for notetaking during an interview.
6. Identify differences in technique when interviewing in person as opposed to interviewing in a telephone conversation.
7. Follow up an interview with appropriate correspondence (letters of appreciation).

CONCEPT AREA

6. Using the Design Process as a Group Study

TASK/COMPETENCY

6.7 Describe the use of sketches and detail and assembly drawings in the design process.

ASSESSMENT STANDARD

S6.7 Description must cover how each type of drawing would help solve an assigned problem.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. Demonstrate how sketching is used as a quick means of expressing an idea.
2. Explain how sketches lead to detail and assembly drawings.
3. List the components of a detail drawing.
4. Explain the importance of arranging the views of an assembly drawing.
5. Have students construct a small cube out of poster board, first using written instructions and then using detail and assembly drawings. Discuss the importance of drawings in visualizing the construction process.
6. Demonstrate newer forms of CAD and sketching software.

CONCEPT AREA

6. Using the Design Process as a Group Study

TASK/COMPETENCY

6.8 Use anthropometric tables.

ASSESSMENT STANDARD

S6.8 Tables are used to calculate correctly the specific proportions needed to solve an assigned problem.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. Find the average length of arms, legs, heads, and bodies in the class.
2. Use the tables to calculate average furniture sizes.
3. Use the tables to calculate car interior sizes.

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CONCEPT AREA

6. Using the Design Process as a Group Study

TASK/COMPETENCY

6.9 Select appropriate materials and processes for producing the design project.

ASSESSMENT STANDARD

S6.9 Selections must be justified by calculations.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. List all the types of materials that would satisfy the design specifications.
2. Select the best material for the product after researching its qualities, availability, machinability, and cost.
3. Justify why a certain material was selected.
4. List the processes and necessary skills involved in making the designed project.
5. Develop a chart depicting the industrial processes for the project and technical skills needed to use these processes.

ERIC

CONCEPT AREA

6. Using the Design Process as a Group Study

TASK/COMPETENCY

6.10 Determine objectives for an engineering test.

ASSESSMENT STANDARD

S6.10 Objectives are written for an engineering test to establish a defined margin of safety.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. List the properties of the materials to be tested.
2. Establish method of testing.
3. Set up a system for testing the material safety.

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ERIC

CONCEPT AREA

6. Using the Design Process as a Group Study

TASK/COMPETENCY

6.11 Conduct a technology assessment.

ASSESSMENT STANDARD

S6.11 Assessment must predict both desired and undesired impacts of an assigned engineering project.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. Review technology assessment results.
2. Define the issue or product to be assessed.
3. List the major technologies used or involved in the issue or product.
4. Describe the nontechnological factors involved.
5. Identify areas of society affected by the issue or product.
6. Trace the impacts to obtain data and results.
7. Design options for redesign of product.
8. Analyze options, and discuss results.

ERIC

CONCEPT AREA

6. Using the Design Process as a Group Study

TASK/COMPETENCY

6.12 Formulate an alternate design solution to a problem.

ASSESSMENT STANDARD

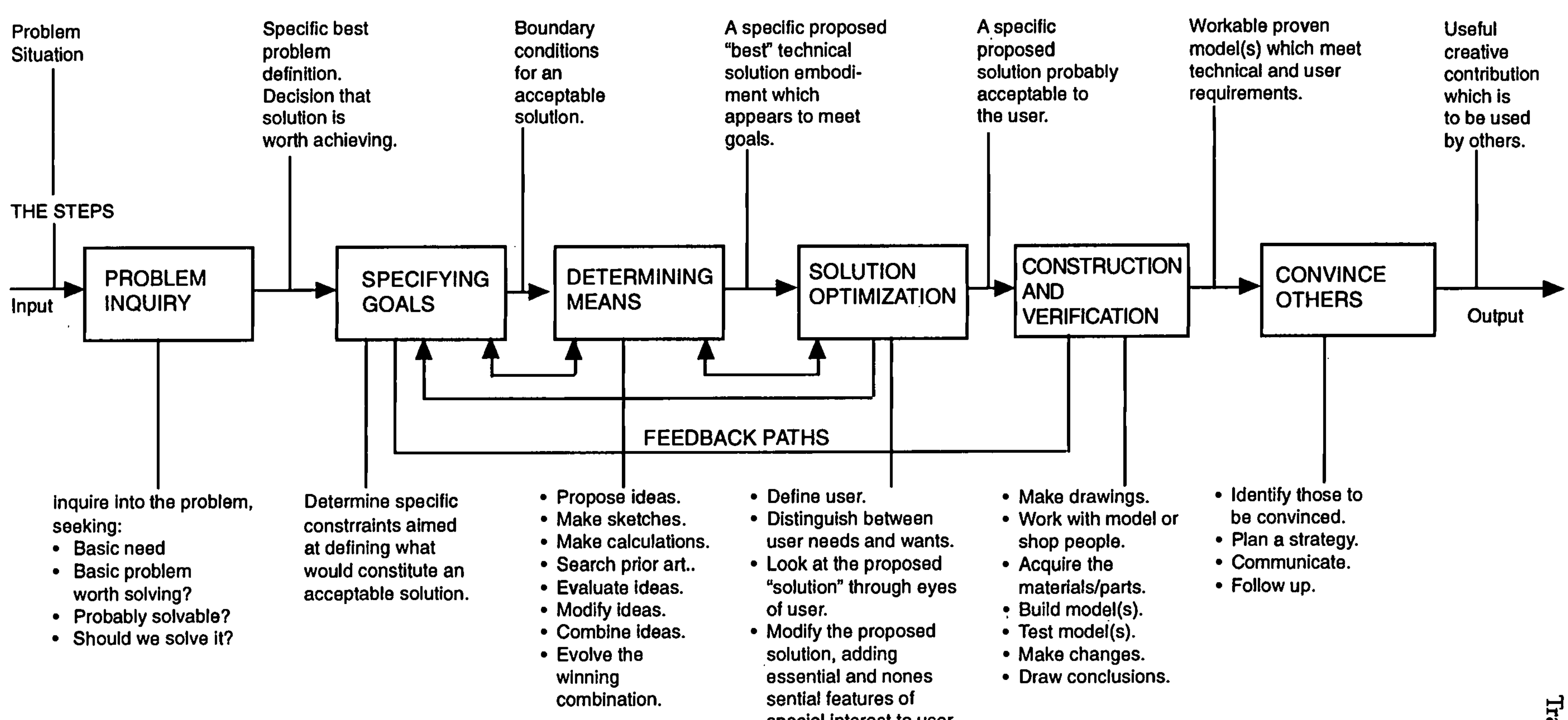
S6.12 Alternate design solution to a specific design problem with exact parameters must be workable.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. Study original design.
2. Review information obtained in technology assessment.
3. Brainstorm new ideas.
4. Prepare a model of the revised product.
5. Analyze and evaluate the new idea in comparison to test and assessment.
6. Present the solution, using graphics and multimedia.

ERIC

PROBLEM SOLVING



The six-step system approach to solving in a mature, disciplined manner an engineering problem requiring a creative soltuion. The figure gives an overview of the approach.

Reproduced from Robert L. Bailey, Disciplined Creativity for Engineers (Stoneham MA: Butterworth Publishers, 1978), p. 69. With permission from the publisher.

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RESOURCES FOR

6. USING THE DESIGN PROCESS AS A GROUP STUDY

EQUIPMENT AND MATERIALS

6.1 Overhead projector

6.3 Addresses for museums, research centers, colleges/universities, testing labs, and other sources of information

6.5 Sample business letters
Computer with word processing software
Computer with modem and access to Internet

6.7 Poster board and supplies for cube construction
Drawing equipment and supplies

6.8 Tape measures, rulers
Anthropometric tables

6.9 Test equipment and supplies for materials properties tests

6.10 Model construction materials such as Fischertechnik

6.11 "Assessing the Impact of Technology" (see References listed below)

6.12 Model construction materials
Computer with applicable software

REFERENCES

Instructional Tasks/Competencies for Materials and Processes Technology. Technology Education Service, Virginia Department of Education.

"Assessing the Impact of Technology." *Supplemental Instructional Resource Guide for High School Technology Education Programs.* Technology Education Service, Virginia Department of Education.

Careers in Engineering and Technology. Beakley. Macmillan Publications, Inc.

Careers in Science and Technology (EP-298). NASA, DOE, & NTA, Washington, DC.

Disciplined Creativity for Engineers. Bailey. Ann Arbor Science, Butterworth Publishers.

ERIC

SME directories. SME Member Relations, One SME Drive, P. O. Box 930, Dearborn, MD 48121.

Case studies. See Appendix E, Parts I and II.

AUDIOVISUAL MATERIALS

6.1 Transparency: *Problem-Solving*.

6.5 Film: *Writing Better Business Letters* (2nd ed.). Division of Instructional Media and Technology, Virginia Department of Education.

CONCEPT AREA

7. COMMUNICATING TECHNICAL INFORMATION

ERIC

CONCEPT AREA

7. Communicating Technical Information

TASK/COMPETENCY

7.1 Present technical information with charts, graphics, and symbols.

ASSESSMENT STANDARD

S7.1 Printout shows how engineering charts, graphics, and symbols aid in the solution of an assigned problem.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. Use mathematical symbols to express a relationship between two or more variables.
2. Use engineering graphics to show the specific structure of an assigned area.
3. Apply formulas and theories to the calculation of forces and surface areas.
4. Show results of operations or calculations in charts.

ERIC

CONCEPT AREA

7. Communicating Technical Information

TASK/COMPETENCY

7.2 Use computer-aided design (CAD) software to prepare drawings.

ASSESSMENT STANDARD

S7.2 Assigned drawings are produced accurately by correct use of software.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. Follow the computer commands to prepare a drawing by using the menu to change functions.

2. Demonstrate the following functions:

   - Enlarge or reduce a drawing by zooming in and out.
   - Pan a drawing by moving it across the screen in any direction.
   - Locate and draw a circle by placing the pointer on the circle's center.
   - Draw lines.
   - Dimension drawings.

ERIC

CONCEPT AREA

7. Communicating Technical Information

TASK/COMPETENCY

7.3 Present technical information through computer-aided design and drafting.

ASSESSMENT STANDARD

7.3 Printout of correct drawings and computations shows selection and execution of appropriate CAD software.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. Identify software for drafting and problem solving.
2. Use CAD system for drafting.
3. Use appropriate computer software to calculate forces or solve similar problems.

ERIC

CONCEPT AREA

7. Communicating Technical Information

TASK/COMPETENCY

7.4 Use computer-aided manufacturing (CAM) software to simulate a manufacturing problem.

ASSESSMENT STANDARD

S7.4 Assigned manufacturing problem is solved correctly by correct use of CAM software.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. Introduce students to CAM software for simulation.

   - Demonstrate the mathematical concept of rotation by explaining what it means to rotate an object 45°, 90°, and 135°.

   - Assign individual students to work on computer at different times. Suggest all start on Test A.

   - Have students use a Product Sheet to design their own product on paper then try to produce it with a software program.

   - Investigate other programs and software.

2. Load software into the computer.

3. Input data or information where appropriate.

4. Observe and check results/output of computer program.

5. Identify uses and benefits of CAM.

6. Arrange for students to visit new industries that use CAM systems.

ERIC

CONCEPT AREA

7. Communicating Technical Information

TASK/COMPETENCY

7.5 Program computer-aided machines and numerical controls.

ASSESSMENT STANDARD

S7.5 Assigned manufacturing problem is solved correctly; CAM system performs to within .010 inch, and X, Y, and Z points for numerical control are established.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. Program a CAM.
2. Find X, Y, and Z quadrants.
3. Label the various points with letters, and establish distances from the origin point on X, Y, and Z quadrants.

ERIC

CONCEPT AREA

7. Communicating Technical Information

TASK/COMPETENCY

7.6 Write a technical report for an engineering activity.

ASSESSMENT STANDARD

S7.6 Written technical report meets all content and style criteria stated in instructor-provided guidelines.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. Work with English teachers to introduce or reinforce technical writing standards.
2. Explain proper writing style for an engineering report.
3. Identify the elements required for an effective engineering report.
4. Display samples of effective technical reports, and have students point out both content and style elements.
5. Help students access information for report, using on-line sources.
6. Construct outlines that illustrate content and chronology of reports in the proper form.
7. Ask students' English teachers to evaluate outlines and reports in terms of style and construction.

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ERIC

RESOURCES FOR

7. COMMUNICATING TECHNICAL INFORMATION

EQUIPMENT AND MATERIALS

7.1 Computer with applicable graphics software

7.2 Computer with applicable drafting software

7.3 Computer with applicable CAD software

7.4 Manufacturing problems
Computer with manufacturing simulation package

7.5 Manufacturing problems
Computer with manufacturing simulation/numerical control package

7.6 Instructor-prepared guidelines
Access to Internet
Sample technical reports

REFERENCES

Descriptive Geometry Workbook. Alkazin. Prakken Publications, Inc.
Disciplined Creativity for Engineering. Bailey. Ann Arbor Science, Butterworth Publishers.
Physics for Technology. Betts. Prentice-Hall.
"Fundamentals of Spatial Relationships," *Engineering Design Graphics*. Earle. Addison-Wesley.
"Basic Descriptive Geometry," *Mechanical Drawing*. French, et al. McGraw-Hill.
"Descriptive Geometry." *Basic Technical Drawing*. Spencer and Dygdon. Macmillan.

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CONCEPT AREA

8. BRIEFING OTHERS ON RESULTS OF ENGINEERING

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CONCEPT AREA

8. Briefing Others on Results of Engineering

TASK/COMPETENCY

8.1 Pre-register for competitive events.

ASSESSMENT STANDARD

S8.1 Pre-registration for a competitive event related to engineering problems must be completed according to TSA rules and standards.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. Interpret the rules and criteria for competitive events involving appropriate engineering problems.
2. Complete pre-registration forms for appropriate competitive events.
3. Prepare materials and problems solved for entry according to the standards of the event.
4. Add teachers and school name to mailing list for TSA, JETS, and various contests, and colleges, museums, or associations.
5. Help students understand the value of competition and the benefits of cooperation.

ERIC Full Text Provided by ERIC

CONCEPT AREA

8. Briefing Others on Results of Engineering

TASK/COMPETENCY

8.2 Participate in construction of a display of problem-solving activities.

ASSESSMENT STANDARD

S8.2 Individual assignment for group construction of display must be completed according to directions.

ENABLING OBJECTIVES/LEARNING ACTIVITIES

1. List ways for effective display of problem-solving activities completed in the course.

2. Design and organize display.

3. Select materials needed for display.

4. Design graphics and text for signs and posters, using computer graphics and CAD software.

5. Suggest possible display sites, such as malls, school board office, bank buildings, engineering firm offices, etc.

6. Obtain permission from proper authorities for date and location.

7. Write news release for local papers to announce the display, and list all students and their projects.

8. Prepare display for competition in regional, state, and national events according to contest criteria.

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RESOURCES FOR

8. BRIEFING OTHERS ON RESULTS OF ENGINEERING

EQUIPMENT AND MATERIALS

8.1 TSA contest rules and standards
Pre-registration forms

8.2 Instructor-prepared directions for individual assignments
Materials and equipment for display construction

REFERENCES

TSA Chapter Handbook. TSA National Office.
TSA Member Guide. TSA National Office.
1994-96 Curricular Resources Guide. TSA National Office.
TSA Rules and Criteria for Virginia and National Contests. Technology Education Service.

APPENDICES

A. Information and Resources

B. Organizing a School or Community Advisory Committee for the Engineering Class

C. Careers Slide/Tape Presentation

D. Library Book Order

E. Engineering Projects and Case Studies

F. Reference Materials for Student Use

G. Evaluation Techniques

H. Professional/Technical Societies and Student Associations

I. Laboratory Facilities and Equipment List

J. Engineering Activities (Bound Separately)

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APPENDIX A

INFORMATION AND RESOURCES

I. General Reference Books

Alkazin, D. M. *Descriptive Geometry Workbook.* Ann Arbor, MI: Prakken Publications, Inc., 1985.

Betts, John E. *Physics for Technology.* Reston, VA: Prentice Hall, 1981.

Kemper, John Dustin. *Engineers and Their Profession.* 3rd ed. New York: Holt, Rinehart and Winston, 1982.

_____. *Introduction to the Engineering Profession.* New York: Holt, Rinehart and Winston, 1985.

Kivenson, Gilbert. *The Art and Science of Inventing.* 2nd ed. New York: Van Nostrand Reinhold Co., Inc., 1982.

