DOCUMENT RESUME

ED 374 218 CE 067 103

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TITLE Principles of Technology. Workshop Presenter's Handbook for Pennsylvania Educators.
INSTITUTION Temple Univ., Philadelphia. Center for Vocational Education.
SPONS AGENCY Pennsylvania State Dept. of Education, Harrisburg.
PUB DATE 93
NOTE 360p.
PUB TYPE Guides - Non-Classroom Use (055)

EDRS PRICE MF01/PC15 Plus Postage.
DESCRIPTORS *Classroom Techniques; High Schools; Industrial Arts Teachers; *Inservice Teacher Education; Laboratories; Mathematics Teachers; Science Teachers; *State Standards; Teaching Methods; *Technology Education; *Workshops
IDENTIFIERS *Pennsylvania; *Principles of Technology

ABSTRACT

This workshop presenter's handbook was developed to provide assistance to those who will serve as Principles of Technology trainers of science, industrial arts/technology education, and mathematics teachers throughout Pennsylvania. The handbook provides trainers with presentation materials, transparency masters, suggested activities, and selected resources to promote structure as well as facilitate the delivery of inservice training to those interested in teaching Principles of Technology. The handbook is organized in three parts. Part 1 (introduction) has the following sections: an overview of the Principles of Technology, Pennsylvania's role in the development of the Principles of Technology curriculum, the potential of the Principles of Technology materials to improve student knowledge levels, and an overview of the instructional design and structure of the Principles of Technology materials. Part 2 (implementation) provides materials to promote the development of skill in the set-up and completion of Principles of Technology laboratory sessions as stand-alone and infused demonstration lessons. Sample student lessons are included. Part 3 (logistics) contains a laboratory equipment list, a vendor list, and information on the following: specification writing, laboratory design and facilities, equipment fabrication plans, guidelines for laboratory management and grading, a safety supplement, and Pennsylvania teacher certification requirements for Principles of Technology. A Principles of Technology miniguide includes materials for conducting a public relations and community awareness campaign. (KC)

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PRINCIPLES OF TECHNOLOGY

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Workshop Presenter's Handbook for Pennsylvania Educators

Principles of Technology
A Workshop Presenters' Handbook for
Pennsylvania Educators

Prepared by

Chester P. Wichowski

at

The Center for Vocational Education
Professional Personnel Development

Temple University
Philadelphia, Pennsylvania

1993

This handbook was developed by using funds from the Carl D. Perkins Vocational and Applied Technology Education Act of 1990, P. L. 101-392 which were administered by the Center for Vocational Education Professional Personnel Development, Temple University, Philadelphia, Pennsylvania.

ACKNOWLEDGEMENT

Acknowledgement is provided to the Pennsylvania Department of Education and the Technology Education Association of Pennsylvania who produced and published the third edition of the Pennsylvania Industrial Arts/Technology Education Safety Guide which served as the foundation document for the safety supplement in this handbook.

Additional acknowledgement is provided to Mrs. Carla Harris for her dedication to high quality in the preparation of the word processed copy used in this handbook.

Also acknowledged for their assistance in reviewing and providing suggestions for the final editing of this handbook are Mr. Wayne Creasy, Principle of Technology Instructor, Columbia-Montour AVTS and Mr. William Waddington, Principles of Technology Instructor, North Penn High School.

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont.)

Preface

This workshop presenter's handbook was developed to provide assistance to those who will serve as Principles of Technology trainers to science, industrial arts/technology education and mathematics teachers throughout Pennsylvania. This handbook provides the trainer with presentation materials, suggested activities and selected resources to promote structure as well as facilitate the delivery of in-service training to those interested in teaching Principles of Technology.

Further utility of this handbook will be achieved as the message it contains reaches the diverse population in the school and the community. In addition to meeting the comprehensive needs of the in-service trainer and the Principles of Technology teacher, others who can benefit from an understanding of what Principles of Technology is and why it should be included in the secondary school curriculum are potential students, counselors, parents, other teachers, school administrators and board members, persons from business and industry as well as members of community organizations.

It is important to consider the specialized needs of the trainer and classroom teacher as well as the more general needs of others when this handbook is used in the delivery of workshops and seminars. The success of a Principles of Technology program in a school requires more than a well prepared teacher in the classroom; it requires an understanding, endorsement and integration of the Principles of Technology program in the school as well as the community. The Handbook for workshop presenters has been developed to serve both of these needs. Trainers and workshop presenters are therefore encouraged to emphasize the classroom as well as the community aspects of these materials when they are used.

This handbook has been divided into three parts; each of these are summarized:

Part One - Introduction

1. Provides an overview of the educational and economic conditions which the Principles of Technology program respond to.

2. Describes Pennsylvanias role in the development of and its commitment to the implementation of the Principles of Technology curriculum materials.

3. Illustrates the potential of the Principles of Technology materials to improve student knowledge levels.

4. Provides an overview of the instructional design and structure of the Principles of Technology materials.

Part Two - Implementation

1. Provides materials to promote the development of skill in the set up and completion of Principles of Technology labs.

2. Provides opportunities for stand-alone and infused demonstration lessons.

Part Three - Logistics

1. Contains a laboratory equipment listing, a vendor list, and information on specification writing.

2. Provides information on lab design and facilities considerations, a set of equipment fabrication plans, guidelines for lab management and grading and includes a separate safety supplement.

3. Describes Pennsylvania teacher certification requirements for Principles of Technology.

4. Includes a Principles of Technology Mini-Guide to aid in public relations and community awareness.

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PRINCIPLES OF TECHNOLOGY

PART ONE - INTRODUCTION

After participating in a workshop on Principles of Technology, the teacher will be able to...

- Describe current education and economic concerns that demonstrate the need for Principles of Technology.
- Describe the role of the Pennsylvania Department of Education and the Centers for Vocational Professional Personnel Development at IUP, Temple, and Penn State in relation to the materials from the Center for Occupational Research and Development (CORD).
- Describe the potential contribution of Principles of Technology for improving both the vocational and academic competence of students.
- Explain the process and instructional design used by the Center for Occupational Research and Development (CORD) to develop the Principles of Technology materials.

OUTCOMES

PRINCIPLES OF TECHNOLOGY WORKSHOP PRESENTER'S HANDBOOK

The outcomes for Training the Trainer in Principles of Technology are based on a core of generic outcomes for new programs in applied academics. These generic Train the Trainer outcomes were a product of a focus meeting involving individuals from the Pennsylvania Department of Education, Bureau of Vocational and Adult Education and the respective Centers for Professional Personnel Development in Vocational Education at Indiana University of Pennsylvania, The Pennsylvania State University and Temple University. The core of generic outcomes for training the Trainers will be utilized in Applied Mathematics, Applied Biology and Chemistry, Applied Communications as well as in the program area of Principles of Technology. Program specific outcomes have been added where appropriate.

The outcomes for use in the Train the Trainer for Principles of Technology are grouped into three sections and include:

PART ONE - INTRODUCTION

After participating in a workshop on Principles of Technology, the teacher will be able to...

1. Describe current education and economic concerns that demonstrate the need for Principles of Technology.

2. Describe the role of the Pennsylvania Department of Education and the Centers for Vocational Professional Personnel Development at IUP, Temple, and Penn State in relation to the materials from the Center for Occupational Research and Development (CORD).

3. Describe the potential contribution of Principles of Technology for improving both the vocational and academic competence of students.

4. Explain the process and instructional design used by the Center for Occupational Research and Development (CORD) to develop the Principles of Technology materials.

PART TWO - IMPLEMENTATION

After participating in a workshop on Principles of Technology, the teacher will be able to...

5. Describe "stand-alone" and "infused" instructional methods for delivering Principles of Technology.

6. Demonstrate the ability to use appropriate instructional materials and equipment in selected laboratory activities.

7. Demonstrate (in a small-group activity) short, practice teaching exercises, involving theory and or laboratory activities.

PART THREE - LOGISTICS

After participation in a workshop on Principles of Technology, the teacher will be able to...

8. Identify sources and write specifications to order equipment and supplies for a Principles of Technology program.

9. Describe the mechanics and logistics for laboratory management, safety, inventory control, grading and other problems which arise during the planning, preparation and delivery for a Principles of Technology program.

10. Describe Pennsylvania teacher certification requirements for Principles of Technology as they relate to teachers presently certified in Physics, General Science, and Industrial Arts\Technology Education.

11. Provide an overview of Principles of Technology to students, parents, counselors, school administrators-board members, and persons in the community.

File B:Outcomes.CW

OUTCOMES ACTIVITY GUIDE 1

1. Outcomes:

   A. Describe current education and economic concerns that demonstrate the need for Principles of Technology.

   B. Describe the potential contribution of Principles of Technology for improving both the vocational and academic competence of students.

2. Methods: Oral presentation and discussion

3. Resources and Materials Needed:

   A. Information Sheet:

      IS-1, The Need for Principles of Technology

   B. Transparencies:

      T-1, National Goals in Education
      T-2, Problems with American Secondary Education that Deserve Solutions
      T-3, Advanced Technology Occupations Require...
      T-4, Foundations in Applied Academics
      T-5, Applied Academics Helps Students Heading From High School to Work
      T-6, Applied Academics for Career-Oriented Students in A Tech-Prep Program
      T-7, Principles of Technology is...
      T-8, Principles of Technology has Roots in...

   C. Videotapes:

      Background to Principles of Technology - Dr. Leno Pedrotti
      An Overview of Principles of Technology

4. Suggested Activities:

   A. Play the videotape, Background to Principles of Technology - Dr. Leno Pedrotti and use Information Sheet IS-1 and Transparencies T-1 through 3 to make a presentation on current educational and economic conditions in America. In a large or small group discussion format, seek comment on the validity of these conditions in the U.S., in PA and local schools/communities.