McCrory, David, and George R. Maughan. *Resources in Technology.* Worcester, MA: Davis Publications, Inc.

Meriam, J. L. *Engineering Mechanics Statics and Dynamics.* New York: John Wiley & Sons, 1978.

Morris, George E. *Engineering—A Decision-Making Process.* Boston: Houghton Mifflin, 1977.

Naisbitt, John. *MegaTrends.* Warner Books, 1984.

Pelegrino, Charles R., and Joshua Stoff. *Chariots for Apollo: The Making of the Lunar Module.* New York: Atheneum Press, 1985.

Red, W. Edward. *Careers in Engineering and Technology.* Belmont, CA: Brooks/Cole Division, Wadsworth, Inc., 1983.

Red, W. Edward, and Benjamin Mooring. *Engineering—Fundamentals of Problem Solving.* Belmont, CA: Brooks/Cole Division, Wadsworth, Inc., 1983.

Schwaller, Anthony E. *Energy Technology: Sources of Power.* Worcester, MA: Davis Publications, Inc., 1980.

Strakosk, George. *Vertical Transportation Elevators and Escalators.* New York: John Wiley & Sons.

Technical Communications. Technical Core Course available from The Center for Occupational Research and Development, 601C Lake Air Drive, Waco, TX 76107.

Thode, Bradley R. *Material Processing.* Albany, New York: Delmar Publishers, 1982.

VGM Career Horizons publications. Order from Goodheart-Willcox, 123 W. Taft Drive, South Holland, IL 60473:
Opportunities in Chemical Engineering.
Opportunities in Civil Engineering.
Opportunities in Electronic and Electrical Engineering
Opportunities in Engineering Technology
Opportunities in Mechanical Engineering.

Wulffson, Don L. *The Invention of Ordinary Things.* New York: Lothrop, Lee, and Shepard Books, 1981.

II. Magazines/Periodicals Related to Engineering and Technology

Aerospace. Aerospace Industries Association, 1725 DeSales Street N.W., Washington, DC 20036.

Air & Space. Air and Space Museum, Smithsonian Institute, Washington, DC 10560.

American Heritage of Invention and Technology. P.O. Box 52606, Boulder, CO 80322.

CAD Educator Bulletin. Autodesk Inc., 2320 Marinship, Sausalito, CA 94965.

CADalyst. CADalyst Publications, 282-810 W. Broadway, Vancouver, B. C., Canada V5Z 4C9.

Final Draft. Quarterly newsletter for AutoCAD users.

High Technology. Technology Publishing Co., 38 Commercial Wharf, Boston, MA 02110.

L5 News. L5 Society, 1060 East Elm, Tucson, AZ 85719.

The Lamp. Exxon Corporation, 1251 Avenue of the Americas, New York, NY, 10020-1198.

Manufacturing Forum. Department of Industrial Education and Technology, Ball State University, Muncie, IN 47306.

NASA Report to Educators. Educational Programs Office, NASA Headquarters, Washington, DC 20546.

NASA Tech Briefs. 41 E. 42nd Street, Suite 921, New York, NY 10017.

News in Engineering. College of Engineering, The Ohio State University, Columbus, OH 43210.

Popular Science. Subscription Department, Boulder, CO 80302.

Rhino Robots User Report. Rhino Robots, Inc., 3402 N. Mattis, P.O. Box 4010, Champaign, IL 61820.

SSI Newsletter. Space Studies Institute, 285 Rosedale Road, P.O. Box 82, Princeton, NJ 08540.

Science 95. (Title corresponds to current year.) Science 95 Subscription Department, P. O. Box 10790, Des Moines, IA 50340.

The Technology Teacher. A Journal of the International Technology Education Association. ITEA, 1914 Association Drive, Reston, VA 22091. (Journal is included in $50.00 membership fee in ITEA.)

3-D World. Cadkey, Inc., 4 Griffin Road, N., Windsor, CT 06095.

TIES Magazine, Trenton State College, Trenton, NJ. (Free)

III. Booklets and Catalogs for Problem-Solving Activities

Aerospace Engineers: We're Tomorrow-Minded People. Educational Programs Officer, NASA Administration, Washington, DC.

Aerospace Scientists. Educational Programs Officer, NASA Administration, Washington, DC.

The Art of Successful Invention. Washington, DC: Schlesinger. Kelly Wafner Associates, Inc., 1973.

Bracing Wood Trusses. Available from local building materials supplier.

A Catalog of Learning Resource Information. Autodesk, Inc., 2320 Marinship Way, Sausalito, CA 94965.

ERIC

Earthquakes. National Coordinating Center for Curriculum Development, College of Engineering and Applied Sciences, State University of New York at Stony Brook, Stony Brook, NY 11794.

Engineering and You. Brochure from JETS Guidance Department, 1420 King Street, Alexandria, VA 22314-2794.

The Engineering/High-Tech Student's Handbook: Preparing for Careers of the Future. David R. Reyes-Guerra and Alan M. Fischer with the editors of Peterson's Guides. Available in local library.

Engineering Library for Pre-College Students and Teachers (catalog of brochures, books, and videos). JETS, Department GF, 1420 King Street, Suite 405, Alexandria, VA 22314-2794.

Engineersmanship. Harrisberger. Monterey, CA: Brooks/Cole Publishing Co., 1982.

Experiments: Properties of Gas and Heat Energy. (Order No. N00085). Educational Programs, American Gas Association, Department PRO, 1515 Wilson Boulevard, Arlington, VA 22209.

Far Out Factories Manufacturing in Space. Weiss. New York: Lodestar Books,1984.

Flywheels. National Coordinating Center for Curriculum Development, College of Engineering and Applied Sciences, State University of New York at Stony Brook, Stony Brook, NY 11794.

Gas Centered Projects for Science Fairs. (Order No. N0045). Educational Programs, American Gas Association, Department PRO, 1515 Wilson Boulevard, Arlington, VA 22209.

Industrial Research Laboratories of the United States, 13th ed. Edited by Jacques Cattell Press. New York: R. R. Bowker Co., 1970.

Innovation. Free booklet from E. I, DuPont de Nemours, Public Relations, Chestnut Run, Wilmington, DE.

Inventions: The Complete Patented Works of R. Buckminister Fuller. St. Martins Press, 1983.

Odyssey of the Mind: Problems to Develop Creativity. Micklus. Glassboro, NJ: Creative Competitions, Inc., 1984.

Parliamentary Procedures at a Glance. Jones, Garfield O. Booklet from Hawthorn Books, Inc., 260 Madison Avenue, New York, NY 10016.

Problems! Problems! Problems! Micklus and Gourley. Glassboro, NJ: Creative Competitions, Inc., 1983.

Problems in Search of a Calculator. National Coordinating Center for Curriculum Development, College of Engineering and Applied Sciences, State University of New York at Stony Brook, Stony Brook, NY 11794.

Research/Penn State. Published quarterly by Penn State University, 114 Kern Building, University Park, PA 16802.

Robert Marllart's Bridges: The Art of Engineering. Billington. Princeton, NJ: Princeton University Press, 1979.

Software and Module Catalog. Hearlihy & Co., 714 W. Columbia Street, Springfield, OH 45504.

Technology Activities. Thomas A. Hughes Jr., Editor. The best project ideas from *The Technology Teacher,* April 1984.

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TSA publications. Order from TSA National Office, 1908 Association Drive, Reston, VA 22091:

TSA Curricular Resources Guide

TSA Member Guide ($25.00 for package of 30)

TSA Chapter Handbook.

Robots & Robotology. Warring. Blue Ridge Summit, PA: Tab Books, 1984.

Working with the Atom: Careers for You. Atomic Industrial Forum, Inc., 7101 Wisconsin Avenue, Bethesda, MD 20814-4891.

The World of Airplanes. Midwest Products Co., Inc., Hobart, IN 46342.

The World of Work. Free set of career education booklets on engineer, technician, etc., available from Educational Communications, General Electric Company, Fairfield, CT 06431.

The Young Engineer—An Annotated Bibliography 1890-1978. P. E. Gillespie, Editor. Accreditation Board for Engineers and Technology, New York, NY 10017.

Your Engineering Career Kit. Accreditation Board for Engineers and Technology, New York, NY 10017.

IV. Computer Software, Interfacing, and Applications

Bits and Pieces: Understanding and Building Computer Devices. Moth. New York: Charles Scribner's Sons, 1984.

Computer Applications in Technology. Barnes and Windham. Order from Ext. Instruction & Materials Center, The University of Texas, Austin, TX.

Computer Interfaces and Software. Vernier Software, 2920 S. W. 89th Street, Portland, OR 97220.

Computer Programs for Industrial Arts/Technology Education. Sarapin and Post. Order from Goodheart-Willcox, 123 W. Taft Drive, South Holland, IL 60473.

Electronics Microcomputer Circuits. Tokheim.146 practical projects, $9.95. Hightstown, NJ: McGraw-Hill Book Company.

Electronics Kit. Unilab, Inc., 1604 Walker Lake Road, Mansfield, OH 44906.

Practical Things to Do with a Microcomputer. Tatchell and Cutter. Tulsa, OK: EDC Publishing, 1983.

Print Shop. Broderbund Software. Purchase Apple or IBM versions from local dealer.

Product Matrix and Catalog of Kits and Software. Modern School Supplies, Inc., P.O. Box 958, Hartford, CT 06143.

Rapid Access Technology Software. Shopware Education Systems, 101 Hill Road, Aberdeen WA 98520.

Rocky's Boot (a simulation game that teaches digital logic systems). Order from dealer or software catalog.

Scientific Measurements. MP 040 D-A, Apple II, IIe Disk. Program offers examples and exercises in reading three instruments: Graduate Cylinder, Metric Ruler, and Triple Beam Balance. Micro Learningware, Hwy 66 S., Box 307, Mankato, MN 56002-0307.

Scientific Method. MP 049 D-A, Apple II, IIe Disk. Program leads student through experiment simulations on Observation, Generalization, Measurement, and Verification. Micro Learningware, Hwy 66 S., Box 307, Mankato, MN 56002-0307.

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Simple Machines. MP 051 D-A, Apple II, IIe Disk. Program covers six machines: Lever, Pulley, Wheel, and Axle, Inclined Plane, Wedge, and Screw. Micro Learningware, Hwy 68 S., Box 307, Mankato, MN 560020-0307.

Three Mile Island (a simulation game concerning power plant control systems). Obtain from dealer or catalog.

V. Films and Videotapes

Aerospace Resources International, P. O. Box 5872, Friendship Station, Washington, DC 20016-1472:

Space (Related AVs and Posters) Catalog.

AIT, P. O.Box A, Bloomington, IN 47402:

Art of Learning Grades 9-12. Six 20-minute programs for high school students preparing to go to college.

Calculus Grades 12-College. Twenty-one 30-minute programs for a complete course.

Math Topics Grades 10-12. Ten 20-minute programs providing a bridge between pencil and paper math lessons and the actual uses and applications of mathematics.

You, Me, and Technology series. High school, college students. Twelve 20-minute programs on the tradeoffs between the costs and benefits of technological innovation.

American Iron and Steel Institute, 1000 16th Street N. W., Washington, DC 20036:

The Science of Steelmaking. Free filmstrip.

Division of Instructional Media and Technology, Virginia Department of Education, P.O. Box 2120, Richmond, VA 23216:

Effective Writing

Research Skills

Writing Better Business Letters

Your Study Skills.

Educational Programs Office, NASA Langley Research Center, Mail Stop 145B, Technical Library, Hampton, VA 23665:

NASA Film Catalog. Teachers may also send blank tapes for duplicating almost all movies.

Lucerne Media, 37 Ground Pine Road, Morris Plains, NJ 07950:

Metals and Alloys.

Films, Inc., Preview Library, 144 Wilmette Avenue, Wilmette, IL 60091:

Using Materials (#548-6314)

Combining the Principles (#548-6332-7).

Karol Media, 22 Riverview Drive, Wayne, NJ 07470:

Phillips Search for Solutions. Series of nine movies or videos on problem solving as related to almost any area of science and technology.

Library Filmstrip Center, 608 E. Locust Street, Bloomington, IL 61701:

CAD/CAM Technology. Six filmstrips/cassettes.

Robotics Filmstrip Series. Titles on industry, subsystems, applications, and human factors; six filmstrips/cassettes for $210.00.

Manufacturing Forum, Ball State University, Muncie, IN 47306:
Product Design.

Modern Talking Picture Service, 5000 Park Street, N., St. Petersburg, FL 33709:
The Original Recyclers. (#24974, 10 min.)
Pre-Engineering. (#154, 26 min.)

National Geographic Society, Education Services, P.O. Box 98019, Washington, DC 20090-8019:
Technology's Price (25 min.)

Phillips Petroleum Co., C-25 Phillips Building, Bartlesville, OK 74004:
The Search for Solutions. Series of videotapes including "Adaptation," "Trial and Error," and "Context."

Society of Manufacturing Engineers, Education Department, One SME Drive, P. O. Box 930, Dearborn, MI 48121:
Leadership and Productivity. Innovations in manufacturing, CAD, and CAM; 25-minute 16 mm film.
Robotics Filmstrip Series. Titles on industry, subsystems, applications, and human factors; six filmstrips/cassettes for $210.00.

Technology Education Service, Virginia Department of Education, P. O. Box 2120, Richmond, VA 23216-2120:
The Challenge of Manufacturing. Sponsored by SME.

University of Illinois Film Library, 1325 S. Oak Street, Champaign, IL 61820, 1-800-367-3450:
It Couldn't Be Done. Rental fee $27.00.
The Flight of the Gossamer Condor. Rental fee $19.00.

Virginia Department of Education, P.O.Box 2120, Richmond, VA 23216:
Audiovisual Materials Catalog for Virginia Public Schools. Available in school library; see films and video tapes listed in the Technology Education section.

VI. Math, Science and Technology Resources

Betts, John E. *Physics for Technology*, 2nd ed. Reston, VA: Reston Publishing Co., Inc., Prentice-Hall.

Benchmarks for Science Literacy, Project 2061. American Association for the Advancement of Science, New York: Oxford University Press, 1993.

Boyce, et al. *Mathematics for Technical and Vocational Studies.* New York: John Wiley & Sons, 1982. Shop examples, trigonometry, and problems in geometry construction and protractor.

Earle, James H. *Fundamentals of Spatial Relationships.* Reading, PA: Addison-Wesley, 1973.

Ferguson and Ferguson. *Trigonometry in Action.* Portland, ME: J. Weston Walch,1981.

French, Vierck, Helsel, and Vrbanick. *Mechanical Drawing.* New York: Gregg/McGraw Hill, 1990.

Gehring, Gary B. "Making Vector Analysis Easier." *School Shop*, May 1983.

Harmin, Merrill. *Inspiring Active Learning: A Handbook for Teachers.* Alexandria, VA: Association for Supervision and Curriculum Development, 1994.

Hood, George J.; Palmerlee, Albert S.; and Baier, Charles J. *Geometry of Engineering Drawing*, 5th ed. New York: McGraw-Hill Book Company, 1969.

How Can I Get in Touch With Project Sci-Math? Helps students apply mathematics to science and other practical areas. Modules 1 and 2 also have Teacher's Guides.

Write for details to Sci-Math Curriculum, Area Cooperative Education Services, 295 Mill Road, North Haven, CT 06473.

Introduction to Graph Theory with Applications. National Science Foundation, 1983.

Investing in Our Future (Science, Math, Engineering, and Technology Education). Office of Science and Technology Policy, The White House, Washington, DC 20500.

Mathematics in Electricity. Solves math problems with electrical circuits. Order from Technology Education Service, Virginia Department of Education.

Mathematics, Science, and Technology Education Programs That Work. National Diffusion Network, U. S. Department of Education, Washington, DC 20208-5645.

Math/Science/Technology Projects for the Technology Teacher, 1985. Order from ITEA, 1914 Association Drive, Reston, VA 22091.

National Coordinating Center for Curriculum Development, College of Engineering and Applied Sciences, State University of New York at Stony Brook, Stony Brook, NY 11794:

Applied Algebra and Geometry Modules
Problem Formulation in Algebra Mixtures: Algebra and Chemistry
Using Geometric Logic
Mathematics Resource Guide
Problems in Search of a Calculator.

Pathways to Excellence: A Federal Strategy for Science, Mathematics, Engineering, and Technology Education. Order from NASA Education Division, 300 E Street, S. W., Washington, DC 20546.

Popowski, John D. *Mathematical Tools for Machine Technology.* North Scituate, MA: Breton Publishing Co., 1982.

Problem Solving in Algebra. Encyclopedia Britannica, 425 North Michigan Avenue, Chicago, IL 60611.