   B. Play the videotape, An Overview of Principles of Technology and use Transparencies T-4 through 8 to: (1) introduce the Principles of Technology Program, (2) describe its potential for the improvement of student growth and (3) identify the student target population it is intended to benefit.

THE NEED FOR PRINCIPLES OF TECHNOLOGY

Recently identified goals for education in America call for increases in the math and science scores of high school students as well as increases in the number of qualified technicians who can maintain the skills necessary for the everchanging complex technologies of tomorrow. Yet according to many reports, graduates of our Nations high schools tend to know less at a time when the high-tech world of work needs them to know more. Further, this may be a condition which reflects a dilemma that is pervasive and is likely to impact on the economic future of the United States if allowed to continue.

The obvious solution to this problem in the form of increased educational emphasis of math and science programs is however not an avenue of change which can be taken as directly as one may wish. Inspection of existing math and science programs, enrollment patterns, learning styles and the needs of a technological work force are necessary in order to further define the problem and develop a solution.

Many of the advanced math and science programs in the areas of calculus, physics and chemistry which grew out of the curriculum revision efforts of the sixties were designed on a pure science approach using an inquiry method to instruction. These programs have provided an excellent foundation for secondary graduates, despite their relatively low numbers, who go on to study science and engineering at the Baccalaureate level.

Most secondary students, do not however enroll in these advanced programs either because of lack of interest, limited levels academic ability or the perceived degree of difficulty associated with these courses. The general science and general math courses which are typically pursued as an alternative to the more theoretically pure courses by most students do not provide the skills necessary for the technological needs of the labor market or the level of preparation needed for post-secondary study. Principles of Technology, which is based on a combination of physics with supportive math and the technological foundations of industry, provides a new and viable choice to the secondary student in the nineties in order to prepare for careers that will extend into the next century.

Principles of Technology is a course designed to prepare students more effectively for technical careers. The complexity and rapid change of modern technology require training that is applicable to more than a single job. Technicians who work with, or on, high-tech equipment must have a broad understanding of the technical concepts and principles that govern the behavior of the systems and subsystems that make up this equipment. Technicians must understand the mechanical, fluid, electrical, and thermal principles on which modern equipment operates. If technicians understand the principles on which their current work is based, future application of those principles to new technology will be more readily achievable.

Principles of Technology was designed to:

- provide a well-grounded science alternative for secondary students enrolled in general or vocational programs.
- increase the employability of vocational students.
- emphasize principles rather than specifics of technology and provide an understanding of the mathematics associated with these principles.
- increase student interest by incorporating video presentations, demonstrations, hands-on laboratory exercises and special exercises for students requiring additional help in mathematics.
- maintain the academic rigor needed to meet some of the increased requirements for high school science.

The Principles of Technology course may be offered as an alternative to increased course work in traditional general science. As noted by the National Commission on Secondary Vocational Education, many states have responded to recent criticisms of the secondary school by increasing the number of academic courses required for graduation. The Commission recommends that high school students who do not plan to go to college and who purposefully choose a vocational program "be allowed to satisfy some requirements for high school graduation--for example in the areas of mathematics, science, English, or social study--with selected courses in areas of vocational education that are comparable in content coverage and rigor." Principles of Technology is a way of doing that.

Principles of Technology can also serve as a vehicle to aid in the integration of vocational and academic subject material. Further utility to students and the needs of the technological labor market is served through the use of Principles of Technology when linkages are made to tech-prep consortia as well as other 2+2 or articulated efforts between secondary and post-secondary programs.

File B:Outcomes.CW2

NATIONAL GOALS IN EDUCATION

- INCREASE LEVELS OF INVOLVEMENT AND ACHIEVEMENT OF HIGH SCHOOL STUDENTS IN MATH AND SCIENCE

- INCREASE NUMBER AND QUALITY OF TECHNICIANS FOR WORK IN TOMORROW'S ADVANCED TECHNOLOGIES

PROBLEMS WITH AMERICAN SECONDARY EDUCATION THAT DESERVE SOLUTIONS

- *LOOKING AT SOME PROBLEMS*
  - "SOME 20 MILLION AMERICANS AGED 16 TO 24 SKIP COLLEGE. EVEN OF THOSE WHO DO GO, HALF DON'T COMPLETE FOUR YEARS SO THAT ABOUT 75% OF AMERICAN YOUTHS ENTERING THE WORK FORCE ARRIVE WITH LESS THAN A BACHELOR'S DEGREE."
  - "YOUNGSTERS COMING OUT OF HIGH SCHOOL TEND TO KNOW LESS AT A TIME WHEN THE HIGH-TECH WORLD OF WORK NEEDS THEM TO KNOW MORE."
  - "MALE HIGH-SCHOOL GRADUATES NOW EARN ONLY ABOUT HALF WHAT COLLEGE GRADUATES DO, DOWN FROM NEARLY TWO-THIRDS ABOUT 20 YEARS AGO."

- *THINKING ABOUT SOLUTIONS*
  - RECOGNIZE DIFFERENT LEARNING STYLES.
  - DEVELOP COURSE MATERIALS/PROGRAMS TO EXPLOIT DIFFERENT LEARNING STYLES.
  - SET UP 4+2 TECH PREP PROGRAMS TO DELIVER TRAINED, PRODUCTIVE WORKERS.

* As reported in Wall Street Journal, May 19, 1992.

ADVANCED TECHNOLOGY OCCUPATIONS REQUIRE

- SYSTEMS ORIENTATION
- COMBINATION OF SKILLS – INTERDISCIPLINARY
  - ELECTRICAL
  - MECHANICAL
  - FLUID
  - THERMAL
  - OPTICAL
  - MICROCOMPUTERS
- STRONG TECHNICAL BASE
  - CAPABLE OF LEARNING NEW SPECIALTIES AS THE TECHNOLOGY CHANGES
- INTERPERSONAL / COMMUNICATION SKILLS

FOUNDATIONS IN APPLIED ACADEMICS

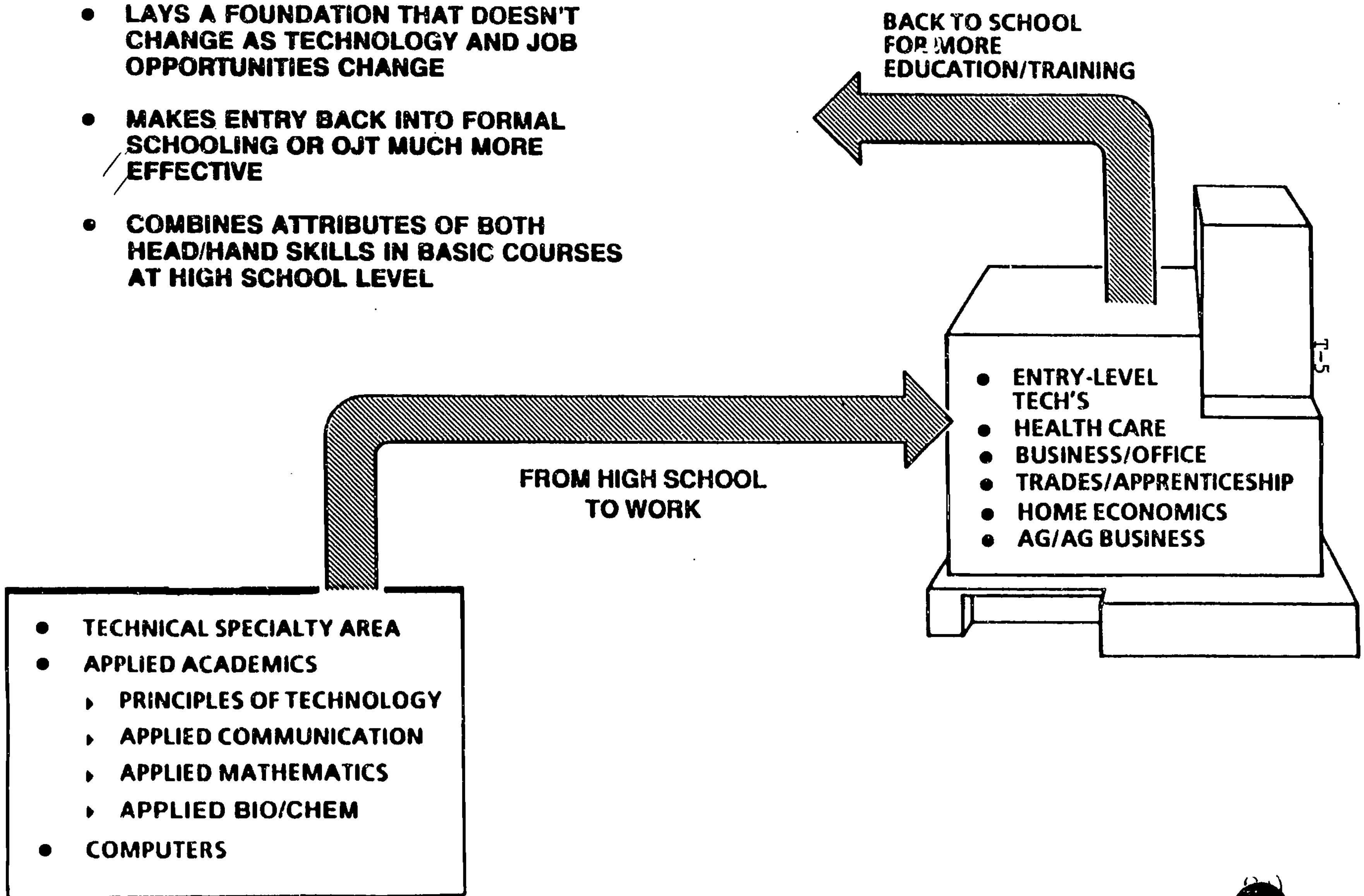
- PRINCIPLES OF TECHNOLOGY (APPLIED PHYSICS)
- APPLIED COMMUNICATION
- APPLIED MATHEMATICS
- APPLIED BIOLOGY / CHEMISTRY

EACH COURSE MUST ADHERE TO THE FOLLOWING GUIDELINES

- BE DOABLE BY STUDENTS IN THE MID 50% OF HIGH SCHOOL POPULATIONS
- FOCUS ON PROBLEM SOLVING
- BE PRACTICAL AND RELEVANT
- EMPHASIZE ASSOCIATED HANDS-ON LEARNING
- RETAIN INTEGRITY OF COURSE CONTENT

APPLIED ACADEMICS HELPS STUDENTS HEADING FROM HIGH SCHOOL TO WORK

- LAYS A FOUNDATION THAT DOESN'T CHANGE AS TECHNOLOGY AND JOB OPPORTUNITIES CHANGE
- MAKES ENTRY BACK INTO FORMAL SCHOOLING OR OJT MUCH MORE EFFECTIVE
- COMBINES ATTRIBUTES OF BOTH HEAD/HAND SKILLS IN BASIC COURSES AT HIGH SCHOOL LEVEL



T-5

APPLIED ACADEMICS FOR CAREER-ORIENTED STUDENTS IN A TECH-PREP PROGRAM

- LAYS A FOUNDATION IN MATH, SCIENCE, AND COMMUNICATIONS FOR SMOOTH ENTRY INTO POSTSECONDARY PROGRAMS
- COMBINES ATTRIBUTES OF BOTH HEAD/HAND SKILLS IN BASIC COURSES AT HIGH SCHOOL LEVEL
- DOES NOT CLOSE DOORS FOR ENTRY INTO 4-YEAR COLLEGE PROGRAMS

2-YEAR POSTSECONDARY PROGRAMS
ASSOCIATE DEGREE

- AUTOMATED MANUFACTURING
- TELECOMMUNICATIONS
- COMPUTERS
- NURSING
- INFORMATION MANAGEMENT
- BUSINESS AND MARKETING

↑

4+2
TECH PREP

- TECHNICAL SPECIALTY AREA
- APPLIED ACADEMICS
  - PRINCIPLES OF TECHNOLOGY
  - APPLIED COMMUNICATION
  - APPLIED MATHEMATICS
  - APPLIED BIO/CHEM
- COMPUTERS

PREPARATION FOR TECHNICAL CAREERS AT THE HIGH SCHOOL LEVEL

PRINCIPLES OF TECHNOLOGY IS

- AN APPLIED SCIENCE (PHYSICS) COURSE THAT TARGETS THE MID 50% OF HIGH SCHOOL STUDENTS AND ADULTS IN RETRAINING PROGRAMS

- AN INTEGRATED INSTRUCTIONAL PACKAGE THAT INCLUDES VIDEO, PRINT AND LABORATORIES

- BASED ON THE APPLICATION OF PRINCIPLES IN MECHANICAL, FLUID, ELECTRICAL AND THERMAL SYSTEMS-- AND ON AN EMPHASIS OF THE ANALOGIES BETWEEN THESE SYSTEMS

- HEAVILY LABORATORY ORIENTED WITH HALF OF THE COURSE CONCENTRATING ON PROBLEM-SOLVING MATH LABS AND HANDS-ON HARDWARE LABS

PRINCIPLES OF TECHNOLOGY HAS ITS ROOTS IN:

- EMERGENCE OF HIGH TECHNOLOGY
- UTC PHYSICS (POSTSECONDARY-LEVEL APPLIED PHYSICS)
- IMPLICATIONS OF NATIONAL STUDIES
- IMPORTANT CHANGES IN EDUCATION FOR TECHNICAL CAREERS

PRINCIPLES OF TECHNOLOGY WILL:

- BUILD ON THE TALENTS NON-BACCALAUREATE BOUND STUDENTS POSSESS
- IMPROVE STUDENT SKILLS IN MATH AND SCIENCE
- SERVE AS A FOUNDATION COURSE FOR TECHNICAL CAREERS

OUTCOMES ACTIVITY GUIDE 2

1. Outcomes:

   A. Describe the role of the Pennsylvania Department of Education and the Centers for Vocational Professional Personnel Development at IUP, Temple, and Penn State in relation to the materials from the Center for Occupational Research and Development (CORD).

   B. Explain the process and instructional design used by the Center for Occupational Research and Development (CORD) to develop the Principles of Technology materials.

2. Methods: Oral presentation and discussion

3. Resources and Materials Needed:

   A. Information Sheet:

      IS-2, The Role of PDE and University Centers for Vocational Professional Development

      IS-3, Format and Structure of Principles of Technology

      IS-4, The Development of Principles of Technology

   B. Transparencies:

      T-9, Principles of Technology is Organized Around Four Common Energy Systems
      T-10, Principles of Technology Instructional Materials for a Typical Unit
      T-11, Recommended Unit Instructional Sequence for Principles of Technology
      T-12, Instructional Sequence in a Typical Unit in Principles of Technology

   C. Videotape:

      Unit 4, Overview on Resistance
      Unit 4, Resistance in Mechanical Systems

   D. Principles of Technology Printed Material:

      Student Workbooks
      Student Resource Books
      Teachers Guides

4. Suggested Activities:

A. Using Information Sheet IS-2, describe the role of PDE and the University Centers for Vocational Education Professional Personnel Development to the Principles of Technology materials.

B. Using Information Sheet IS-3 and 4 and Transparencies T-9 through 12, provide an orientation to the format and structure of the Principles of Technology materials.

C. Play the following two videotapes in order to provide on introduction to the videotape segments of a Principles of Technology unit and subunit:

1. Unit 4, Overview on Resistance
2. Unit 4, Resistance in Mechanical Systems

D. Distribute copies of Principles of Technology Student Workbooks, Student Resources Book and Teachers Guide and provide a guided review of component parts of each.

THE ROLE OF PDE AND UNIVERSITY CENTERS FOR VOCATIONAL PROFESSIONAL DEVELOPMENT

Educational leaders at the Bureau of Vocational and Adult Education at Pennsylvania's Department of Education (PDE) believe that it is imperative for teachers to forge a link between academic and vocational program content, and prepare a rigorous, challenging, and coherent program of studies for students. A program such as this is aimed at preparing youth for success in high school and beyond the high school level in post-secondary school, in the future job market, and for life skills which contribute to the young person's success as members of American society.

Educational leaders in Pennsylvania accomplished this goal by adding Pennsylvania to the consortium of states active in promoting Applied Academics, and by facilitating collaborative planning between educational institutions at the secondary and post-secondary levels. In 1991, the Centers for Vocational Professional Development in three universities in Pennsylvania were chosen to lead the Commonwealth's educators in providing teacher workshops in Applied Academics such as Applied Mathematics, Applied Communications, Applied Biology and Chemistry, and Principles of Technology. The three universities were Indiana University of Pennsylvania, Temple University and The Pennsylvania State University.

Vocational Educators at these schools accepted the challenge and since 1991, have been working hard to help PDE realize its goals. University faculty from the Centers for Vocational Professional Development serve as facilitators for local educational agencies which request assistance in fulfilling the following objectives:

1. Promote collaboration between high school administrators, directors of vocational-technical schools, and education specialists such as math teachers, curriculum coordinators, guidance personnel and other personnel at Intermediate Units. Applied academic program materials have been placed in intermediate units and can be duplicated upon request from members of local educational agencies.

2. Promote opportunities for teachers of academic and vocational courses to work together plan and deliver instruction in applied academics. Planning sessions include information on learning styles, teaching strategies and cooperative curriculum development.

3. Provide courses and workshops that promote teaching methods which focus on problem-solving, critical thinking, and decision-making skills for learners.

4. Provide a forum for curriculum updating--especially in technological courses that include rigorous academic components.

5. Refine the academic competence of new instructors who are entering the vocational teaching profession without the benefit of a college degree.

6. Provide training seminars that show teachers of vocational and academic courses how to use "real-world" problems in their classroom presentations.

Educators who need assistance in reaching these objectives may request help by contacting the following agencies:

Director of Applied Academics Programs
Bureau of Vocational and Adult Education
Pennsylvania Department of Education
333 Market Street, 6th floor
Harrisburg, Pennsylvania
17126-0333
(717) 783-6592

Coordinator, Applied Academics Programs
Center for Vocational Professional Development
Reschini House
Indiana University of Pennsylvania
Indiana, Pennsylvania
15705
(412) 357-4434

Coordinator, Applied Academics Programs
Department of Vocational Industrial Education
Rackley Building
The Pennsylvania State University
University Park, Pennsylvania
16802
(814) 863-2596

Coordinator, Applied Academics Programs
Temple University
Department of Curriculum, Instruction, and Technology in Education
Vocational Education Programs
Ritter Hall 338-A
Philadelphia, Pennsylvania
19122
(215) 787-3263

FORMAT AND STRUCTURE OF PRINCIPLES OF TECHNOLOGY

Principles of Technology is designed to be both academically rigorous and practical for 10th, 11th and 12th grade students planning technical careers. It includes 14 units of instruction, with each unit typically comprising 26 sessions. Principles of Technology is usually delivered over the last two years of high school.

Principles of Technology was developed as a companion to the Unified Technical Concepts (UTC) Course developed by the Center for Occupational Research and Development, Waco, Texas. The UTC Course is a two semester post-secondary physics course.

Each of the 14 units in Principles of Technology deals with an underlying principle of today's technology and applies it to four energy systems--mechanical, fluid, thermal, and electrical. The units also cover the associated mathematics needed to understand and apply the principles covered. Most often, the units are presented over two years in the recommended instructional sequence presented in transparency T-11.

INSTRUCTIONAL MATERIALS

For each unit there is a comprehensive student text and a teacher's guide. There are also 74 video programs totaling about 500 minutes. The teacher's guide includes approximately 50 demonstrations that can be carried out with readily available apparatus. The student text is self-contained and details over 100 hands-on laboratories. At regular intervals, the student text also includes evaluation items and written exercises.