The Problem Solvers. Supplemental books for math and science. Sold in college bookstores, or order from Research and Education Associates, 505 Eighth Street, New York, NY 10016.

Schaum's Outline Series. Supplemental books for math and science, sold in college bookstores.

Sci-Math: Modules 1 and 2. Menlo Park, California: Addison-Wesley Publishing Co., Innovative Division.

Science Activities. Source of experiments, explorations, and projects. Heldref Publications, Department 13-A, 4000 Albemarle Street N. S., Washington, DC 10016. Subscription $35.00.

Science for All Americans, Project 2061, American Association for Advancement of Science, 1989. (Also deals with math and technology) 1333 H. Street, N. W., Washington, DC 20005.

A Sourcebook of Application of School Math. Prepared by a joint committee of the Mathematical Association of America and the National Council of Teachers of Mathematics, 1980.

ERIC

Spencer, Henry C., and John T. Dygdon. *Basic Technical Drawing*. New York: Macmillan Publishing Co., 1980.

Technology: A Project 2061 Panel Report. AAAS, 1333 H Street, N. W., Washington, DC 20005.

Unified Technical Concepts for Physics. $24.00, Applications (lab manuals) Vol. I and II, $18.00 each. Order from The Center for Occupational Research and Development, 601C Lake Air Drive, Waco, TX 76710.

VII. Speakers, Tours, and Resource Persons

Bath County Pumped Storage Project, Virginia Power. P. O. Box 26666, Richmond, VA 23261.

Bell Atlantic. 703 East Grace Street, Richmond, VA 23219.

Bristol Steel & Iron Works, Inc. 300 Piedmont Street, P. O. Box 471, Bristol, VA 24201.

SME Member Relations, One SME Drive, P. O. Box 930, Dearborn, MI 48121:
Directory of SME Student Chapters/Units and Their Faculty Advisors
Directory of SME Chapters for Professionals.

National Technical Information Service. U. S. Department of Commerce, Operations Division, Springfield, VA 22151.

National Aeronautics and Space Administration. Langley Research Center, Educational Programs Office, Mail Stop 154, Hampton, VA 23365.

National Bureau of Standards. U. S. Department of Commerce, Route 270, Gaithersburg, MD 20234.

Virginia Department of Highways and Transportation. Offices located throughout the state.

Virginia VIEW Career Hotline, VPI & SU. 1-800-542-5870.

U. S. Patent Office. Washington, DC 20231.

Teacher education faculty or students from the following colleges may be available to speak to classes in their region of the state. Contact the Technology Education Department at the appropriate school:
James Madison University
Norfolk State University
Old Dominion University
Virginia State University
Virginia Tech.

Universities with engineering programs may allow high school students to visit their campuses and talk with students. Contact these universities to request help:
University ofVirginia
Virginia Commonwealth University
Virginia Military Institute
Virginia Tech.

APPENDIX B

ORGANIZING A SCHOOL OR COMMUNITY ADVISORY COMMITTEE FOR THE PRE-ENGINEERING PROGRAM

Advisory committees help many agencies and schools develop and maintain links with the community. A program advisory committee can serve the Pre-Engineering Program by

- introducing industrial and community leaders who want to help teachers and young people
- informing more people of the curriculum of technology education
- obtaining support and assistance for educational programs, such as speakers, supplies, equipment, and consultation with students on problem-solving projects/ideas.

An advisory committee may meet at the school in the afternoon. If more than one hour is needed, the meeting may be scheduled for the evening, for example, 7:00 or 7:30 p.m.

To organize a community advisory committee:

Step 1. Discuss the need with your principal and/or local supervisor/director.

Step 2. Make a list of engineers and other people in the region whom you know or have heard about. Watch the newspapers for people involved in the community and schools, or maybe a parent or friend of a friend.

Step 3. Visit or call each person to discuss how you would like them to meet you at the school and help with the program.

Step 4. Send out notice of the first meeting and location.

Step 5. Prepare an agenda and handouts, and distribute to people as they arrive at the meeting. Introduce people to each other.

Step 6. Share information, and ask for suggestions and help.

Step 7. Have students talk about their activities, projects, problems, and progress.

Step 8. Encourage committee to comment, commend, and contribute to students and program.

Step 9. Thank people for coming, and set tentative date to meet or see them again.

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In-School Consultants

This committee or team is composed of other teachers willing to assist students with interdisciplinary problem solving on engineering projects. The committee may include teachers from the fields of mathematics, physical and life sciences, social studies, and fine arts as well as a librarian and guidance counselor.

To establish the in-school consultant team:

Step 1. Obtain approval from the school principal.

Step 2. Determine purpose and function.

Step 3. Select members.

Step 4. Appoint members/consultants.

Step 5. Organize and manage the first meeting.

Step 6. Establish consultants' roles.

Step 7. Plan a program of work or a one- or two-year plan involving the committee on a continuous basis.

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Invitation to Membership

To members of the Community Advisory Committee:

We have invited you to help us motivate students to pursue careers in technology and engineering. You can help by meeting with the technology education teacher and others listed below who are on the Community Advisory Committee:

Engineers	____________
Technicians	____________
Community college program personnel	____________
Teacher education faculty	____________
Superintendent's office	____________
PTA or PTSO	____________
Associations such as SME or ASTME	____________
Service branches	____________
Education reporter for local newspaper	____________
Retired business and industry leaders	____________

To members of the In-School Consultants Team:

Many teachers in the school will be able to help motivate students and reinforce math and science through technology activities, projects, or problems. Some students will pursue technical careers, while others may choose engineering. School personnel listed below will be of great help as they consult, advise, and counsel technology education students.

School principal	____________
Science teacher	____________
Algebra teacher	____________
Geometry teacher	____________
English teacher	____________
Guidance counselor	____________
Librarian	____________
Other technology education teachers	____________

Meeting Suggestions

The committees should meet as often as necessary, but at least twice a year.

First meeting: During September or October, after students have started an activity

Final meeting: During May or June to observe Final Reporting Seminar when students present results and demonstrate projects, models, or products

APPENDIX C

CAREERS SLIDE/TAPE PRESENTATION

Engineering: An Introduction to the Field and Its Careers, developed by Dr. James A. Jacobs, Norfolk State University, is suggested as an aid to career exploration. The slides and script are available from the Technology Education Service, Virginia Department of Education, P. O. Box 2120, Richmond, VA 23216-2120.

The 35-minute presentation is divided into three parts. After viewing the program and participating in class discussion of its major points, the student should be able to achieve the following objectives. Presenting the objectives prior to each part of the program will enable students to focus their attention on the major content areas.

OBJECTIVES:

Part I

A. List five engineering specialties, and name a product, system, or procedure generated by each specialty.

B. Evaluate the field of engineering in terms of personal interests and aptitudes to determine what type of position may be desirable to begin career preparation.

C. Express a personal concern for society and the environment, then cite an example of how engineering may help to address the concern.

D. Determine which products or systems should be considered high or advanced technology and those that are products of standard engineering.

E. Illustrate the importance of standards and codes for engineering by describing two standards or codes that are indispensable to a modern technological society.

F. Cite at least four government agencies or technical societies that develop standards for engineering, and list a product, system, or procedure related to each.

G. Exhibit a positive attitude toward the field of engineering, and seek further information about the topics shown in the program.

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Part II

A. Define the following terms.

1. engineer
2. technician
3. craftsperson
4. scientist
5. technologist
6. standards
7. codes
8. modeling
9. high tech
10. systems
11. product
12. AAS
13. Tech Prep program

B. Describe the preparation normally required to enter career positions on the engineering team.

C. Evaluate the field of engineering in terms of personal interests and aptitudes to determine what type of position may be desirable to begin career preparation.

D. Exhibit a positive attitude toward the field of engineering, and seek further information about the topics shown in the program.

Part III

A. List four phases of the "engineering method."

B. Evaluate the field of engineering in terms of personal interests and aptitude to determine what type of position may be desirable to begin career preparation.

C. Exhibit a positive attitude toward the field of engineering, and seek further information about the topics shown in the program.

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APPENDIX D

LIBRARY BOOK ORDER

Bailey, Robert L. *Disciplined Creativity for Engineers.* Stoneham, Massachusetts: Ann Arbor Science, Butterworth Publishers, 1978.

Bame, E. Allen and Cummings, Paul. *Exploring Technology.* Worcester, Massachusetts: Davis Publications, Inc., 1988.

Beakley, George C. *Careers in Engineering and Technology.* 3rd ed. New York: Macmillan Publications, Inc., 1980.

Blotter, Thomas P. *Introduction to Engineering.* Somerset, New Jersey: John Wiley & Sons.

Furnas, C. C., and McCarthy, J. *The Engineer.* New York: Time-Life Books, 1971.

Hutchinson, John, and Karsnitz, John. *Design and Problem Solving in Technology.* Delmar, 1994.

Jacobs, James A., and Kilduff, Thomas F. *Engineering Materials Technology.* Englewood Cliffs, New Jersey: Prentice Hall, Inc., 1985.

Kemper, John Dustin. *Introduction of the Engineering Profession.* New York: Holt, Rinehart and Winston, 1985.

Krick, Edward V. *An Introduction to Engineering Concepts, Methods and Issues.* New York: John Wiley, 1976.

Morris, George E. *Engineering–A Decision-Making Process.* Boston: Houghton Mifflin, 1977.

Red, W. Edward. *Careers in Engineering and Technology.* Belmont, California: Brooks/Cole Division, Wadsworth, Inc., 1983.

Red, W. Edward, and Mooring, Benjamin. *Engineering–Fundamentals of Problem Solving.* Belmont, California: Brooks/Cole Division, Wadsworth, Inc., 1983.

Schwaller, Anthony E. *Energy Technology: Sources of Power.* Worcester, Massachusetts: Davis Publications, Inc., 1980.

Unified Technical Concepts–Physics for Technicians. 2nd ed. The Center for Occupational Research and Development, 601C Lake Air Drive, Waco, Texas 76710, 1984.

High School Project Engineering. JETS, Dept. GF, 1420 King Street, Suite 405, Alexandria, VA 22314-2794.

Science Interactions. Glencoe, 1993.

Mathematics Interactions. Glencoe, 1993.

APPENDIX E

ENGINEERING PROJECTS AND CASE STUDIES

I. Case Studies

Engineering Case Library. A 55-page catalog of case studies designed for classroom use in various engineering disciplines. Send $2.00 for catalog to American Society for Engineering Education, 11 DuPont Circle, N. W., Suite 200, Washington, DC 20036. Also request publications list.

10 Cases in Engineering Design by H. O. Fuchs and R. F. Steidel, Jr. Longman, 1973.

II. Space Projects

NASA Tech Briefs. NASA, 41 E. 42nd Street, Suite 921, New York, NY 10017.

Solar Sail Project. A spacecraft under development for future investigations of solar system. Write for more information to the Secretary, D-130, World Space Foundation, P. O. Box Y, South Pasadena, CA 91030.

III. Engineering Projects

Principles of Engineering–Case Study Activities. New York State Department of Education, Technology Education Office, Albany, NY 12234.

Making Steel With Money. Free filmstrip from American Iron and Steel Institute, 1000 16th Street, N. W., Washington, DC 20036.

IV. Energy Projects

Teacher's Kit on Nuclear Energy. Free kit from Atomic Industrial Forum, Inc., 7101 Wisconsin Avenue, Bethesda, MD 20814-4891.

Technical courses below available from The Center for Occupational Research and Development, 601C Lake Air Drive, Waco, TX 76710:

Energy Audits

Energy Production Systems

Introduction to Lasers

Energy Case Studies for Principles of Engineering. New York State Department of Education, Technology Education Office, Albany, NY 12234.

V. Civil or Construction Projects

Building the Arch. Jefferson National Expansion Memorial Association, 1976.

McCullough, David. *The Great Bridge.* New York. Simon & Schuster, 1983.

McCullough, David. *The Path Between the Seas.* New York: Simon & Schuster, 1977.

Soo Locks. Sault Sainte Marie, MI. U. S. Army Corps of Engineers, Detroit District.

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VI. Laser Projects

Kettlekamp, Larry. *Lasers, The Miracle of Light*. New York: William Morrow & Co., Inc., 1979.

Woods, H.P., J.R. Verboys, and G.A. Evans. *Lasers: Activities for the Classroom*. Worcester, MA: Davis Publications, 1990.

VII. Problem Solving

TransTech Catalog of Problem Solving. Activities from Creative Learning Systems, Inc., 16510 Via Esprillo, San Diego, CA 92127-1708.

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APPENDIX F

MATERIALS FOR STUDENT USE

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I. PHYSICAL PROPERTIES OF SELECTED MATERIALS

Physical Properties of Common Metals and Alloys

Metal or Alloy	Density at 20°C (grams per cm^3)	Specific Heat at 20°C	Melting Point Centigrade	Coefficient Linear Expansion at 20°C (per C° x 10^{-6})	Resistivity at 20°C (micro-ohms per cm)
Aluminum	2.7	0.21	659	26.0	2.82
Brass	8.6	0.992	900	19.0	7.0
Cadmium	8.65	0.55	321	28.8	7.62
Chromel 180	8.95	0.092	1100	16.1	29.8
Copper	8.9	0.091	1083	17.0	1.72
German Silver	8.4	0.094	1100	18.4	33.0
Gold	19.3	0.031	1063	14.3	2.44
Iron	7.8	0.115	1535	11.0	10.0
Lead	11.3	0.031	327	29.0	22.0
Magnesium	1.74	0.245	651	26.0	4.6
Manganin	8.4	.---	910	18.7	44.0
Nichrome Alloy	8.2	.---	1500	13.7	100.0
Platinum	21.4	0.032	1755	8.8	10.0
Silver	10.5	0.056	960	18.8	1.59
Tungsten	18.7	0.034	3400	4.3	5.5
Zinc	7.1	0.092	419	26.3	5.8

Physical Properties of Common Liquids

Liquid	Density at 20°C (grams per ml)	Specific Heat 15°C (cal/g-C°)	Boiling Point at 760mm Hg (°C)	Coefficient of Volume Expansion at 20°C (per C° x 10^{-3})	Index of Refraction for Sodium Light
Acetic Acid	1.05	0.468	118.1	1.071	1.37
Acetone	0.7908	0.52	56.2	1.49	1.36
Alcohol, Ethyl	0.789	0.56	78.5	1.12	1.36
Alcohol, N-Propyl	0.7796	0.586	97.2	0.956	1.33
Aniline	1.022	0.488	184.4	0.858	1.39
Benzene	0.879	0.406	80.1	1.24	1.50
Carbon Disulfide	1.263	.---	45.0	1.15	1.63
Carbon Tetrachloride	1.595	0.20	76.8	1.24	1.4664
Chloroform	1.50	0.234	6.13	1.27	1.4433
Ether, Diethyl	0.714	0.54	34.6	1.66	1.35
Glycerol	1.26	0.56	290.0	0.51	1.47
Mercury	13.6	0.033	357.0	0.182	1.62
Toluene	0.867	0.395	110.6	1.099	1.4961

II. PHYSICAL PROPERTIES OF BALSA WOOD

Specific Gravity: 0.13

Modulus of Elasticity: 364,000 #/Sq. In.

Modulus of Rupture: 25,400 #/Sq. In.

Flexure: 24,819 #/Sq. In.

Compression: 1138 #/Sq. In.

Tension: 700 #/Sq. In.

Bearing: 1586 #/Sq. In.

Compiled by ASCE (American Society of Civil Engineers)

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III. Periodic Table of The Elements

In the periodic table the elements are arranged in order of increasing atomic number. Vertical columns headed by Arabic numerals are called ***Groups***. A horizontal sequence of elements is called a ***Period***. The most active elements are at the top right and bottom left of the table. The staggered line (Groups 13-17) roughly separates metallic from non-metallic elements.

Groups--Elements within a group have similar properties and contain the same number of electrons in their outside energy shell.

- The first group (1) includes hydrogen and the alkali metals.
- The last (18) contains the ***inert*** gases.
- Group 17 includes the halogens.
- The elements intervening between groups 2 and 13 are called ***transition elements***.
- Short vertical columns without Arabic numeral headings are called subgroups.

Periods--In a given period the properties of the elements gradually pass from a strong metallic to a strong non-metallic nature, with the last number of a period being an inert gas.