The teachers guide serves as a companion to all student materials. In it are notes to the instructor printed on the left side of the guide with the corresponding student page printed on the right. Explanations of more difficult subject matter, with suggested teaching strategies are also included.

A student resource book has been developed as a result of the revision effort for the second edition of Principles of Technology. In it are tables of physical constants, conversion tables, unit by unit reference material, a comprehensive glossary and a series of preparatory math skills labs designed to strengthen basic math skills if necessary.

TEACHING/LEARNING PLAN

The first class for each unit is an introduction and overview of the unit's content. The last class is designed for a unit review/summary and test. The 24 intervening classes are divided into four subunits of six classes each. All principles of technology materials were designed for class periods of 50 minutes. A double class period is recommended for the completion of lab activities.

Each subunit deals with the unit's major technical principle as it applies in one of the four energy systems. A subunit usually consists of two days of lecture/discussion, a math skills lab, a hands-on lab and a subunit review. Video segments are used throughout. The instructional sequence for a typical unit with component subunits is illustrated in transparency T-12.

Before attempting the regular math skills labs, students are evaluated through a diagnostic pre-test to determine if they have the needed mathematics skills. There are 18 remedial math labs for students who may need assistance. Those who do not have adequate math skills must complete preparatory work before they can begin the 48 remaining regular math skill labs. Students who are highly skilled are challenged by more difficult mathematics exercises throughout the course.

THE DEVELOPMENT OF PRINCIPLES OF TECHNOLOGY

The development of the Principles of Technology program began in 1983 as a cooperative activity involving a consortium of 43 state and two Canadian provincial education agencies in association with the Agency for Instructional Technology (AIT) and The Center for Occupational Research and Development (CORD). In total, the participating educational agencies, including Pennsylvania, contributed developmental funding of more than $3 million for the creation of Principles of Technology and provided field sites for the formative implementation, use and development of these materials.

The initial drafts of print materials and scripts of video components, prepared by CORD and AIT, were reviewed for content by an independent, eight-member team of specialists in vocational education, physics and instructional media. Materials were also reviewed for content by the consortium agencies prior to field testing.

Before they were released for general use, all materials were extensively field tested and appropriately revised. All participating state and provinces committed at least two vocational schools and or comprehensive high schools to serve as test sites for the pilot use of these materials.

The schedule of activities for the development of the Principles of Technology materials is summarized in the following outline:

A.	Instructional Design	
	1. Units 1-7	1983-84
	2. Units 8-14	1984-85
B.	Pilot Testing	
	1. Units 1-7	1984-85
	2. Units 8-14	1985-86
C.	Revisions for First Edition	1984-86
D.	Formative Review by Cooperating Agencies	1984-85
E.	Classroom Use Within Cooperating States and Provinces	1985-86
F.	General Availability of Instructional Materials	1987
G.	Revisions for Second Edition	1990-91

TECHNOLOGY

PRINCIPLES OF TECHNOLOGY IS ORGANIZED AROUND FOUR COMMON ENERGY SYSTEMS

MECHANICAL

FLUID { HYDRAULIC / PNEUMATIC }

ELECTRICAL

THERMAL

RATIONALE: THE ASSEMBLY, DISASSEMBLY, TROUBLESHOOTING, MODIFICATION AND REPAIR OF MODERN TECHNOLOGY SYSTEMS OFTEN INVOLVE THESE FOUR ENERGY SYSTEMS AND THE BASIC PRINCIPLES BEHIND THEM.

PRINCIPLES OF TECHNOLOGY

INSTRUCTIONAL MATERIALS FOR A TYPICAL UNIT

- 6 VIDEO SEGMENTS (40-50 MINUTES)
- 135 PAGES OF STUDENT TEXT
- 8 HANDS-ON APPLICATION LABS
- 4 CLASSROOM DEMONSTRATIONS
- 4 MATH PRACTICE LABS
- 270 PAGES OF TEACHER'S GUIDE

OVERALL PROGRAM

- TWO-YEAR DURATION
- 14 UNITS TOTAL
- 140-150 CLASSES PER YEAR
- 50-MINUTE CLASSES PER DAY
- 90 HANDS-ON APPLICATION LABS
- 46 MATH LABS
- 74 VIDEO SEGMENTS (700 MIN'S)
- 18 REMEDIAL MATH SKILLS LABS

PRINCIPLES OF TECHNOLOGY

RECOMMENDED UNIT INSTRUCTIONAL SEQUENCE FOR PRINCIPLES OF TECHNOLOGY

FIRST YEAR

FORCE
WORK
RATE
RESISTANCE
ENERGY
POWER
FORCE TRANSFORMERS

SECOND YEAR*

MOMENTUM
WAVES AND VIBRATIONS
ENERGY CONVERTORS
TRANSDUCERS
RADIATION
OPTICAL SYSTEMS
TIME CONSTANTS

*In the second year, Momentum must be taught first. The order of instruction is then flexible, with some exceptions: Radiation must precede Optical Systems. Waves and Vibrations must precede Radiation; Energy Convertors must precede Transducers.

It is also possible to switch Force Transformers (Unit 7) with Momentum (Unit 8) and maintain continuity of instruction in a two year program.

INSTRUCTIONAL SEQUENCE IN A TYPICAL UNIT IN PRINCIPLES OF TECHNOLOGY

RESISTANCE

SUBUNIT TITLE	CLASS	CLASS ACTIVITY
OVERVIEW OF RESISTANCE UNIT	1	OVERVIEW VIDEO ON RESISTANCE CLASS DISCUSSION
RESISTANCE IN MECHANICAL SYSTEMS	2	MECHANICAL RESISTANCE SUBUNIT VIDEO CLASS DISCUSSION
	3	CLASS DISCUSSION AND DEMONSTRATION ON MECHANIC RESISTANCE
	4	MATH SKILLS LAB
	5*	LAB--REDUCING FRICTION WITH LUBRICANTS
	6*	LAB--STREAMLINING SHAPES TO REDUCE AIR DRAG
	7	REVIEW OF MECHANICAL RESISTANCE
RESISTANCE IN FLUID SYSTEMS	8	FLUID RESISTANCE SUBUNIT VIDEO CLASS DISCUSSION
	9	CLASS DISCUSSION AND DEMONSTRATION ON FLUID RESISTANCE
	10	MATH SKILLS LAB
	11*	LAB--MEASURING FLUID RESISTANCE IN PIPES
	12*	LAB--MEASURING RESISTANCE IN AIR FILTERS
	13	REVIEW OF FLUID RESISTANCE

* Recommend Double Class Period for Labs.

SUBUNIT TITLE	CLASS	CLASS ACTIVITY
RESISTANCE IN ELECTRICAL SYSTEMS	14	ELECTRICAL RESISTANCE SUBUNIT VIDEO CLASS DISCUSSION
	15	CLASS DISCUSSION AND DEMONSTRATION ON ELECTRICAL RESISTANCE
	16	MATH SKILLS LAB
	17*	LAB--OHM'S LAW AND SERIES CIRCUITS
	18*	LAB--OHM'S LAW AND PARALLEL CIRCUITS
	19	REVIEW ON ELECTRICAL RESISTANCE
RESISTANCE IN THERMAL SYSTEMS	20	THERMAL RESISTANCE SUBUNIT VIDEO CLASS DISCUSSION
	21	CLASS DISCUSSION AND DEMONSTRATION ON THERMAL RESISTANCE
	22	MATH SKILLS LAB
	23 *	LAB--MEASURING THERMAL INSULATION
	24 *	LAB--EFFECTS OF THERMAL INSULATION
	25	REVIEW OF THERMAL RESISTANCE
SUMMARY OF RESISTANCE UNIT	26	SUMMARY VIDEO ON RESISTANCE CLASS DISCUSSION

* Recommend Double Class Periods for Labs.

PRINCIPLES OF TECHNOLOGY

PART TWO - IMPLEMENTATION

After participating in a workshop on Principles of Technology, the teacher will be able to...

- Describe "stand-alone" and "infused" instructional methods for delivering Principles of Technology.
- Demonstrate the ability to use appropriate instructional materials and equipment in selected laboratory activities.
- Demonstrate (in a small-group activity) short, practice teaching exercises, involving theory and or laboratory activities.

OUTCOME ACTIVITY GUIDE 3

1. Outcome

   A. Demonstrate the ability to use appropriate instructional materials and equipment in selected laboratory activities.

2. Method: Team and small group lab activity

3. Resources and Material Needs:

   A. Principles of Technology Teachers Guides and Student Workbooks for units 1, 2, 4, 5 and 7

   B. Lab equipment and supplies for labs 1M2, 1T3, 2E2, 4M2, 4F2, 5MF1, 7E1/E2, and 7F1

4. Suggested Activities

   A. Divide workshop participants into two groups and assign into lab teams consisting of teachers with dissimilar backgrounds if possible (i.e. a lab team composed of an industrial education teacher, a math teacher and/or a physics teacher).

   B. Have lab teams from each group set-up and complete labs as follows:

Group A	Group B
*1MS1	4FS
*1MS4	4M2
1M2	*5MS1
1T2	5MF1
2E2	*7MS3
7E1/E2	7F1

   *Math Skills Labs

   NOTE: Logistical considerations due to lab equipment availability or facility limitations may require some reconfiguration of the lab/group listings.

   C. Rotate groups when all teams have completed all labs in their respective groups.

OUTCOME ACTIVITY GUIDE 4

1. Outcome

   A. Demonstrate (in a small-group activity) short, practice teaching exercises, involving theory and or laboratory activities.