LIGHT METALS (groups 1–2) — NON METALS (groups 13–17)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Hydrogen 1.0080 H 1																	Helium 4.003 He 2
Lithium 6.939 Li 3	Beryllium 9.012 Be 4											Boron 10.811 B 5	Carbon 12.01115 C 6	Nitrogen 14.007 N 7	Oxygen 15.999 O 8	Fluorine 18.998 F 9	Neon 20.183 Ne 10
Sodium 22.990 Na 11	Magnesium 24.312 Mg 12											Aluminum 26.981 Al 13	Silicon 28.086 Si 14	Phosphorus 30.974 P 15	Sulfur 32.064 S 16	Chlorine 35.453 Cl 17	Argon 39.948 Ar 18
Potassium 39.102 K 19	Calcium 40.08 Ca 20	Scandium 44.956 Sc 21	Titanium 47.90 Ti 22	Vanadium 50.942 V 23	Chromium 51.996 Cr 24	Manganese 54.938 Mn 25	Iron 55.847 Fe 26	Cobalt 58.933 Co 27	Nickel 58.71 Ni 28	Copper 63.54 Cu 29	Zinc 65.37 Zn 30	Gallium 69.72 Ga 31	Germanium 72.59 Ge 32	Arsenic 74.922 As 33	Selenium 78.96 Se 34	Bromine 79.909 Br 35	Krypton 83.80 Kr 36
Rubidium 85.47 Rb 37	Strontium 87.62 Sr 38	Yttrium 88.905 Y 39	Zirconium 91.22 Zr 40	Niobium 92.906 Nb 41	Molybdenum 95.94 Mo 42	Technetium (99) Tc 43	Ruthenium 101.07 Ru 44	Rhodium 102.91 Rh 45	Palladium 106.4 Pd 46	Silver 107.87 Ag 47	Cadmium 112.40 Cd 48	Indium 114.82 In 49	Tin 118.69 Sn 50	Antimony 121.75 Sb 51	Tellurium 127.60 Te 52	Iodine 126.90 I 53	Xenon 131.30 Xe 54
Cesium 132.90 Cs 55	Barium 137.34 Ba 56	57-71	Hafnium 178.49 Hf 72	Tantalum 180.95 Ta 73	Tungsten 183.85 W 74	Rhenium 186.21 Re 75	Osmium 190.2 Os 76	Iridium 192.2 Ir 77	Platinum 195.09 Pt 78	Gold 196.97 Au 79	Mercury 200.59 Hg 80	Thallium 204.37 Tl 81	Lead 207.19 Pb 82	Bismuth 208.98 Bi 83	Polonium (210) Po 84	Astatine (210) At 85	Radon (222) Rn 86
Francium 223 Fr 87	Radium (226) Ra 88	89-103	Unq 104	Unp 105	Unh 106	Uns 107	108	109	110	111	112	113	114	115	116	117	118

Lanthanum 138.91 La 57	Cerium 140.12 Ce 58	Praseodymium 140.91 Pr 59	Neodymium 144.24 Nd 60	Promethium (147) Pm 61	Samarium 150.35 Sm 62	Europium 151.96 Eu 63	Gadolinium 157.25 Gd 64	Terbium 158.92 Tb 65	Dysprosium 162.50 Dy 66	Holmium 164.93 Ho 67	Erbium 167.26 Er 68	Thulium 168.93 Tm 69	Ytterbium 173.04 Yb 70	Lutetium 174.97 Lu 71
Actinium 227 Ac 89	Thorium 232.04 Th 90	Protactinium (231) Pa 91	Uranium 238.03 U 92	Neptunium (237) Np 93	Plutonium (242) Pu 94	Americium (243) Am 95	Curium (247) Cm 96	Berkelium (249) Bk 97	Californium (251) Cf 98	Einsteinium (254) Es 99	Fermium (253) Fm 100	Mendelevium (256) Md 101	Nobelium (254) No 102	Lawrencium (257) Lr 103

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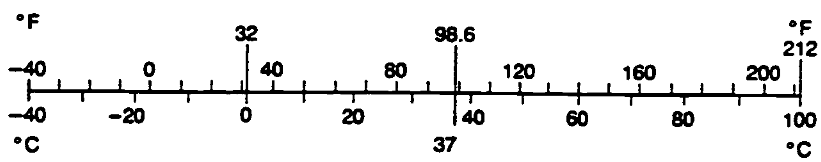
IV. METRIC CONVERSION TABLES

Conversions TO Metric Measures

	Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH	in	inches	2.54	centimeters	cm
	ft	feet	30.48	centimeters	cm
	yd	yards	0.9	meters	m
	mi	miles	1.6	kilometers	km
AREA	in^2	square inches	6.5	square centimeters	cm^2
	ft^2	square feet	0.09	square meters	m^2
	yd^2	square yards	0.8	square meters	m^2
	mi^2	square miles	2.6	square kilometers	km^2
		acres	0.4	hectares	ha
MASS (Weight)	oz	ounces	28	grams	g
	lb	pounds	0.45	kilograms	kg
		short tons (2000 lb)	0.9	tonnes	t
VOLUME	tsp	teaspoons	5	milliliters	ml
	Tbsp	tablespoons	15	milliliters	ml
	fl oz	fluid ounces	30	milliliters	ml
	c	cups	0.24	liters	l
	pt	pints	0.47	liters	l
	qt	quarts	0.95	liters	l
	gal	gallons	3.8	liters	l
	ft^3	cubic feet	0.03	cubic meters	m^3
	yd^3	cubic yards	0.76	cubic meters	m^3
TEMP. $°C = \frac{5}{9}(°F - 32)$	°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



Conversions FROM Metric Measures

	Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH	mm	millimeters	0.04	inches	in
	cm	centimeters	0.4	inches	in
	m	meters	3.3	feet	ft
	m	meters	1.1	yards	yd
	km	kilometers	0.6	miles	mi
AREA	cm^2	square centimeters	0.16	square inches	in^2
	m^2	square meters	1.2	square yards	yd^2
	km^2	square kilometers	0.4	square miles	mi^2
	ha	hectares (10,000 m^2)	2.5	acres	
MASS (Weight)	g	grams	0.035	ounces	oz
	kg	kilograms	2.2	pounds	lb
	t	tonnes (1000 kg)	1.1	short tons	
VOLUME	ml	milliliters	0.03	fluid ounces	fl oz
	l	liters	2.1	pints	pt
	l	liters	1.06	quarts	qt
	l	liters	0.26	gallons	gal
	m^3	cubic meters	35	cubic feet	ft^3
	m^3	cubic meters	1.3	cubic yards	yd^3
TEMP. $°F = \frac{9}{5}(°C + 32)$	°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F

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V. MATH/PHYSICS REFERENCE

Powers of Ten

Prefixes and symbols to form decimal multiples and/or submultiples.

Power of Ten	E Notation	Decimal Equivalent	Prefix	Phonic	Symbol
10^{12}	E+12	1 000 000 000 000	tera	ter'a	T
10^{9}	E+09	1 000 000 000	giga	ji'ga	G
10^{6}	E+06	1 000 000	mega	meg'a	M
10^{3}	E+03	1 000	kilo	kil'o	k
10^{2}	E+02	100	hecto	hek'to	h
10	E+01	10	deka	dek'a	da
10^{-1}	E−01	0.1	deci	des'i	d
10^{-2}	E−02	0.01	centi	sen'ti	c
10^{-3}	E−03	0.001	milli	mil'i	m
10^{-6}	E−06	0.000 001	micro	mi'kro	μ
10^{-9}	E−09	0.000 000 001	nano	nan'o	n
10^{-12}	E−12	0.000 000 000 001	pico	pe'ko	p
10^{-15}	E−15	0.000 000 000 000 001	femto	fem'to	f
10^{-18}	E−18	0.000 000 000 000 000 001	atto	at'to	a

Mechanics

Coefficient of Friction: $\mu = \frac{F}{N}$
μ = coefficient of friction
F = force of friction N = force normal to surface

Velocity: $v_{av} = \frac{d}{t}$
v_{av} = average velocity
d = distance traveled t = elapsed time

Acceleration: $a = \frac{v_f - v_i}{t}$
a = acceleration v_i = initial velocity
v_f = final velocity t = elapsed time

Newton's 2nd Law of Motion: $F = m \cdot a$
F = force m = mass a = acceleration

Law of Universal Gravitation: $F = G\frac{m_1 \cdot m_2}{d^2}$
F = force of attraction $m_1 \cdot m_2$ = product of masses
G = gravitational constant d = distance between their centers

Centripetal Force: $F = \frac{m \cdot v^2}{r}$
F = centripetal force
m = mass v = velocity r = radius of path

Pendulum: $T = 2\pi\sqrt{\frac{l}{g}}$
T = period l = length g = acceleration of gravity

Work: $W = F \cdot d$
W = work F = force d = distance

Mechanical Advantage: $IMA = \frac{F_E \cdot d}{F_R \cdot d}$ $AMA = \frac{F_R}{F_E}$
IMA = ideal mechanical advantage AMA = actual mechanical advantage
F_E = effort force
F_R = resistance force d = distance

Mechanical Equivalent of Heat: $W = J \cdot Q$
W = work J = mechanical equivalent of heat Q = heat

Energy

Kinetic Energy: $K = \frac{1}{2} m \cdot v^2$
K = kinetic energy m = mass v = velocity

Potential Energy: $V = m \cdot g \cdot h$
V = potential energy g = acceleration of gravity
m = mass h = vertical distance (height)

Relationship between Mass and Energy: $E = m \cdot c^2$
E = energy m = mass c = velocity of light

Light

Wave Formula: $v = f \cdot \lambda$
v = wave speed f = frequency λ = wave length

Uniformly Illuminated Surface: $E = \frac{\Phi}{A}$
E = illumination
Φ = luminous flux A = uniformly illuminated area

Images in Mirrors and Lenses: $\frac{S_o}{S_i} = \frac{D_o}{D_i}$
S_o = object size D_o = object distance
S_i = image size D_i = image distance

Focal Length of Mirrors and Lenses: $\frac{1}{f} = \frac{1}{D_o} + \frac{1}{D_i}$
f = focal length
D_o = object distance D_i = image distance

Index of Refraction: $n = \frac{\sin \Theta_i}{\sin \Theta_r}$
n = index of refraction
Θ_i = angle of incidence Θ_r = angle of refraction

Electricity

Electric Current: $I = \frac{q}{t}$
I = current q = quantity of charge t = time

Coulomb's Law of Electrostatics: $F = k\frac{q_1 \cdot q_2}{d^2}$
F = force between two charges
k = proportionality constant
$q_1 \cdot q_2$ = product of charges
d = distance separating charges

Capacitance of a Capacitor: $C = \frac{q}{V}$
C = capacitance of a capacitor
V = potential difference between plates
q = charge on either plate

Ohm's Law of Resistance: $E = I \cdot R$
E = emf of source I = current in the circuit
R = resistance of the circuit

Joule's Law: $Q = I^2 \cdot R \cdot t$
Q = heat energy I = current R = resistance t = time

Faraday's Law of Electrolysis: $m = z \cdot I \cdot t$
m = mass z = electrochemical equivalent
I = current t = time

Induced emf: Coil in a Magnetic Field: $E = -N\frac{\Delta\Phi}{\Delta t}$
E = induced emf N = number of turns
$\Delta\Phi/\Delta t$ = the change in flux linkage in a given interval of time

Induced emf: Conductor in a Magnetic Field: $E = B \cdot l \cdot v$
E = induced emf B = flux density of the magnetic field
l = length of conductor
v = velocity of conductor across magnetic field

Instantaneous Voltage: $e = E_{max} \sin \Theta$
e = instantaneous voltage
E_{max} = maximum voltage
Θ = angle between the plane of the conducting loop and the perpendicular to the magnetic flux (displacement angle)

Instantaneous Current: $i = I_{max} \sin \Theta$
i = instantaneous current
I_{max} = maximum current
Θ = displacement angle

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Mechanical Equivalent of Heat is the work required to produce a unit quantity of heat.

0.427 kilogram-meter (kg-m) = 1 calorie

$$\frac{\text{Work}}{\text{mechanical equivalent of heat}} = \text{heat}$$

VALENCES SHOWN BY COMMON RADICALS

Name	Symbol	Valence
Acetate	$C_2H_3O_2$	—1
Bicarbonate	HCO_3	—1
Bisulfate	HSO_4	—1
Carbonate	CO_3	—2
Chlorate	ClO_3	—1
Chromate	CrO_4	—2
Ferricyanide	$Fe(CN)_6$	—3
Ferrocyanide	$Fe(CN)_6$	—4
Hypochlorite	ClO	—1
Nitrate	NO_3	—1
Nitrite	NO_2	—1
Permanganate	MnO_4	—1
Phosphate	PO_4	—3
Sulphate	SO_4	—2
Sulphite	SO_3	—2

EXPONENTIAL NUMBERS

Multiplication by a positive power of 10 corresponds to moving the decimal point to the right; multiplication by a negative power of 10 corresponds to moving the decimal point to the left.

1.33×10^4 is 13,300

1.33×10^{-4} is 0.000133

Numbers expressed with powers of 10 cannot be added or subtracted directly unless the powers of 10 are the same.

$1.23 \times 10^4 + 1.23 \times 10^5 =$
$1.23 \times 10^4 + 12.3 \times 10^4 = 13.5 \times 10^4$

$1.23 \times 10^{-4} - 1.23 \times 10^{-5} =$
$1.23 \times 10^{-4} - 0.123 \times 10^{-4} = 1.11 \times 10^{-4}$

When the powers of 10 are multiplied, exponents are added; when divided, exponents are subtracted.

$(1.23 \times 10^4) \times (1.23 \times 10^5) =$
$(1.23 \times 1.23) \times (10^4 \times 10^5) = 1.51 \times 10^9$

$$\frac{1.23 \times 10^{-4}}{1.23 \times 10^{-5}} = \frac{1.23}{1.23} \times \frac{10^{-4}}{10^{-5}} = 1.00 \times 10$$

SOME ACID—BASE INDICATORS

Indicator	Color Change Acid	Basic
Alizarin Yellow	Yellow	Red
Bromocresol Green	Yellow	Blue
Litmus	Red	Blue
Methyl Orange	Red	Yellow
Methyl Red	Red	Yellow
Phenolphthalein	Colorless	Red
Thymol Blue	Red	Yellow

PRESSURES AND DENSITIES

Pressure $= \frac{\text{Force}}{\text{Area}}$

1 column of water 1 foot deep = 62.4 pounds per square foot. or 0.433 pounds per square inch. 1 column of water 1 centimeter deep = 1 gram per square centimeter.

Specific Gravity = number of times a substance is as heavy as an equal body of water, or Specific gravity (liquid) =

$$\frac{\text{Weight of Liquid}}{\text{weight of equal volume of water}}$$

Density $= \frac{\text{Weight}}{\text{Volume}}$

Pressure = depth × density, or force per unit area. An increase in pressure is transmitted equally through the liquid.

Specific Gravity (Solid) =

$$\frac{\text{Weight of Body}}{\text{loss of weight in water}}$$

OR Specific Gravity (Solid)

$$\frac{\text{Weight of Body}}{\text{weight of equal volume of water}}$$

One cubic yard of air weighs about 2 pounds. Atmospheric pressure at sea level = about 15 pounds per square inch.

DEFINITIONS: CONCENTRATION OF SOLUTIONS

1) Mole Fraction: The number of moles of solute per unit total moles of solution.

2) Molarity: The number of moles of solute per liter of solution.

3) Molality: The number of moles of solute per 1,000 g. of solvent.

4) Formality: The number of formula weights of solute per liter of solution.

5) Normality: The number of equivalents of solute per liter of solution.

BASIC LAWS AND TABLES

UNITS

Kilo—means one thousand
Centi—means one-hundredth
Milli—means one-thousandth
Micro—means one-millionth

1 Kilometer (km) = 1,000 meters = 0.621 mile

1 Meter (m) = 100 centimeters = 39.4 inches

1 Centimeter (cm) = 10 millimeters (mm) = 0.394 inches

1 Kilogram (kg) = 1,000 grams = 2.20 pounds

1 Gram (g) = 1,000 milligrams (mg) = 0.0353 ounce.

1 Liter (l) = 1,000 milliliters = 1.06 quarts

1 Milliliter (ml) = 1.000027 cubic centimeters (cc)

1 Atomic Mass Unit = 1.66×10^{-24}g

Avogadro Number = 6.0235×10^{23}

TEMPERATURE MEASUREMENTS

In scientific work, the Centigrade or Celsius (°C) and Kelvin (K) scales are most commonly used. The Kelvin scale is an absolute temperature scale, in which zero degrees ideally represents the lowest attainable temperature.