   B. Describe "stand-alone" and "infused" instructional methods for delivering Principles of Technology.

2. Method: Team and small group lab activity

3. Resources and Material Needs:

   A. Principles of Technology Teachers Guides and Student Workbooks for units 1, 2, 4, 5 and 7

   B. Lab equipment and supplies for labs 1M2, 1T3, 2E2, 4M2, 4F2, 5MF1, 7E1/E2, and 7F1

4. Suggested Activities:

   A. While retaining the groups and team assignments already established, seek volunteers or select two teams within each group to prepare and deliver a demonstration lesson to other group members in each of the following:

      1. A presentation involving a concept from one of the completed lab activities in a stand alone fashion, (i.e. in a self-contained Principles of Technology classroom which is not coordinated with other related subjects or instructors in math or vocational classes).

      2. A presentation or a set of presentations involving a concept from one of the completed labs which represents content that has been infused (i.e. coordinated and/or team taught by a Principles of Technology teacher, with a math teacher and/or a vocational teacher).

   B. Discuss the advantages and disadvantages of "stand alone" and "infused" instruction in a Principles of Technology program.

   C. Through small group discussions, identify particular Principles of Technology, math and vocational subject concepts that could be enhanced through the use of an "infused" instructional method.

Measuring Forces

Lab 1M2

LAB OBJECTIVES

When you've finished this lab, you should be able to do the following:

1. ***Measure forces—in newtons or pounds—by using appropriate scales.***
2. ***Suspend a weight from two cords. Measure the tension (force) in each cord.***
3. ***Make a scale drawing (vector diagram) that illustrates the force in each rope.***
4. ***Use the vector diagram to determine the resultant force.***

LEARNING PATH

1. ***Preview the lab. This will give you an idea of what's ahead.***
2. ***Read the lab. Give particular attention to the Lab Objectives.***
3. ***Do lab, "Measuring Forces."***

MAIN IDEAS

- ***Forces can be measured with devices such as spring scales.***
- ***Forces can be presented visually by using a vector diagram.***

Cables or ropes often are used to lift, pull or suspend heavy objects. When a cable lifts a heavy weight, the force in the cable must not be so great that the cable breaks. By knowing the ***weight*** of the object to be suspended or moved, and the way the cables are arranged to pull on the object, we can calculate the maximum force in the cable. Figure 1 shows how cables (or ropes) can be used to suspend a traffic light at an intersection or lift heavy objects.

Scales are used to measure forces or weights. The amount of force required to balance (hold) the object is just equal to the total weight of the object. Most scales exert a balancing force by stretching springs. Other scales, such as freight scales or those found in department stores, apply a balancing force by compressing springs.

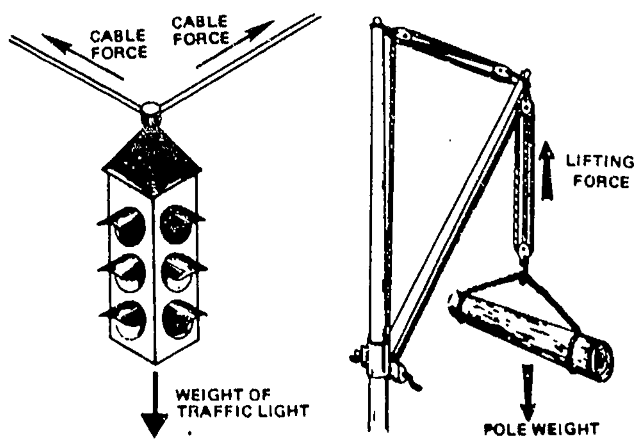


Fig. 1 Forces are used to suspend or move heavy objects.

A scale is calibrated ("marked off") to read correctly by determining the distances that known weights stretch or compress the spring. An appropriate mark is made on the scale for each weight applied. Then, when unknown weights are hung from the scales, or placed on the scales, the pointer on the scale indicates the correct weight.

In this lab, you'll suspend a heavy weight between two ropes. Then you'll measure the force (tension) in each rope with a spring scale. You'll also use a protractor to measure the angle formed between the ropes. Then you'll make a drawing that models the data from your measurements. The model will be used to find the resultant force of the two suspending forces.

LABORATORY

EQUIPMENT

Heavy duty support stand with appropriate attachment points along the top. (This item is supplied by vendors as a unit and will be used in many laboratories that follow.)
Three spring scales (balances), 0-28 lb
Laboratory mass set that includes various kg masses and a weight hanger
Cord, 30-lb test, of lengths 24 inches and 10 inches
Cord or string, about 5 feet long
Protractor
Ruler (12 inch/30 centimeter)

PROCEDURES

Part 1: *Measuring Forces in Equilibrium*

Getting started. Before you begin to set up the lab equipment, study Figure 1. There you see a heavy duty support stand, and an arrangement of spring scales, cords, and hanging weights. You are to arrange your lab equipment similar to that shown in this figure.

1. Fasten the top hook of one spring scale to an eyebolt or other device at position A. Do the same for a second spring scale at position B. Next, tie a single knot at the exact center of the 24-inch length of cord. Then tie the ends of this cord to the bottom hooks of the scales attached to positions A and B.
2. Tie the 10-inch cord onto the 24-inch cord at the knot. Be sure it is tied on ***securely***.
3. Tie the bottom end of the 10-inch cord to the top hook of the third spring scale. Attach the weight hanger to the spring scale and carefully place a mass of ***4 kilograms*** on the hanger.
4. Tie a string, ***horizontally***, from one post of the support stand to the other, at the exact level of the knot. Later, this string will serve as a horizontal (level) reference line for measuring angles.
5. Compare your setup to that shown in Figure 1. They should be similar.

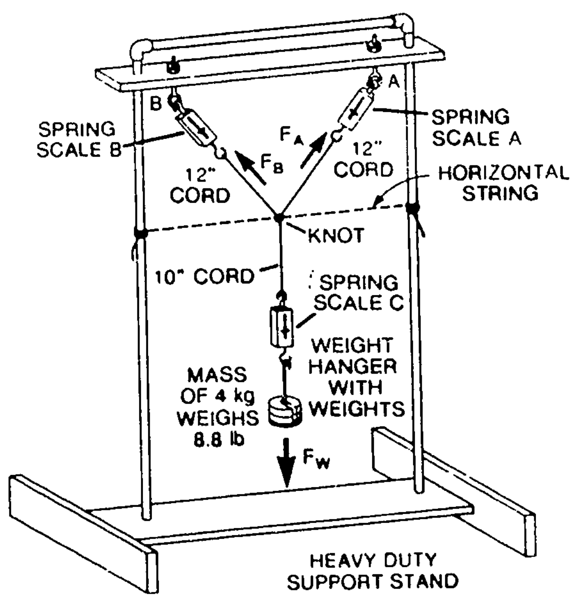


Fig. 1 Lab setup.

You are now ready to take data. You will need the spring scales to find the forces along the cords. You will use a protractor to measure certain angles between the cords—to get the directions of the forces.

6. Look at the drawing in Figure 2. It shows the knot with the three forces pulling on the knot. The forces are labeled F_A (toward position A), F_B (toward position B), and F_W (toward the hanging weight). Also, two angles are shown, angle A (often written as ∠A) and angle B (∠B).

7. Gently pull down about one inch on the 4-kg mass, then let it return to its original position. Now read the force (in pounds) indicated on spring scale A. Write the value down on a piece of scrap paper. Repeat the above procedure two more times, obtaining two more readings. The three readings may all be the same. In any case, record the highest reading you obtained, as F_A, in column 1 of the Data Table.

8. Repeat the procedure in Step 7 for the force indicated on spring scale B. Record the value as F_B in column 1 of the Data Table.

9. Do the same for spring scale C, between the knot and the hanging weight. Record the value as F_W in column 1 of the Data Table.

10. You are now going to use your protractor to measure angles made by the cords. Study Figure 3 before you proceed. Notice that the index point of the protractor must be at the center of the knot, and that the horizontal reference cord must be along the bottom edge of the protractor.

11. Align the protractor carefully—with the knot and the horizontal reference line—as shown in Figure 3. (The horizontal cord should be along the 0° indicators on the protractor.) Holding the protractor steady, read and jot down the angle where the cord attached to spring scale A crosses the protractor. Call this ∠A. Without moving the protractor, read and jot down the angle where the cord attached to spring scale B crosses the protractor. Call this ∠B.

12. Record ∠A and ∠B in column 2 of the Data Table. Notice that ∠A is the angle that force F_A makes with the horizontal reference cord. And ∠B is the angle that force F_B makes with the same reference line. From Figure 3, you can see that the angle between F_A and F_B is just ∠B − ∠A. Call this difference ∠AB and record the value in the Data Table.

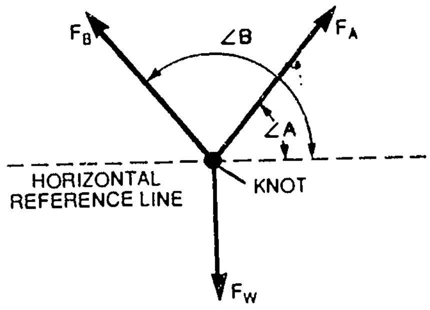


Fig. 2 Sketch of forces and angles.

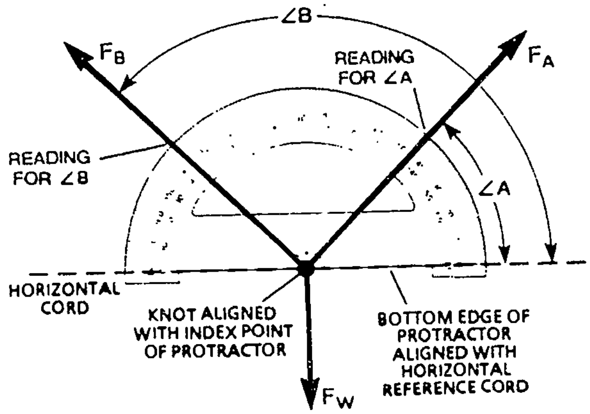


Fig. 3 Measuring angles with a protractor.

DATA TABLE

Column 1	Column 2
Force measure (lb)	Angle measure (degrees)
F_A =	∠A =
F_B =	∠B =
F_W =	∠AB = ∠B − ∠A =

Part 2: *Graphical Representation of Forces F_A, F_B and F_W*

Now that you've taken your data, it's important that you learn a simple method of analyzing forces. Figure 4a shows a sample Data Table with a typical set of data. (The data you obtained with your setup will probably not agree with the data shown here.) Figure 4b shows the typical values on a sketch of the forces and angles involved in Figure 2.

Now let's analyze the forces by following the step-by-step procedure outlined below. Read through each step carefully, referring to Figures 5a and 5b on the following page. Be sure you understand each step because you will follow a similar procedure with the data you obtained with your setup.

1. Select a plain sheet of paper. You can use a sheet with a grid on it if you wish, but plain paper will work just as well. Based on the values of the forces you measured, select a convenient scale, such as 1 cm = 1 lb, or ½ inch = 1 pound. Think carefully before you choose the scale. If you choose a scale like 1 in. = 1 lb, your drawing may not fit on the page. Or, if you choose a scale like ⅛ in. = 1 lb, your drawing may be too small. For the typical data shown in Figure 4a, we've chosen a scale of 1 cm = 1 lb. As you'll see when you examine Figure 5 that follows, the choice of this scale makes it easy for us to draw large, clear diagrams using most of the page.
2. On the blank page, we first draw a horizontal reference line across the page, through the center. See Figure 5. Near the left edge of this line we draw the vector F_W to represent the hanging weight. Since we hung 4 kg of mass on the hanger (see Figure 1), and each kilogram weighs 2.2 lb (as given in Table 1-1 of the text), we calculate the weight in pounds as follows:

$$4\text{ kg} \times \left[\frac{2.2\text{ lb}}{1\text{ kg}}\right] = \left[\frac{4 \times 2.2}{1}\right]\left[\frac{\cancel{\text{kg}}\cdot\text{lb}}{\cancel{\text{kg}}}\right] = 8.8\text{ lb}$$

3. Next, using the chosen scale of 1 cm = 1 lb, we draw a line of appropriate length to represent the hanging weight of 8.8 lb. Since the scale is 1 cm = 1 lb, the length is clearly 8.8 cm. For a more "complicated" choice of scale, we could have found the length as outlined here:

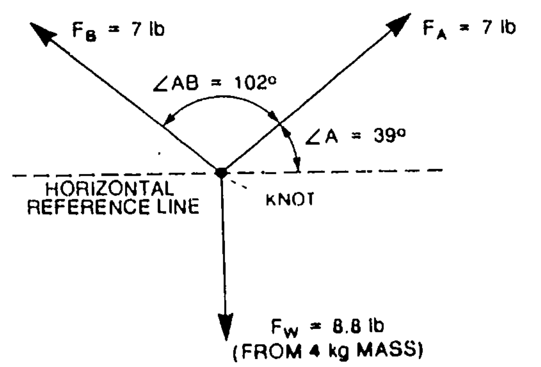
$$8.8\text{ lb} \times \left[\frac{1\text{ cm}}{1\text{ lb}}\right] = \left[\frac{8.8 \times 1}{1}\right]\left[\frac{\cancel{\text{lb}}\cdot\text{cm}}{\cancel{\text{lb}}}\right] = 8.8\text{ cm}$$

Thus we draw the vector F_W as a line 8.8 cm long, pointing straight down—the same direction that the hanging weight pulls on the knot. The final drawing for vector F_W is shown in Figure 5a.

4. On this same figure, a little to the right of the center point on the horizontal reference line, we make a clear dot to represent the knot. Now, with the help of a ruler and protractor, we draw the vector F_A, beginning at the dot. When completed, the vector F_A must represent a force of 7 lb acting at an angle of 39° above the horizontal reference. From the scale 1 cm = 1 lb, we can see quickly that the 7-lb force F_A should be represented by a line 7 cm long, drawn at an angle of 39°. The tail of the arrow (vector) is at the dot and a neat arrowhead is drawn at the other end of the vector. Figure 5b shows vector F_A.

Forces	Angles
F_A = 7 lb	∠A = 39°
F_B = 7 lb	∠B = 141°
F_W = 8.8 lb (4 kg of mass weighs 8.8 lb)	∠AB = ∠B − ∠A ∠AB = 141° − 39° = 102°

a. Typical values of forces and angles for setup shown in Figure 1

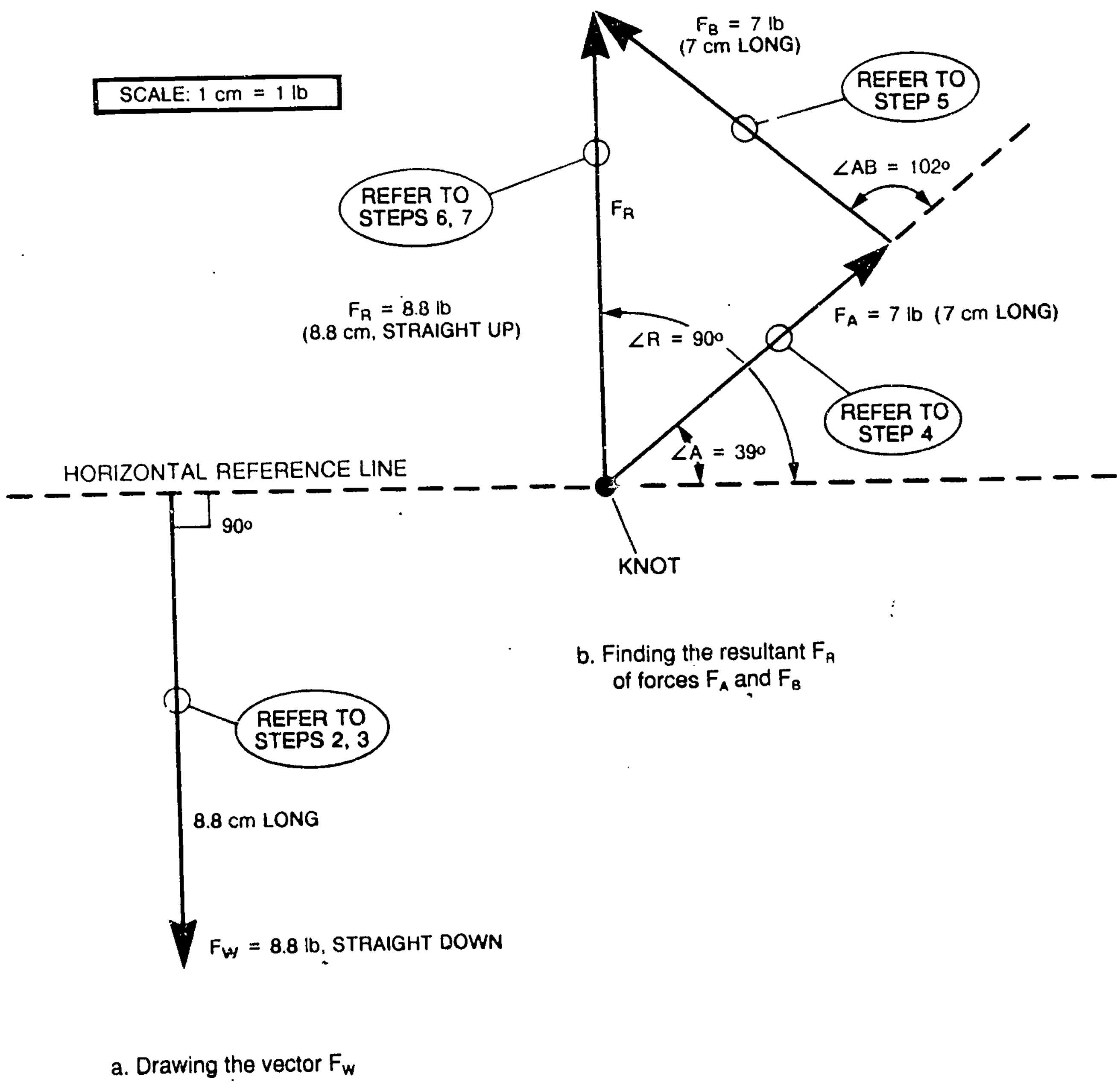


b. Sketch of forces and angles, with typical values

Fig. 4 Data used in sample force analysis.

5. Next we extend a dotted line along vector F_A, as shown in Figure 5b. With the index of the protractor located at the tip of vector F_A, and the bottom edge of the protractor along F_A and the dotted line, we measure off $\angle AB$ to be 102°. This is the angle between force F_A and force F_B. See Figure 5b. Then we draw a line along the 102° direction and mark off 7 centimeters. The 7-cm line segment represents vector F_B—7 pounds at an angle of 102° with vector F_A. Figure 5b shows the completed vector F_B.

6. Finally we draw a line from the ***tail*** of vector F_A to the ***head*** of vector F_B, as shown in Figure 5b. This line, F_R, is the ***resultant*** of vectors F_A and F_B. It represents the *single force* that can replace



a. Drawing the vector F_W

b. Finding the resultant F_R of forces F_A and F_B

Fig. 5 Drawing the vector diagrams.

(is equivalent to) the separate forces F_A and F_B that hold up the hanging weight.

7. Now we need to find the ***magnitude*** and ***direction*** of the resultant F_R. First we use a ruler to measure the length of F_R in Figure 5b. Then we use a protractor to measure $\angle R$, the angle F_R makes with the horizontal reference. For "good" results the length of F_R should be somewhere between 8.5 cm and 9.0 cm, and $\angle R$ should be close to 90°. For perfect results—shown in Figure 5b but not usually achieved in real laboratory experiments—the length should be exactly 8.8 cm and F_R should point straight up ($\angle R$ equals exactly 90°). That's because the resultant vector F_R must be ***equal and opposite*** to the vector F_W. Thus, since F_W is 8.8 cm long and pointed straight down (as we drew in Figure 5a), F_R should be, ideally, 8.8 cm long and pointed straight up.