Comparison of Various Temperature Scales

(°F) Fahrenheit	(K) Kelvin	(°C) Centigrade
212°	373°	100°
32°	273°	0°
−459°	0°	−273°

Fahrenheit—Centigrade: Conversions

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

Boyle's Law:

$p_1 \times V_1 = p_2 \times V_2$ at constant temperature. Zero degrees Kelvin is the lowest possible temp.

In Kelvin absolute temperature scale: water boils at 373K, freezes at 273K.

Charles' Law: $\frac{V_1}{V_2} = \frac{T_1}{T_2}$ at constant pressure.

Combination of Charles' and Boyle's Laws:

$$\frac{V_1p_1}{T_1} = \frac{V_2p_2}{T_2}$$

When heated through one degree Centigrade, any gas expands 1/273 of its volume at 0 degrees Centigrade if the pressure remains constant.

One BTU is the heat required to raise the temperature of 1 pound of water through 1 degree Fahrenheit.

One Calorie is the heat required to raise the temperature of 1 gram of water through 1 degree Centigrade.

Specific Heat: heat required to raise the temperature of a unit mass of that substance through 1 degree. If q is total heat and m is mass, $q = m \times s \times (t_2 - t_1)$.

Heat of melting, or heat of fusion, L, is the quantity of heat needed to melt one unit weight of a substance without changing its temperature, or $q = m \times L$

80 calories of heat is required to melt 1 gram of ice without raising its temperature.

Boiling Point of Liquid: that temperature at which the vapor pressure is equal to the pressure above the liquid.

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VI. GLOSSARY OF ENGINEERING TERMS

1. ANALYSIS: Breaking up of any whole into parts to determine the relationship or functions of its parts; involves simplification of a real-life problem into manageable parts

2. ARTIFICIAL INTELLIGENCE: The property of a machine capable of reason by which it can learn functions normally associated with human intelligence

3. CASE STUDY: A compact, written description of an actual problem situation from industry that combines some of the technical detail with personal viewpoint; illustrates the interfaces between theory and practice

4. COMPUTER GRAPHICS: The application of the capabilities of a computer to the analysis and synthesis of engineering problems and the communication of solutions in a graphic format

5. DESCRIPTIVE GEOMETRY: A set of principles that enables the geometry of an object to be identified and delineated by graphic means; the theory by which spatial problems involving angles, shapes, sizes, clearances, and intersections are solved

6. DESIGN: The process of inventing physical things that display new physical order, organization, or form in response to function

7. DESIGN PROCESS (ENGINEERING DESIGN PROCESS): A system that establishes and defines solutions to and pertinent structures for problems not solved before, or new solutions to problems which have been solved in a different way

8. ENGINEER: A problem solver; a human link between the scientist and the consumer; one who takes knowledge into useful application, providing for human material needs and well-being; one who provides designs for the purpose of easing the burdens of physical toil and converting the materials and forces of nature to the use of all people

9. ENGINEERING: The profession in which a knowledge of the mathematical and natural sciences gained by study, experience, and practice is applied with judgment to develop ways to use, economically and with concern for the environment and society, the materials and forces of nature for the benefit of people

10. EXPERIMENTATION: A process that leads to discovery of something not previously known

11. FAILURE: A conduction caused by rupture, excessive deformation, or loss of required geometry through wear or corrosion so that the structure, device, or component can no longer fulfill its purpose; caused by design errors or deficiencies in the design or the selection of material, imperfections in material due to manufacture, overleading or other abuses in service, inadequate maintenance and repair, or environmental factors

12. FAILURE ANALYSIS: The definite procedure, usually requiring the efforts of a team of people, to determine the causes of a failure and propose corrective action, thus translating failure analysis into design knowledge

13. FLUID MECHANICS: The science concerned with fluids, either at rest or in motion; a branch of the study of the dynamics of non-rigid bodies

14. GRAPHIC ARTS: Those methods of applied arts used to form a visual end product that conveys information or is a decoration; includes drawing, painting, all types of printing, and book construction.

15. GRAPHICS: The art of drawing a three-dimensional object on a two-dimensional surface according to mathematical rules of projection; the application of graphic principles and practices to the solution of engineering problems; the language of engineers

16. HYDRAULIC: Operated or effected by the action of water or other fluid of low viscosity

17. INSPECTION: Determination of acceptance or rejection of a product based on a comparison of the attributes of a product with specifications

18. INVENTION: A new device, contrivance, or process devised or fabricated for the first time

19. MANAGEMENT: Supervision and control of personnel and resources required for the development and design of new technology products or processes; the making of decisions involving equipment, the labor force, and the financial assets of a company to produce a desirable product in a competitive environment or to conduct successfully a plant's operations

20. MANAGEMENT ENGINEERING: A main specialty area in industrial engineering concerned with the design, improvement, and installation of integrated systems of people, materials, and equipment

21. MATERIALS: A part of the matter in the universe; substances with properties which make them useful in structures, devices, machines, or products

22. MATERIALS SCIENCE: The study of the nature, behavior, and use of materials applied to engineering; an interdisciplinary study of chemistry, physics, and crystallography

23. MECHANICS: A branch of science that deals with the behavior of physical systems under the action of forces; divided into the study of statics and dynamics

24. MODEL: A concept, a mental picture, a graph, or a mathematical equation which helps to explain or understand observations; a human idea subject to change; something that describes a problem; an idealization of a real-world situation that aids the designer in the analysis of a problem; an aid to visualizing and thinking about a problem

25. MODELING: Describing a problem

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R26. PATENT: A certificate of grant by a government of an exclusive right with respect to an invention for a limited period of time

27. PROBABILITY: The likelihood of the occurrence of an event, measured by a formula

28. PROCESS: The means by which materials are made or transformed into a product

29. PRODUCT: Something made by industry; the completed objective of a project such as a new bridge

30. PROJECT: Usually an activity that produces a product over a long time duration; e.g., a new building

31. QUALITY ASSURANCE: Basically a method for managing quality control activities and ensuring that a viable quality control function is in operation; the total set of operations and procedures included within the production system, the goals of which are conformance of product output to design specifications

32. QUALITY CONTROL: Prevention of defects and the detection of product deficiencies; the statistical procedures employed in sampling production and monitoring the variability of the product

33. RESEARCH AND DEVELOPMENT (R & D): (a) Basic or pure research: expansion of existing knowledge; (b) Applied research: the search for a use for the discovery of new knowledge; (c) Development: the production of a process, system, or machines that will use the principles involved in the discovery and be commercially useful and profitable

34. SCIENTIFIC LAW: A general description of the behavior of matter

35. SCIENTIFIC METHOD: A progression of sequential events through which new scientific knowledge enlarges the body of existing knowledge, starting with existing knowledge and proceeding through scientific curiosity, hypothesis, logical analysis, acceptance as proof, and communication to the scientific community, completing a knowledge loop linking all components in the process

36. SCIENTIFIC PRINCIPLE: Description of a more specific behavior of matter than laws

37. STATISTICS: A branch of scientific method used in dealing with phenomena that can be described numerically for purpose of anaysis in order to base decisions on them; a body of methods for making wise decisions in the face of uncertainty

38. STATISTICAL ANALYSIS: Use of statistical tools as parameters, inferences, tests of hypotheses, confidence limits, and analysis of variance to develop known properties of statistical distribution of data which provides a basis for engineering decision making

39. STRUCTURE: (a) building, bridge, tank, highway, or similar item that is built or constructed and designed to sustain a load; (b) the configuration of elements that make up a whole

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40. SYNTHESIS: The process of modeling; assembly of the elements of a problem into a workable whole; a pulling together

41. SYSTEM: An entire combination of hardware, information, and people necessary to accomplish some specified mission

42. SYSTEM DESIGN: The techniques developed to ensure that all components of a design system work harmoniously as a coherent unit

43. SYSTEMS ENGINEERING: The design of a complex interrelationship of many elements (systems) to maximize an agreed-upon measure of system performance, taking into consideration all of the elements related in any way to the system

44. TECHNOLOGY: The application of science to achieve a practical goal or purpose

45. TESTING: A culminating activity in the development of products in which the structural and operational performance of a product is examined and serious flaws uncovered; the objectives of testing may be (a) to supply routine information on the quality of a product, (b) to develop new or better information or known materials or to develop new materials, or (c) to obtain accurate measures of fundamental properties

46. THERMODYNAMICS: A branch of physics that deals with the transformation (or reverse) of heat into other forms of energy, and with the laws governing such conversions

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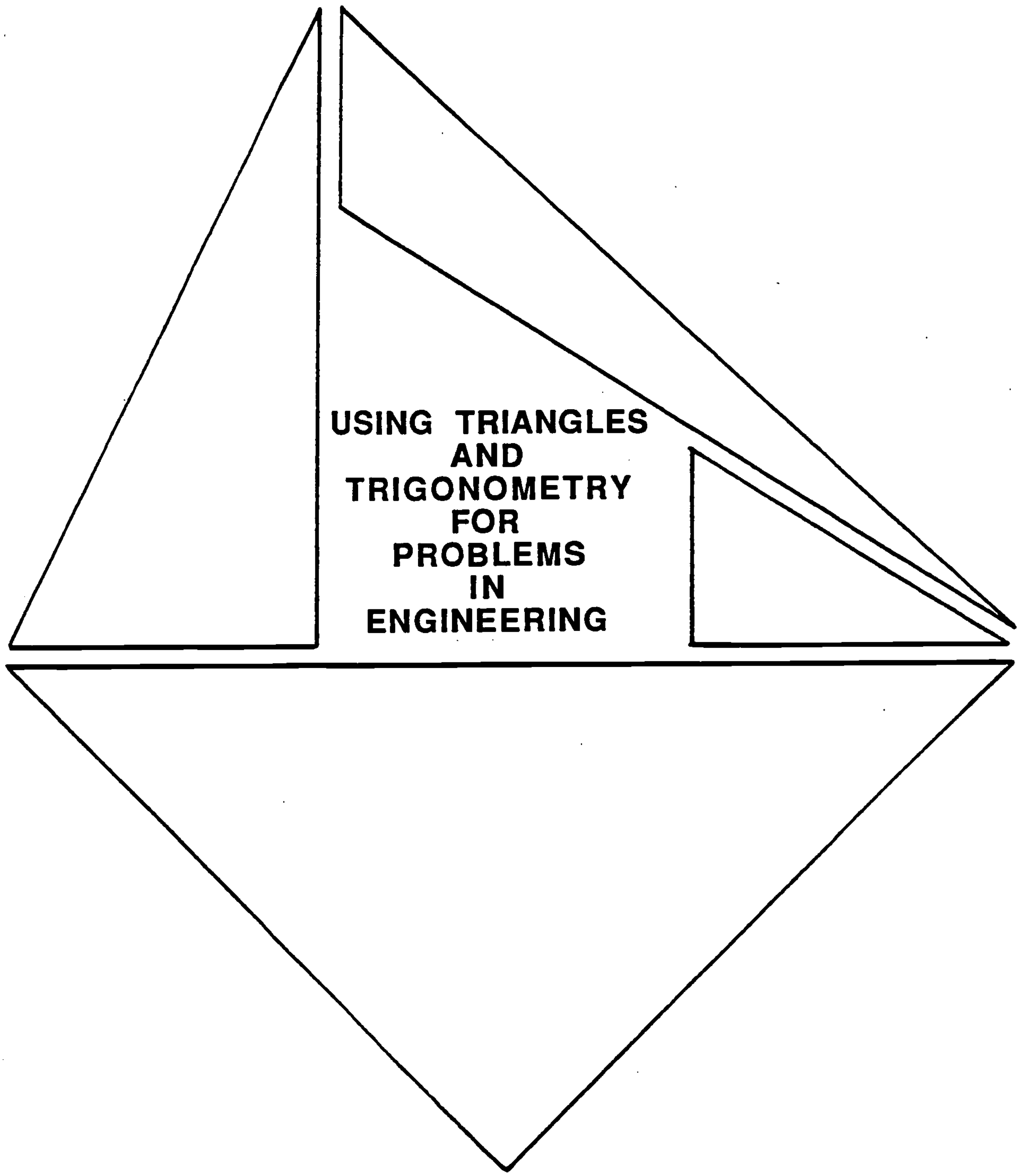
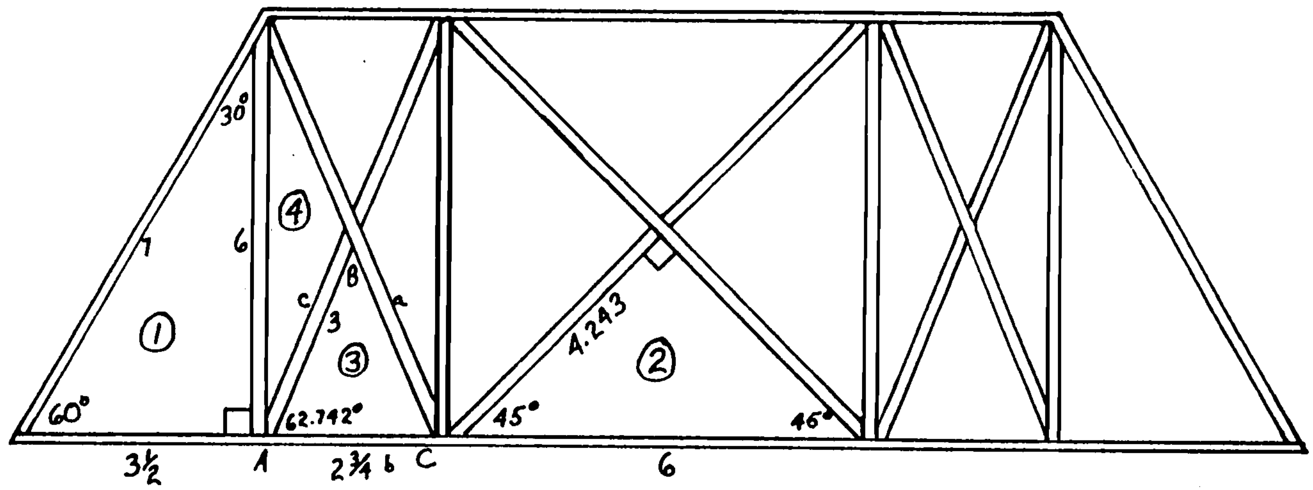
VII. TRIGONOMETRIC FUNCTIONS OF THE TRIANGLE



Instructions prepared by William C. Blough for the Introduction to Engineering Program at Buffalo Gap H.S.

TRIANGLES RELATED TO BRIDGE BUILDING

3/8 SCALE



TRIANGLE:

1. 30°, 60°, 90° Formula $2a = c$ $2 \cdot 3.5 = C$ $7 = C$

2. 45°, 45°, 90° Formula $a = \sqrt{2} \cdot X$ $\frac{a}{\sqrt{2}} = X$ $\frac{6}{\sqrt{2}} = X$ $4.243 = X$

3. Law of Cosines $a^2 = b^2 + c^2 - 2bc \text{ Cos } A$

$$\frac{b^2 + c^2 - a^2}{2bc} = \text{Cos } A \qquad \frac{2.75^2 + 3^2 - 3^2}{2 \cdot 2.75 \cdot 3} = \text{Cos } A \qquad .458 = \text{Cos } A$$

$62.742° = A$

$A = 62.742°$
$B = 54.516°$
$C = 62.742°$

4. $\angle A = 27.258°$
$\angle B = 125.484°$
$\angle C = 27.258°$

TRIANGLES

The solution of triangles and vectors is important to the engineering and building professions, because a triangle, unlike any other geometric form, is the only rigid structure. Any time its angle is changed, a member length must be changed to accommodate the angle change. Conversely, any time a member length is changed, an angle must be changed. Therefore, once a triangle is fixed, it will remain fixed unless it fatigues or is physically borken down by a force or pressure.

The square, on the other hand, can be subjected to forces which will cause it to change its intersecting angles, while the member lengths will remain the same. Angles can be changed in the same way within other geometric shapes as well, except for the triangle. For this reason, the triangle is the shape chosen for solving in trigonometry and by engineers for construction purposes.

Triangles can be divided into four categories:

(1) 30° - 60° - 90°

(2) 45° - 90°

(3) odd right triangle

(4) irregular triangle.

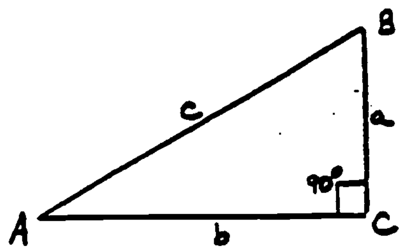
Each of the triangle groups above has a specific set of formulas for solving it. *Solving* means finding member lengths, angles, etc. Once you solve the triangle, then this will allow you to plot/solve vectors, which show the reultant force and direction of that force on the members.