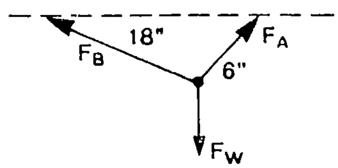
Part 3: *Making a Vector Diagram of Your Data*

Now it's your turn. If you understood the procedure outlined in Part 2, you should not have much trouble making your own vector diagrams.

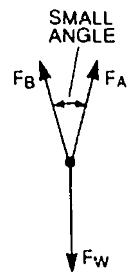
1. Follow the steps outlined in Part 2. Use the data you collected (from Data Table) and make vector diagrams for F_W, F_A and F_B, as was done in Figure 5. Begin with a sheet of plain (or grid) paper.
2. When you finish drawing F_A and F_B, draw the resultant F_R and determine its magnitude and direction as outlined in Part 2. Is your F_R equal and opposite to F_W? If not, can you give reasons why it's not? Can you identify several sources of error in this experiment?

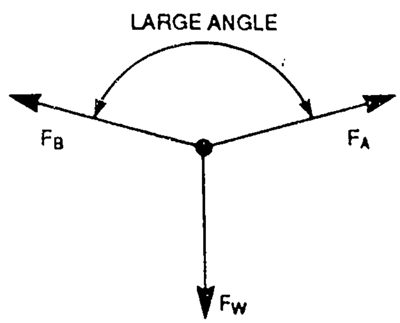
CHALLENGE QUESTIONS

1. In this lab experiment you just finished, you suspended the hanging weight at the center of the 24-inch cord. As a result you probably found that the spring scale readings for F_A and F_B were equal—at least as close as you were able to read the spring scales. Thus the two cords, tied to positions A and B, each carried half the load in holding up the 4-kg mass. Suppose that you had tied the knot in the cord at a point 6 inches from one end and 18 inches from the other, and then suspended the weight at the knot. Then the diagram might have looked like this: For this case, which force (F_A or F_B) do you think would have to be larger? How could you check out your guess?



2. Look at the two diagrams below of forces F_A and F_B holding up a weight F_W.
   a. For which case must the cord be the strongest to hold the weight?
   b. At what angle (between F_A and F_B) would each spring scale read *exactly half* of the hanging weight?





Review

1. ***View and discuss the video, "Force in Mechanical Systems."***
2. ***Review the Objectives and Main Ideas of the print materials in this subunit.***
3. ***Your teacher may give you a test over Subunit 1, "Force in Mechanical Systems."***

Measuring Temperature with Thermocouples

Lab 1T2

LAB OBJECTIVES

When you've finished this lab, you should be able to do the following:

1. *Draw a thermocouple circuit. Briefly explain how a thermocouple works.*
2. *Set up a thermocouple circuit for temperature measurement.*
3. *Measure Celsius temperature with a thermocouple to within plus or minus (±) 2 C°.*
4. *If you know the voltage reading of a thermocouple, use the thermocouple calibration table to find the temperature.*

LEARNING PATH

1. *Preview the lab. This will give you an idea of what's ahead.*
2. *Read the lab. Give particular attention to the Lab Objectives.*
3. *Do the lab, "Measuring Temperature with Thermocouples."*

MAIN IDEAS

- *A thermocouple can be used to measure temperature difference.*
- *If reference junctions are known, measurement junctions can be determined.*

A ***thermocouple*** is a temperature-measuring device that produces a voltage reading in response to a temperature difference. It's simple, rugged and easy to use. A thermocouple can be used to measure temperature under conditions and in places where an ordinary thermometer can't be used. Furnaces, boilers and nuclear reactors are examples of some of the many places thermocouples can be used. The ability to read temperatures far away from the actual point of measurement is a major benefit. This benefit, combined with others, makes the thermocouple the most widely used temperature-measuring device in industry. Figure 1 shows the use of a thermocouple in the temperature measurement of superheated steam flowing through an insulated pipe.

MEASURING TEMPERATURE WITH A THERMOCOUPLE

In use, the ***reference junction*** of the thermocouple is kept at a known temperature. This is usually the freezing point of water (0°C). This reference temperature is maintained by placing the reference junction in an ice-water mixture. The other junction, the ***measurement junction,*** is then brought into contact with the substance whose temperature is to be measured. The voltage reading made by a sensitive voltmeter is an indication of the temperature difference between the two junctions. By knowing the voltage reading, you can determine the unknown temperature with the help of appropriate reference tables.

HOW TO USE A TEMPERATURE CALIBRATION TABLE

Table 1 is a temperature calibration table for the chromel-constantan thermocouple used in this lab. This table is based on a reference temperature of 0°C. The first column at the left contains temperature values in 10-degree jumps, from −20°C to 320°C. The row across the top of Table 1 contains additional temperatures in 2-degree jumps, from 0°C to 10°C. The rest of Table 1 contains voltage values in millivolts.

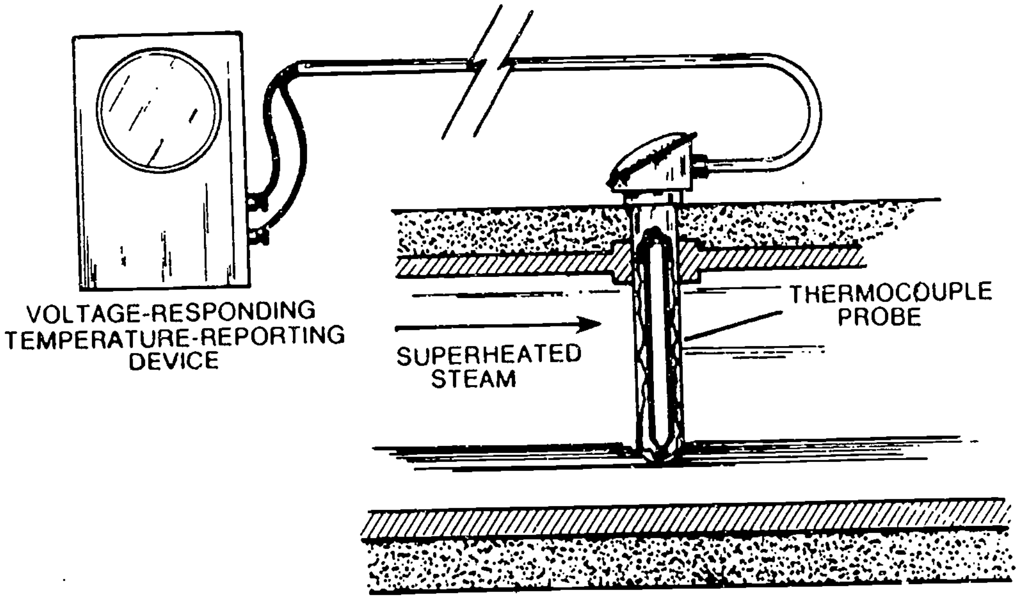


Fig. 1 Temperature measurement with thermocouple.

43

TABLE 1. TYPE-E THERMOCOUPLE

Chromel-Constantan Reference Junction at 0°C (Temperatures in °C and Thermoelectric Voltages in mV)						
	0°C	2°C	4°C	6°C	8°C	10°C
-20°C	-1.15 mV	-1.26 mV	-1.38 mV	-1.49 mV	-1.60 mV	-1.71 mV
-10°C	-0.58	-0.70	-0.81	-0.93	-1.04	-1.15
0°C	0.00	-0.12	-0.23	-0.35	-0.47	-0.58
0°C	0.00	0.12	0.23	0.35	0.47	0.58
10°C	0.59	0.71	0.83	0.95	1.07	1.19
20°C	1.19	1.31	1.43	1.56	1.68	1.80
30°C	1.80	1.92	2.05	2.17	2.30	2.42
40°C	2.42	2.54	2.67	2.80	2.92	3.05
50°C	3.05	3.17	3.30	3.43	3.56	3.68
60°C	3.68	3.81	3.94	4.07	4.20	4.33
70°C	4.33	4.46	**4.59**	4.72	4.85	4.98
80°C	4.98	5.12	5.25	5.38	5.51	5.65
90°C	5.65	5.78	5.91	6.05	6.18	6.32
100°C	6.32	6.45	6.59	6.72	6.86	7.00
⋮	⋮	⋮	⋮	⋮	⋮	⋮
280°C	19.48	19.64	19.79	19.95	20.10	20.26
290°C	20.26	20.41	20.57	20.72	20.88	21.03
300°C	21.03	21.19	21.35	21.50	21.66	21.81
310°C	21.81	21.97	22.13	22.28	22.44	22.60
320°C	22.60	22.75	22.91	23.07	23.23	23.38

Example A shows in detail how Table 1 is used to determine a temperature, given a thermocouple voltage reading.

Example A: *Using a Temperature Calibration Table*

Given: The reference-junction temperature of a chromel-constantan thermocouple is 0°C. The voltage measured is 4.6 mV.

Find: The temperature of the measurement junction.

Solution:

1. First, locate the voltage nearest to the value 4.6 mV in the table. This is seen to be 4.59 mV. (See boxed number in Table 1.)
2. Move horizontally from 4.59 mV to the left-most column and read the temperature. (See horizontal arrow in Table 1.) The temperature value is 70°C.
3. Move vertically from 4.59 mV to the top row and read the temperature value. (See vertical arrow in Table 1.) The value is 4°C.
4. Add the two temperature values.

   70°C + 4°C = 74°C. The temperature is 74°C.

A voltage reading of 4.6 mV—obtained with a chromel-constantan thermocouple on which the reference temperature is 0°C—tells us that the temperature of the unknown junction is very close to 74°C.

In summary, if you know the thermocouple voltage, you can use a calibration table to find the unknown temperature at the measurement junction. Use the following general procedures:

Step 1: Locate the given thermocouple voltage readi.ıg in the table.