In physics there are some useful facts about triangles that are used to solve problems about forces and velocities.

1. 30° - 60° - 90° right triangle. It is useful to remember that the hypotenuse of such a triangle is twice as long as the side opposite the 30° angle.

2. 45° - 45° - 90° right triangle. The sides opposite 45° angles are equal. The length of the hypotenuse is *l*•2, where *l* is the length of a side.

3. Trigonometric functions. These are ratios of the lengths of sides of a right triangle and depend on the magnitude of one of its acute angles. Using right triangle ABC below we define the following trigonometric function of $\angle A$



sine $\angle A = \frac{a}{b}$

cosine $\angle A = \frac{b}{c}$

tangent $\angle A = \frac{a}{b}$

These functions are usually abbreviated as sin A, cos A, and tan A.

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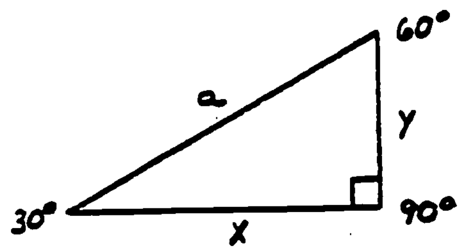
30° - 60° - 90° TRIANGLE

For right triangles like the 30° - 60° - 90° triangle, you must know two sides or one side and one angle to calculate.

Formulas:



Solving for the hypotenuse (H):

H = 2 • short side (y)

Solving for the long side (x):

long side (x) = $\sqrt{3}$ • short side (y)

Example:

Find the short side (y):

$x = 6$

$x = \sqrt{3} \cdot y$

$6 = \sqrt{3} \cdot y$

$\frac{6}{\sqrt{3}} = y$

$3.46 = y$

Find the hypotenuse (H):

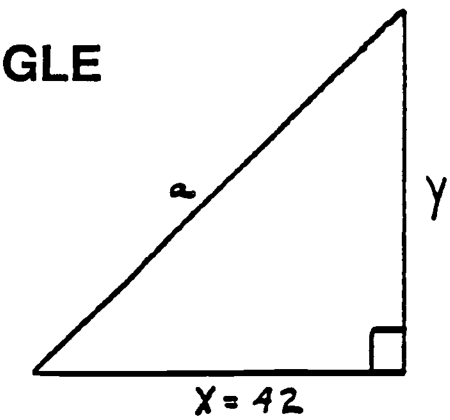
$a = ?$

$2 \cdot y = H$

$2 \cdot 3.46 = H$

$6.92 = H$

45° TRIANGLE



Formula:

If x is horizontal and y is vertical, with a as the hypotenuse, then $x = y$.

To solve for the hypotenuse (a):

$$a = \sqrt{2} \cdot x$$

Examples:

Find the hypotenuse (a):

$x = y$	$a = \sqrt{2} \cdot x$
$x = 42$	$a = \sqrt{2} \cdot x$
$y = 42$	$a = 59.39$

Find x/y when hypotenuse (a) is known:

$a = 10$

$a = \sqrt{2} \cdot x$

$10 = \sqrt{2} \cdot x$

$\frac{10}{\sqrt{2}} = x$

$7.07 = x$

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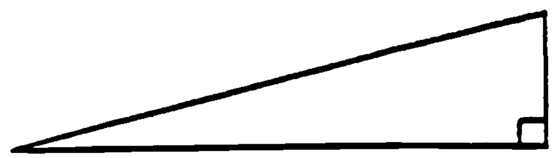
ODD RIGHT TRIANGLE



The total degrees in the angles of a triangle must equal 180˚. Therefore, $A + B + C = 180˚$.

To find the side lengths or member lengths, use the following formulas:

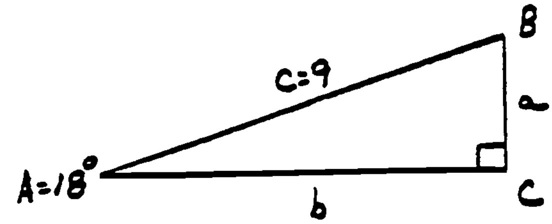
Name	Definition
sine	$\frac{\text{opposite side}}{\text{hypotenuse}}$
cosine	$\frac{\text{adjacent side}}{\text{hypotenuse}}$
tangent	$\frac{\text{opposite side}}{\text{hypotenuse}}$
Pythagorean Theorem	$c^2 = a^2 + b^2$ or $c = \sqrt{a^2 + b^2}$

Examples:

$A + B + C = 180°$

$180° - (A + C) = B$

$180° - (18 = 90) = 72°$



Solve for a:

$\text{Sin } A = \frac{a}{c}$

$\text{Sin } 18° = \frac{a}{9}$

$\text{Sin } 18° \cdot 9 = a$

$2.78 = a$

Solve for b:

$\text{Cos } A = \frac{b}{c}$

$\text{Cos } 18° = \frac{b}{9}$

$\text{Cos } 18 \cdot 9 = b$

$8.56 = b$

ODD RIGHT TRIANGLE (continued)

To solve using the Pythagorean Theorem:

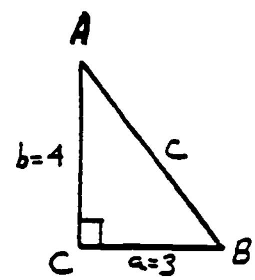
$c^2 = a^2 + b^2$

$c^2 = 3^2 + 4^2$

$c^2 = 9 + 16$

$c^2 = 25$

$c = 5$



Solve for c:

$$\text{Tan } B = \frac{\text{opposite side}}{\text{adjacent side}}$$

$$\text{Tan } B = \frac{b}{a}$$

$$\text{Tan } B = \frac{4}{3}$$

Tan B = 1.33

$\angle$ B = 53.13°

- Tan is a function to find the proportion of sides. When Tan B is remaining, use the ***inverse*** key and then the ***Tan*** key for the answer in degrees.

A = 180° - (B + C)

A = 180° - (53.13° + 90°)

A = 180° - 143.13°

A = 36.87°

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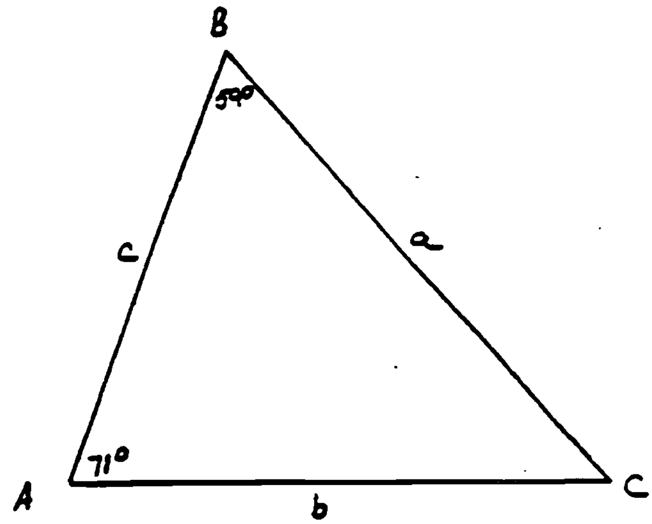
IRREGULAR TRIANGLE (no 90° angle)

To solve using the Law of Sines, you must know at least three parts of the triangle, and at least one of those parts must be a side.

Law of Sines: $\frac{a}{\text{Sin A}} = \frac{b}{\text{Sin B}} = \frac{c}{\text{Sin C}}$

Example:



$A + B + C = 180°$

$180° - (A + B) = C$

$180° - (71° + 59°) = C$

$180° - 130° = C$

$50° = C$

Solve for a:

$$\frac{a}{\text{Sin A}} = \frac{c}{\text{Sin C}}$$

$$\frac{a}{\text{Sin } 71°} = \frac{10}{\text{Sin } 50°}$$

$$a = \frac{10 \cdot \text{Sin } 71°}{\text{Sin } 50°}$$

$a = 12.34$

Solve for b:

$$\frac{b}{\text{Sin B}} = \frac{c}{\text{Sin C}}$$

$$\frac{b}{\text{Sin } 59°} = \frac{c}{\text{Sin } 50°}$$

$$b = \frac{10 \cdot \text{Sin } 59°}{\text{Sin } 50°}$$

$b = 11.19$

To solve the irregular triangle when all three sides are given, the Law of Cosines is used to find the angle.

Formulas:

$a^2 = b^2 + c^2 - 2bc \cos A$

$b^2 = a^2 + c^2 - 2ac \cos B$

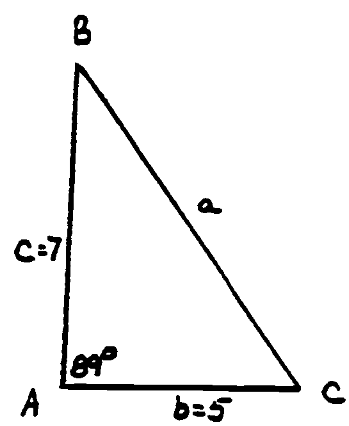
$c^2 = a^2 + b^2 - 2ab \cos C$

Example:

$\angle A = 89°$

$c = 7$

$b = 5$



Solve for a:

Step 1:

$a^2 = b^2 + c^2 - 2bc \cos A$

$a^2 = (5)^2 + (7)^2 - 2(5)(7) \cos 89°$

$a^2 = 25 + 49 - 70 \cdot \cos 89°$

$a^2 = 72.78$

$a = 8.5$

Step 2:

$\frac{a}{\sin A} = \frac{b}{\sin B}$

$\frac{8.5}{\sin 89°} = \frac{5}{\sin B}$

$\frac{8.5}{\sin 89.5} = \frac{5}{\sin B}$

$\frac{\sin 89.5}{8.5} = \frac{5}{\sin B}$

$.588 = \sin B$

$36.026° = B$

Step 3:

$A + B + C = 180$

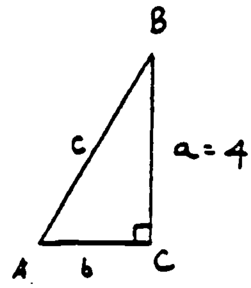
$180 - (A + B) = C$

$180 - (89° = 36.026°) = C$

$54.974° = C$

TRIANGLE PROBLEMS

1.



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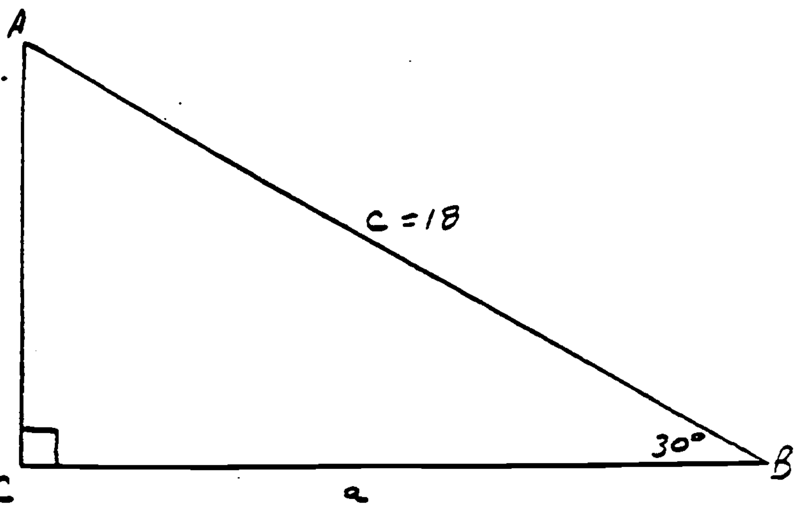

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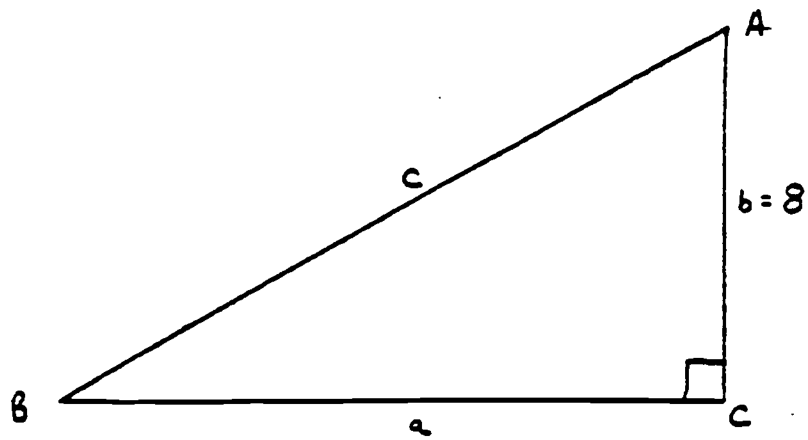

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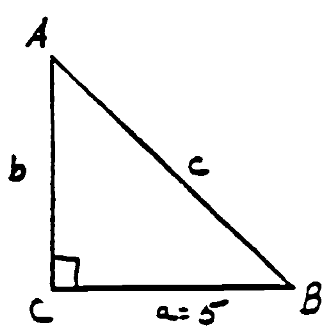

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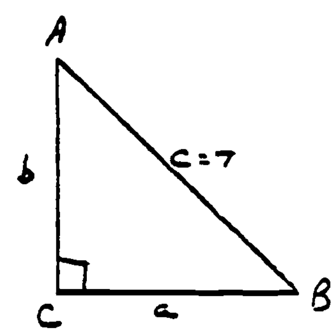

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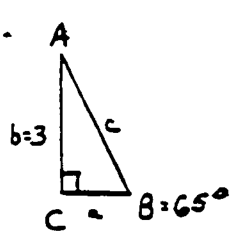

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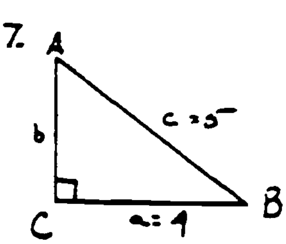

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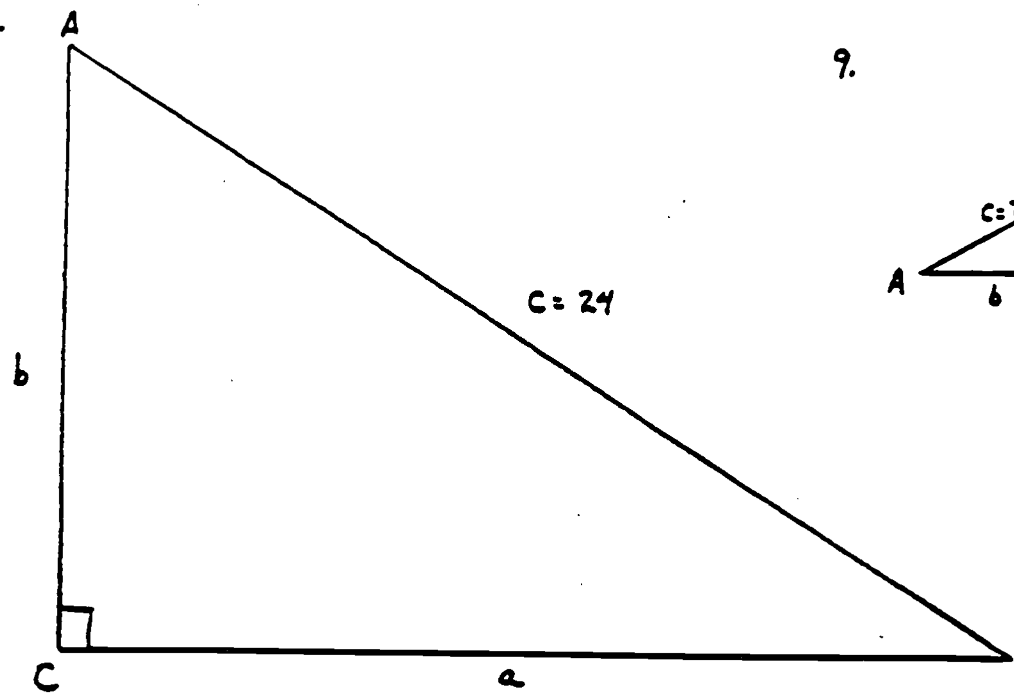

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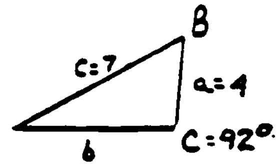

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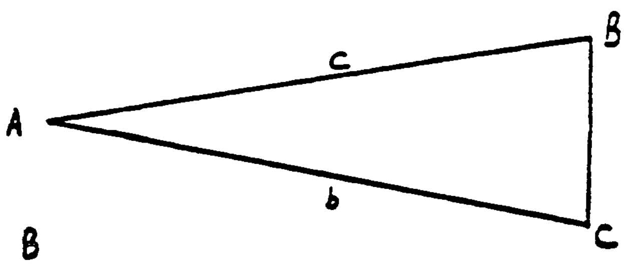

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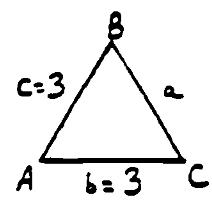

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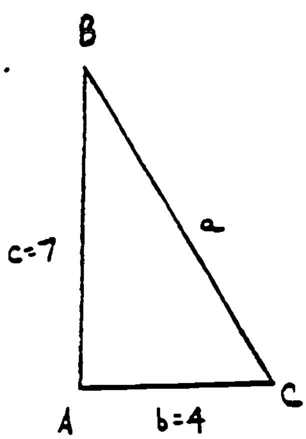

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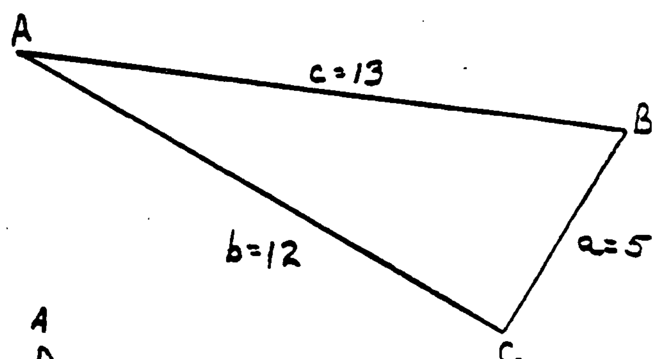

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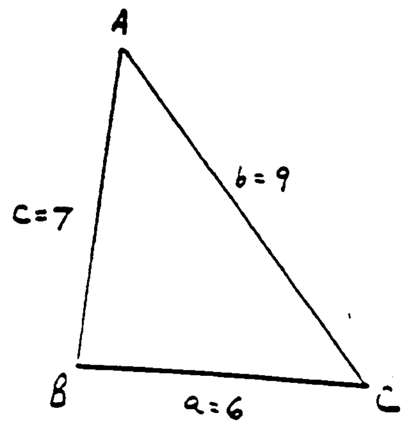

VIII. ENGINEERING APPROACH TO DESIGN PROBLEM-SOLVING STEPS

I. Formulate Problem and Criterion Statements

II. Identify Constraints to the Design

III. Identify or Invent Alternate Designs

IV. Analyze Factors that Affect Performance

V. Monitor Results for Optimization, Testing, and Implementation

These problem-solving steps were suggested by Dr. Thomas T. Liao, Professor and Chair, Department of Technology and Society, College of Engineering and Applied Sciences at SUNY-Stony Brook.

IX. WEEKLY LOG

STUDENT ENGINEER ____________ GRADE LEVEL ____________ FIELD OF ENGINEERING ____________

DATE	ACTIVITY	TIME
Monday ______		
Tuesday ______		
Wednesday ______		
Thursday ______		
Friday ______		

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XI. ENGINEERING PROBLEM/PROJECT

PROCESS	APPLICATION
State a problem.	• What could you do to improve a small table fan?
Collect information.	• It may be that the fan you use at home works well, but how well? • Find out how much air your fan produces. Calculate speed and volume. • How does your fan compare to your other fans, or those used by friends or relatives? • How much electricity does the fan use?
Create ideas and solutions.	• What are some ways you might try to improve your fan electrically? Mechanically? • Could you make the motor run faster? • Could you change the blades?
Make technical changes.	• Make the changes to a fan that will improve it. • Ask people or look for books to help. • Work safely with tools and machines.
Report the results.	• Use a chart to show results. • Write a technical report on your solution. • Present an oral report.

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APPENDIX G

EVALUATION TECHNIQUES

Sample Items for Student Feedback Instruments

In order to evaluate whether students have achieved the performance objectives of the Introduction to Engineering and Engineering Design and Development courses, the teacher should use a number of different types of feedback instruments. The instrument with greatest fidelity would be a problem-oriented design project that involves students in the application of engineering concepts and techniques. **Sample A** of this section provides an example that deals with the design of a solar collector. In order to carry out the project, students have to make use of the elements of design and decision making that are outlined.

After the completion of this program, it is also important to assess the general readiness of the students for college engineering studies. **Sample B** includes problems on a practice test that is modeled after the Minnesota Engineering Analogies Test (MEAT).

Periodic quizzes and examinations should also be given to monitor student progress in the course. Question formats should include multiple choice, short essays, and word problems. **Sample C** is a final examination that was used in a freshman engineering course, included as concrete examples of the type of questions that can be used. For testing to be effective, there must be a clean match between performance objectives and test questions.

Sample teacher-prepared problem-solving tests are illustrated in **Samples D** and **E**.

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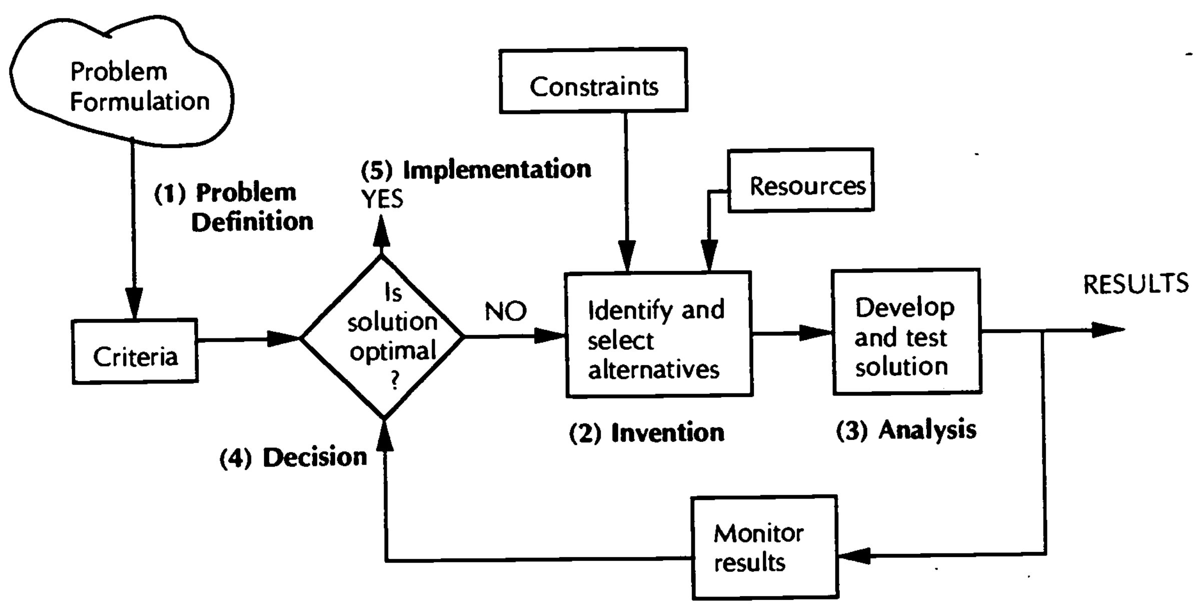
GUIDELINES FOR ENGINEERING DESIGN PROJECT

I. Overview

Your term project should involve the design, construction, and testing of a device or system for solving a technology-based problem. The following engineering approach to problem-solving should be applied:



II. Project Outline

1. General Problem Description
2. Criteria
3. Constraints
4. Resources
5. Potential Solutions to be Explored

III. Final Report Elements

1. Revised project outline
2. Description of final design (with diagrams) with performance information
3. Description of the process of optimization

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SAMPLE A
Continued

Engineering Design Project and Contest: Solar Collector

A. **Design criterion:** The objective is to design a system for heating water with solar energy. The criterion is to design a solar collector that can heat a cup of water to the highest temperature possible.

B. **Constraints:** The prototype solar collector must be designed within the following limitations:
   1. Maximum size: 1000 cm^3
   2. Maximum cost of materials: $5.00
   3. Maximum mass: 1/2 kg
   4. The amount of water to be heated is 200 ml(gram)

C. **Alternative designs:**
   1. Flat plate collector systems
   2. Concentration collector systems
   3. Photovoltaic collector systems

D. **Factors that affect the performance of solar collector systems:**
   1. Solar radiation variables, including energy and power densities and position of the sun
   2. Collector variables, including color of absorber, "greenhouse" phenomena, and type of insulation

E. **Optimization:** Analyze the factors that affect the performance of solar collectors and design a collector system that will
   1. Collect the most solar energy that can be used to heat water.
   2. Prevent the heated water from losing heat to its surroundings.

   Improvements in collector design should be based on testing of alternative design concepts. Keep a log of your design changes to include in your final report.

F. **Contest procedure:** Each collector will be left in the same sunlight for 30 minutes. The collector system that causes 200 ml of water to rise to the highest temperature will be the winner.

MINNESOTA ENGINEERING ANALOGIES TEST (MEAT)

Review Questions*

Directions: In each of the following questions, the analogies are presented in the A : B :: C: ________ format.
For example: Oak : tree :: iron: ________
(1) compound (2) element (3) steel (4) rust.

Element, number 2 of the four choices, is the correct answer because element is related to iron in the same way tree is related to oak. Iron is a type of element and oak is a type of tree.

You have an unlimited period of time to complete this 50-item test. Write the number corresponding to the correct answer in the blank provided.

1. America : Columbus :: Photoelectric emission of electrons: ________
(1) Plank (2) Einstein (3) Roentgen (4) Compton

2. Beta radiation : Electrons :: Gamma radiations: ________
(1) Protons (2) Neutrons (3) Helium atoms (4) Electromagnetic waves

3. $3x^2 : 6x :: 5y$: ________
(1) 5 (2) 10 (3) y (4) 10y

4. Displacement : Velocity :: y: ________
(1) derivative (2) rate of change (3) $\frac{dy}{dx}$ (4) momentum

5. A falling object accelerates uniformly at 9.8 m/sec^2.
Speed after 1 second : 9.8 m/sec :: Distance after 1 second: ________
(1) 9.8 m (2) 4.9 m (3) 19.6 m (4) 1 m

6. Frequency : Period :: Hertz: ________
(1) seconds (2) minutes (3) hours (4) days

7. Assume that a person is visiting different planets.
Variable : Constant :: Weight: ________
(1) Atmosphere (2) Sun (3) Size (4) Mass

8. Light vacuum : 3×10^8 m/sec :: sound in air: ________
(1) 3.3×10^1 m/sec (2) 3.3×10^2 m/sec (3) 3.3×10^3 m/sec (4) 3.3×10^4 m/sec

*These questions were contributed by Dr. Thomas C. Liao, SUNY at Stony Brook, as examples of the types of questions asked on the Minnesota Engineering Analogies Test. These specific problems do not appear on the test, which is protected under copyright.

SAMPLE B
Continued

Explanation of Answers for the MEAT Practice Test

1. **Answer (2)** Columbus discovered America while Einstein discovered that photons of light with sufficient amounts of energy can cause an electron to be emitted from the surface of a material.

2. **Answer (4)** Beta radiation is made up of electrons which have a negative charge. Gamma radiation is made up of high frequency electromagnetic waves.

3. **Answer (1)** 6x is the derivative of $3x^2$ and 5 is the derivative of 5y.

4. **Answer (3)** Velocity is the first derivative of displacement.

5. **Answer (2)** V = at

$$\therefore V = 9.8\ m/sec^2\ (1\ sec) = 9.8\ m/sec$$

$$D = 1/2\ at^2$$

$$\therefore D = \frac{9.8\ m/sec^2}{2}\ (1\ sec^2) = 4.9\ m$$

6. **Answer (1)** Frequency is measured in hertz or cycles/second. Therefore, Period (1/f) is measured in seconds.

7. **Answer (4)** The weight will vary because it depends on the pull of gravity of each planet. However, the mass will remain constant because it is a measure of the amount of material in a substance.

8. **Answer (2)** Speed of light in vacuum is 3×10^8 m/sec while the speed of sound in air is 3×10^2 m/sec.

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FINAL EXAMINATION

PART I - MULTIPLE CHOICE QUESTIONS

Select the most appropriate answer from the choices.

Questions 1-7 Directions: In each of the following questions, the analogies are presented in the A : B :: C: ________ format.
For example: Oak : tree :: iron: ________
(1) compound (2) element (3) steel (4) rust.

Element, number 2 of the four choices, is the correct answer because element is related to iron in the same way that tree is related to oak. Iron is a type of element and oak is a type of tree.

1. Energy : power :: Distance: ________
(a) Work (b) Speed (c) Displacement (d) Force

2. Battery : Flywheel :: Chemical Energy: ________
(a) Mechanical Energy (b) Heat Energy (c) Potential Energy (d) Nuclear Energy

3. A 100-watt bulb is on for 10 hours. Power : 100 watt :: Energy: ________
(a) 10 kilowatt-hours (b) 1 kilowatt-hour (c) 100 watt-hours (d) 10 watt-hours

4. Fusion : Fission :: Combination: ________
(a) Compound (b) Mix (c) Radioactivity (d) Split

5. A pot containing 2 kilograms of water is heated from 20°C to 30°C. Change in temperature: Heat gained :: 10°C: ________
(a) 10 kilocalories (b) 10 BTUs (c) 20 kilocalories (d) 20 BTUs

6. In the design of a binary adder, Carry Digit: And Gate :: Sum Digit: ________
(a) Nor Gate (b) Inclusive Or Gate (c) Exclusive Or Gate (d) Nand Gate

7. Binary : Octal :: 1010: ________
(a) 11 (b) 12 (c) 13 (d) 14

Questions 8-25 Directions: Circle the letter(s) beside the correct answer(s). Read each question carefully; some may have more than one correct answer.

8. Which of the following must be considered in order to evaluate whether electric vehicles can substitute for gasoline-powered vehicles?
(a) Range (b) Acceleration (c) Maximum speed (d) All of the above

9. A major disadvantage of lead-acid storage batteries is that (a) the energy density of lead-acid batteries is very low (b) they contain less explosive capability per kg (c) the acid in the batteries is poisonous (d) they emit highly toxic gases.

SAMPLE C
Continued

10. The economics of solar heating, as indicated by the length of the "payback" period, should improve in the future due to (a) a decrease in the cost of installing solar heating equipment (b) significant improvement in home construction (c) an increase in the cost of present fuels (d) an increase in home fix-it units.

11. A solar collector is located at 41° North latitude. It is tilted at an angle of 30° to the horizontal and faces due South. Which one of the following would increase the annual energy collected?
(a) Paint it a lighter color (b) Orient it so that it faces East (c) Move it to 60° North latitude (d) Increase the angle of tilt to 50°.

12. The primary difference between passive and active solar energy systems is that (a) passive systems do not require hardware (b) passive systems do not require an external source of energy (c) active systems have circulating fluids (d) active systems are more expensive.

13. In the 1980s the primary use of solar energy has been for (a) producing electricity for homes (b) producing electricity for industry (c) hot water and space heating (d) thermal energy for industry.

14. Companies such as LILCO are encouraging the development of electric vehicles because (a) they perform better than gasoline cars (b) they can use off-peak electricity (c) they are easier to maintain (d) they are good for stop-and-go driving.

15. In order to simulate the behavior of a system on a computer, you must have (a) a mathematical model relating system variables (b) an analog computer (c) a microcomputer (d) instructions for the user of the program.

16. Which two of the EST 192 assignments involve consideration of human factors (ergonomics)? (a) Building Accessibility for the Disabled and Human Power (b) Human Power and Yellow Light (c) Yellow Light and Building Accessibility for the Disabled (d) All of the above.

17. Which of the following is not a unit of power?
(a) calorie (b) watt (c) joules/sec (d) ft-lbs/sec.

18. In BASIC, the two commands that relate to the input of data are (a) LET and INPUT (b) INPUT and READ/DATA (c) READ/DATA and PRINT (d) INPUT and PRINT.

19-20. Digital computers function as a result of the interaction of five subsystems, namely (a) INPUT unit (b) OUTPUT unit (c) MEMORY unit (d) ARITHMETIC unit (e) CONTROL unit.

21. The 19th century Jacquard loom was an early precursor of which aspect of modern computers?
(a) Use of integrated circuits (b) Use of high-resolution graphics (c) Use of high-level languages (d) Use of stored programs

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SAMPLE C
Continued

22. Which of the following is <u>not</u> a feature of a program written in Assembly language? (a) Must be translated by an assembler before it is executed (b) Machine independent (c) Usually executes faster than a corresponding program in a high-level language (d) More difficult for a beginner to program than most high-level languages.

23. The ASCII code is a (a) means of setting up a correspondence between characters and groups of binary digits (b) computer programming language (c) set of Assembly language mnemonics (d) method for guaranteeing the security of computer systems.

24. Considerations of how to direct the system to add a number stored in a memory location to the number in the accumulator is likely to be of least interest to a person (a) programming in machine language (b) programming in Assembly language (c) programming in BASIC (d) designing a computer system.

25. The technique of viewing a programing problem as interconnected subproblems as a first attempt in solving the problem may be viewed as (a) top-down programming (b) bottom-up programming (c) unstructured programming (d) programming in a high-level language.

PART II - SHORT ESSAY QUESTIONS

I. When studying the performance of mechanical systems, Newton's three laws of motion are often used.

   A. Describe how Newton's first law of motion is used to explain why seat belts are needed.

   B. Explain how Newton's second law can be used to determine how the mass of a car affects its ability to accelerate.

   C. Use Newton's third law to explain why a car cannot accelerate on an icy surface.

II. Emerging technologies such as modern electric cars and solar energy systems will be widely used only if they can compete with the technology that they are designed to replace. Public acceptance will occur if both the cost is competitive and the performance is improved.

   A. 1. Describe one method of improving the range of electric cars.

      2. Discuss one development that would make electric cars more competitive economically.

SAMPLE C
Continued

B. Two types of solar systems are the solar hot water system and the photovoltaic system.

1. Describe the energy transformation that takes place in each system, and compare the efficiency of the two systems.

2. Which system is more or less cost/effective? Why?

III. Can solar energy be used to power electric cars? The solutions to the following problems will help you answer this question.

A. Given: Energy density of batteries is 35 watt-hrs/kg
Mass of bank of batteries is 200 kg

How much energy is needed to charge this bank of batteries fully?

B. On a sunny day if the average solar power density over a 7-hour period is 500 watt/m^2, how much electrical energy will be produced by 2 square meters of photovoltaic cells that are 10% efficient? (Show all work).

C. What percent of the total required battery energy (from III A) will the photovoltaic system (as used in III B) provide?

IV. Anyone who has flown in a commercial jet airplane is used to such statements as "the airplane is now cruising at 38,000 feet." Though this information is useful, one may still want to know what the altitude is in miles.

Complete the following BASIC program that is designed to print an altitude conversion table for 0 to 100,000 ft. in steps of 10,000 feet. (Remember 5,280 feet = 1 mile).

```
100 REM ALTITUDE CONVERSION
110 PRINT "ALTITUDE", "ALTITUDE"
120 PRINT "IN FEET", "IN FEET"
130 FOR F=0 TO ______ STEP ______
140 ____________
150 PRINT F, M
160 ____________
170 END
```

1st ANNUAL WEIGHT DROP

ASSIGNMENT

You are to design and construct an egg-protecting apparatus commonly referred to as an Egg Protector. You are to follow the rules listed below to exact specifications. Any deviation from the rules will result in your "Getting Egg Everywhere!" Just a little smashing experience!

REQUIREMENT

1. Structural Members: Toothpicks (either round or flat)
   Not to exceed 3 boxes (2,250 quantity)

2. Adhesive Material: Elmer's white glue

3. Size Specifications:
   a. Base - wood material not to exceed 12" square
   b. Structure Height - not to exceed 12"
   c. Structure Width - as wide as you desire

4. Testing Procedures:
   A. 7-pound ball will be dropped through a plastic plumbing tube (15' long).
   B. You will be given a choice as to which method of protecting the egg you desire:

      (1) Deflecting the Weight (good luck!)
      (2) Deflecting the Egg (almost as hard!)

   C. Your structure is to have a resting place for the egg directly under the tube.

   D. The weight will be dropped directly on the egg. You are to protect the egg by kicking it out of the way mechanically with toothpicks or deflecting the force of a 7-pound ball falling at a distance of 15'. (Calculate the force of impact of the weight to get a shock.)

   E. Grading Procedures:

      (1) A+ (No external damage to the egg shell)
      (No wise cracks!)
      (2) C+ (External lacerations of the egg shell)
      (No seepage through lacerations)
      (3) F+ (Total annihilation of the egg)
      (Scrambled eggs)
      (4) Each student will be given one attempt on
      (Date) ______________________________
      (5) All failures will be given (1) week to reconstruct their structures, if possible.
      (6) Second and final attempt will be held the following week.

Contributed by David Alkazin, Chantilly High School, Fairfax County Schools.

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SAMPLE D
Continued

WEIGHT DROP DATA SHEET

Weight Data

Type of weight used: ______________________________

Height of weight: ______________________________

Width of weight: ______________________________

Weight of weight used: ______________________________ grams

Falling distance: 15' or ______________________________ meters

Speed of weight: ______________ meters/sec. or ______________ mph

Impact force of weight: ______________________________

Toothpick Data

Modulus of elasticity of toothpick: ______________________ # / Sq. In.

Modulus of rupture of toothpick: ______________________ # / Sq. In.

Flexure of toothpick: ______________________________ # / Sq. In.

Compression of toothpick: __________________________ # / Sq. In.

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MID-TERM EXAM

PROBLEM:

Design, sketch, draw, and build a bridge that will span a distance of 6 inches and will be able to support a "Matchbox" car throughout the length. The car must start on an abutment and travel the length of the bridge to the other abutment. There must be a superstructure and/or substructure, i.e., it should look like a bridge and not a slab or tunnel. A sag of more than 0.25 inch will be considered a bridge structural failure.

GIVEN:

1 sheet graph and 1 sheet regular paper for sketch and drawing
Drafting equipment
2 sheets of 8.5 x 11 paper (93.5 sq. in./sht.) for construction (try to use less than one sheet)
1 foot of masking tape on plastic
Cutting board if needed to protect work surface
Scissors
Xacto knife or single-edge blade
1 "Matchbox" car–weight 1.5 oz. (Car belongs to my son and you will replace at a cost of $2.50 if damaged.)

GUIDELINES: (Read these very carefully.)

Make sketches on graph paper. Hint: Remember strongest geometric shapes.
Include name and date.
Drawing done with equipment–scale 1/2 inch = 1 foot
Front and side view required–top view optional
Title: (Exam Bridge) (Your Name) (Date) (Scale)
Use 1/8" guidelines 1/2" up from bottom.
The abutments should be 6" apart.
The roadway should be a minimum of 1.5" / with a 0.5" height.
Tape pieces should be a maximum of .75" in length, spaced 1.5" apart on any span. Hint: Use narrow 1/8" strips whenever possible.
Only layers of paper may be in contact at any one point except at single point contacts where braces or trusses are attached.
Tape used to attach bridge to abutment shall be no more than a single 1/8" strip.
Substructure may touch abutments but not work surface.

Consideration will be given to the amount of tape and paper returned. You must calculate the number of square inches of paper remaining* and measure the length of tape remaining. Write your name and number of square inches on the construction paper and turn it in with the remaining tape, your bridge with name on it, your sketch and drawing, the car, and construction equipment.

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*GRADE WEIGHTS: = 1 whole and/or 1 partial sheet

Sketch	10% (show initial through final planning stage)
Drawing	12% (accuracy, linework, lettering, neatness)
Bridge	30% to 45% (30+ = meets guidelines but experiences failure)
Returned Paper	10% (must show calculation; remaining sq. in.)
Returned Tape	5% (write length on returned paper and name on tape)
Question	10% (relate Engineer to each of three areas)

Contributed by Stephen Conrad, Harrisonburg High School, Harrisonburg City Schools.

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APPENDIX H

PROFESSIONAL-TECHNICAL SOCIETIES AND STUDENT ORGANIZATIONS

I. Professional-Technical Societies

Addresses for the following professional/technical societies were obtained from *Encyclopedia of Associations*, 3 Vol. (22nd edition), Karen E. Loek and Susan B. Martin, editors, 1988. Addresses of such associations are subject to change.

Accreditation Board for Engineering and Technology
345 East 47th Street
New York, NY 10017

Aluminum Association
900 - 19th Street, N. W., Suite 300
Washington, DC 20006
Phone (202) 862-5100
John C. Bard, President

American Iron and Steel Institute (AISI)
1000 16th Street, N. W.
Washington, DC 20036
Phone (202) 452-7100
James J. Hughes, Vice-President

American Society for Nondestructive Testing
4153 Arlingate Plaza
Caller #28518
Columbus, OH 43228
Desmond Dewey, Managing Director

American Society of Civil Engineers
345 East 47th Street
New York, NY 10017
Phone (212) 705-7496
Dr. Edward O. Pfang, Executive Director

American Society for Engineering Education
Suite 200
11 DuPont Circle
Washington, DC 20036
Phone (202) 293-7080

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American Welding Institute
R. R. 4, Box 90
Louisville, TN 37777
Phone (615) 970-2150
H. N. Vanderveldt, President

American Welding Society
P. O. Box 351040
550 LeJeune Road, N. W.
Miami, FL 33135
Phone (305) 443-9353
Paul W. Ramsey, Executive Director

Association for Integrated Manufacturing Technology (AIMT)
P. O. Box 1234
Beloit, WI 53511
Phone (608) 364-7949
Lamont Jenkins, Executive Director

National Association of Correction Engineers
P. O. Box 218340
Houston, TX 77218

National Society of Professional Engineers
1420 King Street
Alexandria, VA 22314
Phone (703) 684-2800
Donald C. Weinert, Executive Director

Society of Plastics Engineers (SPE)
14 Fairfield Drive
P. O. 403
Brookfield Center, CT 06805
Phone (203) 775-0471
Robert D. Forger, Executive Director

Society of the Plastic Industry (SPI)
1275 K Street, N. W., Suite 400
Washington, DC 20005
Phone (202) 371-5200
Charles E. O'Connell, President

The American Forestry Association
1319 18th Street, N. W.
Washington, DC 20036

The Metal Powder Industries Federation
105 College Road
East Princeton, NJ 08540

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The Metallurgical Society
420 Commonwealth Drive
Warrendale, PA 15086
Phone (412) 776-9000
Alexander R. Scott, Executive Director

Welding Research Council
345 East 47th Street
New York, NY 10017
Phone (212) 705-7956
Dr. G. W. Oyler, President and Executive Director

II. Student Organizations

Technology Student Association (TSA)

TSA is the national co-curricular student organization. It sponsors many activities and contests designed to enhance the study of technology. For further information, refer to Technology Education Service, Virginia Department of Education, Competitive Events Guidelines, or contact the TSA National Office, 1908 Association Drive, Reston, Virginia 22091.

Technology Student Association (TSA) in Virginia

TSA is also the Virginia co-curricular student organization affiliated with national TSA. Activities planned and executed both in and out of class promote the goals of technology education, and include school and community service projects as well as contests related to areas under study. For further information, contact the Technology Student Association Specialist, Technology Education Service, Virginia Department of Education, P. O. Box 2120, Richmond, Virginia 23216-2120.

Junior Engineering Technical Society (JETS)

JETS is a national organization for pre-college students of technology, engineering, mathematics, and science. Chapters are normally sponsored by industry and advised by an engineering or science professional. JETS sponsors both academic and technology application competitions, and is active in career guidance through its National Engineering Aptitude Search. For further information, contact JETS, Inc., 1420 King Street, Suite 405, Alexandria, Virginia 22314-2794.

APPENDIX I

LABORATORY FACILITIES AND EQUIPMENT LIST

The laboratory for the Pre-Engineering program should be a general or multipurpose facility similar to a Materials and Processes lab. The facility should be accessible to a technical drawing lab and electronics lab or have these stations within the general purpose area. The facility should include a scientific lab for experimentation and testing. A reference/resource area should be designated in an area within the lab, or in the drawing and planning area.

The equipment required for the program will include the equipment used in the Materials and Processes lab; however, additional "special" equipment will be needed.

SPECIAL EQUIPMENT FOR THE PRE-ENGINEERING PROGRAM

1. Computer Aided Drawing (CAD) System
2. Basic Electricity/Electronics Equipment
3. Electronic Test Equipment
4. Calculators (Electronic/Scientific)
5. Computer (386 or better) with graphics monitor and laser printer
6. Universal Tester
7. Laser (Class 2)
8. Balance Beam Scale (Digital)
9. Selected Audio Visual Equipment
10. Fischertechnik Model Building Equipment
11. Microscope (Metallurgical)
12. Special Safety Equipment
13. Pneumatic and Hydraulic Trainer
14. Camera Equipment (35 mm)
15. Electronic Timing Device
16. Plotter for AD Software
17. Interface Controls such as Smart Box EV, available from Modern School Supply

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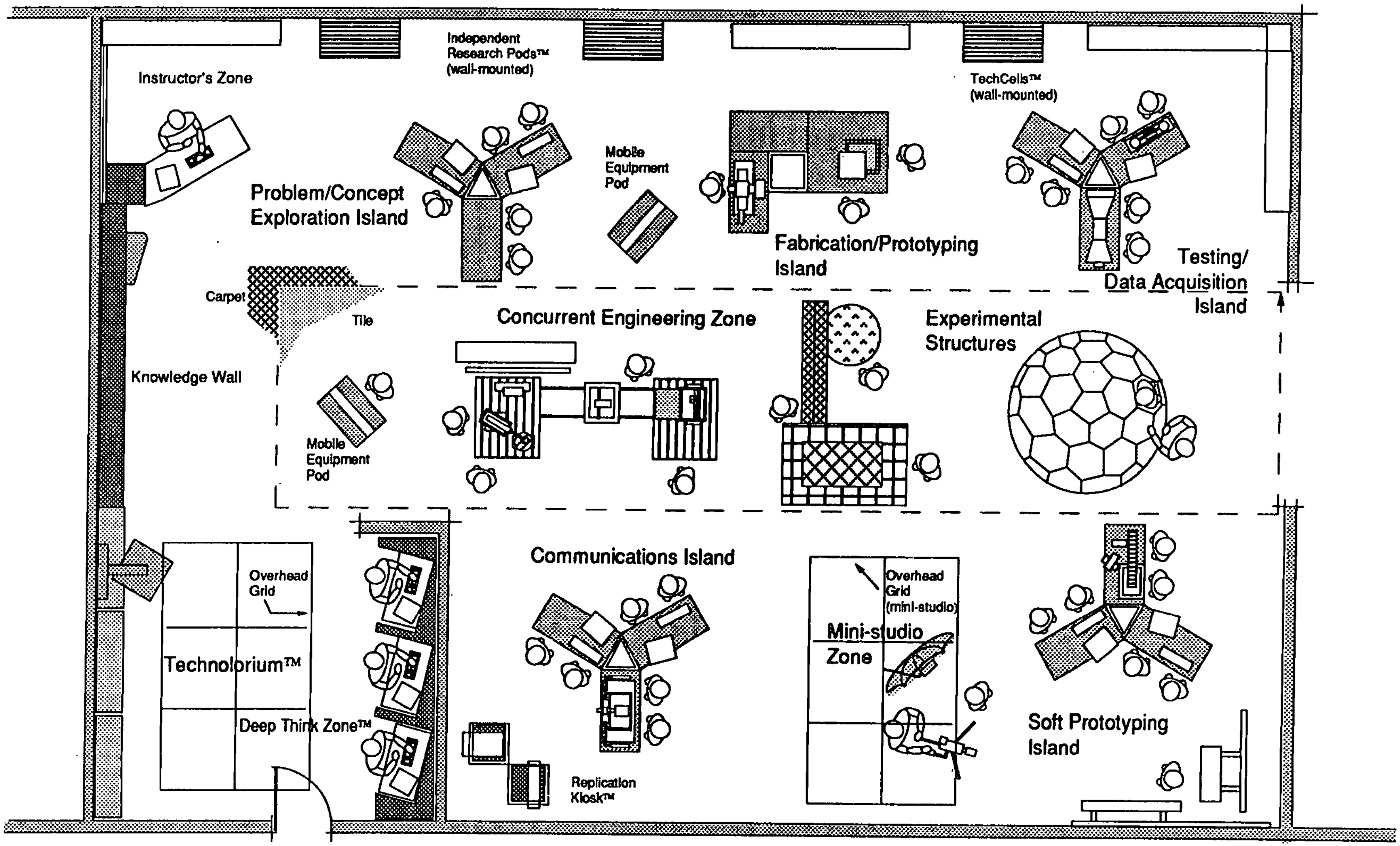

Durkin Designs

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