Step 2: From this reading, move horizontally to the left-most column and read the temperature listed there. This gives the temperature to the nearest 10 degrees.

Step 3: Move vertically from the initial thermocouple voltage to the row at the top of the table and read the temperature listed there. This tells you what to add to the temperature determined in Step 2.

Step 4: Add the two temperature values together. The sum is the temperature of the measurement junction.

The procedure outlined above is the same one you'll use in the laboratory to determine unknown temperatures from voltage readings.

LABORATORY

Several different types of thermocouples are made. The one you'll use in this lab is a type-E thermocouple. Table 1 is a calibration table for this thermocouple. The type-E thermocouple is made of chromel and constantan (two metals). Chromel is a mixture of nickel and chromium. Constantan is a mixture of copper and nickel.

EQUIPMENT

Chromel and constantan thermocouple wire with banana plugs
Digital multimeter with millivolt scale
Hot plate or Bunsen burner
Ring stand with wire gauze (if Bunsen burner is used)
Two beakers, or one beaker and one Styrofoam cup
Ice and water
Room thermometer

PROCEDURES

1. Place a beaker half full of water on the ring stand above the Bunsen burner or on the hot plate. Light the burner, or turn the hot plate on "high." Complete Steps 2 and 3 while the water heats to boiling.
2. Fill the second beaker with water and crushed ice.
3. Construct a type-E thermocouple from chromel and constantan wire by twisting together the ends of a constantan wire and two chromel wires. Be sure that the twisted ends make good contact. (See Figure 2.)
4. Connect the loose ends of the thermocouple wires to the multimeter, as shown in Figure 3. Set the function selector of the multimeter to "DC volts" and the range to the lowest "mV" setting.

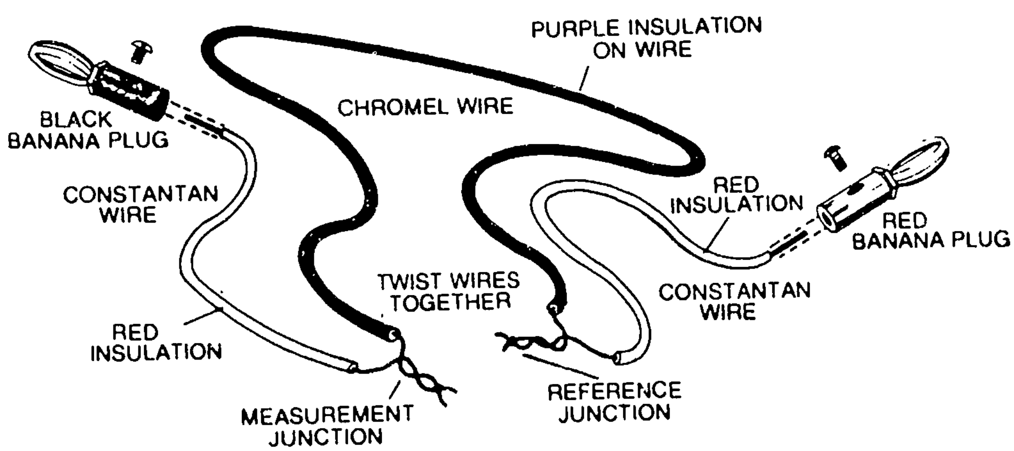


Fig. 2 Wiring a thermocouple.

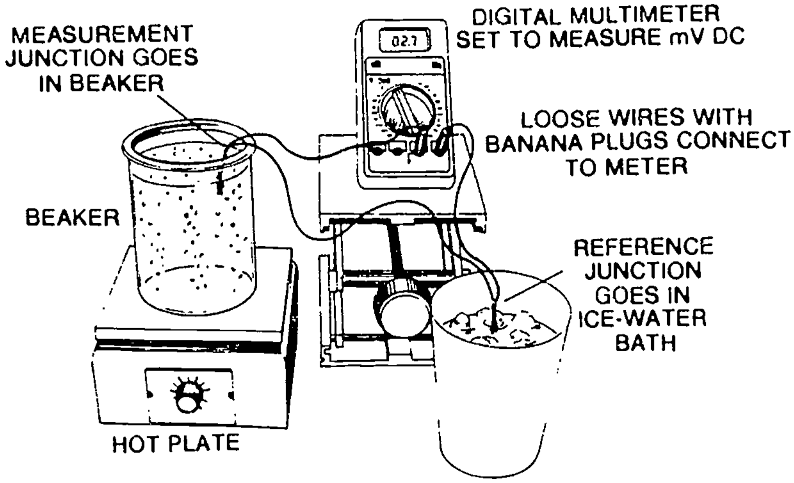


Fig. 3 Lab setup.

5. Place either one of the thermocouple junctions in ice water. This junction becomes the reference junction. Let the other junction lie freely on the table. It should be at the temperature of the room. The voltage reading on the multimeter should be a positive reading; if not, reverse the banana plugs in the meter. Read the voltage on the meter. Record under "Thermocouple Voltage" in the Data Table, opposite "Room Air."
6. With the reference junction in the ice water, place the measurement junction in the hot-water beaker. If the water isn't boiling, watch the voltage reading on the multimeter change as the water approaches the boiling temperature. Read the final voltage—at boiling-water temperature. Record the voltage reading in the Data Table opposite "Boiling Water."
7. Carefully remove the thermocouple measurement junction from the boiling water. Leave the reference junction in the ice water. Carefully remove the Bunsen burner from under the beaker. Hold the measurement junction about 10 cm above the Bunsen burner flame. (If you use a hot plate, hold the thermocouple measurement junction near the hot plate surface.) Read the voltage. Record in the Data Table opposite the appropriate entry.
8. Refer to Table 1, "Thermocouple Calibration Table for Type-E Thermocouples." For each voltage measurement listed in the Data Table, use Table 1 to find the corresponding temperature. Follow the procedure outlined in Example A. Then record each temperature in the Data Table, under the column "Temperature (From Calibration Table)."
9. Check the room thermometer and record room temperature in the Data Table. How does the reading compare with that obtained with the thermocouple?

DATA TABLE

Measurement Junction	Thermocouple Voltage	Temperature (From Calibration Table)
Room Air		
Boiling Water		
Bunsen Burner Flame or Hot Plate Surface (Circle the one you used.)		
Room temperature measured with room thermometer = ____________		

WRAP-UP

1. Think of two situations where a thermocouple would be used to measure a temperature that couldn't be measured with a liquid-in-glass thermometer. Describe those situations.
2. Draw a thermocouple circuit diagram.

Review

1. ***View and discuss the video, "Temperature in Thermal Systems."***
2. ***Review the Objectives and Main Ideas of the print materials in this subunit.***
3. ***Your teacher may give you a test over "Temperature in Thermal Systems."***

52

Work Done by a Solenoid

Lab 2E2

LAB OBJECTIVES

When you've finished this lab, you should be able to do the following:

1. ***Identify the main parts of a solenoid.***
2. ***Describe how the solenoid works.***
3. ***List five devices or applications that use solenoids.***
4. ***Set up a lab experiment to measure the pulling force and the holding force exerted on a solenoid plunger for different voltages applied across the solenoid.***
5. ***Identify the mechanical and electrical work involved in the operation of a solenoid.***

LEARNING PATH

1. ***Preview lab. This will give you an idea of what's ahead.***
2. ***Read the lab. Give particular attention to the Lab Objectives.***
3. ***Do lab, "Work Done by a Solenoid."***

MAIN IDEAS

- ***A solenoid changes electrical work (Work In) into linear mechanical work (Work Out).***
- ***Many devices, including automobile starters, use solenoids.***
- ***When current flows through the coils of a solenoid, a force pulls on a plunger. This draws the plunger into the solenoid body.***
- ***The holding force of a solenoid on a plunger is greater than the pulling force.***

53

A **solenoid** is an electromechanical device. It has two main parts. One part is an electrical part. The other part is a mechanical part. The electrical part is a wire-wound coil. The mechanical part is an iron or steel plunger that moves inside the hollow core of the coil. The two parts are arranged as shown in Figure 1.

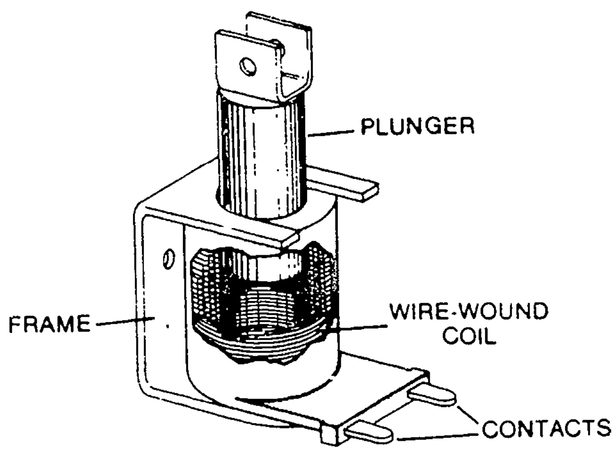


Fig. 1 Cutaway view of a solenoid.

The operation of a solenoid is straightforward. When current moves through the solenoid coil, a magnetic attraction for the solenoid plunger is developed. The higher the current flow, the stronger the magnetic attraction. This magnetic attraction (or force) pulls the plunger into the core of the solenoid and holds it there as long as current flows through the coil.

When current stops flowing, the magnetic force on the plunger disappears. The plunger is free to move. Often, a spring is attached to the plunger to pull it back out of the solenoid. Turning current ON and OFF causes the plunger to move into and out of the solenoid core. For example, if the solenoid plunger is attached to a valve, movement of the plunger acts to open and shut the valve or switch.

WHAT ARE SOME USES FOR SOLENOIDS?

A solenoid is a common part of the starter motor in an automobile. Figure 2 shows a cutaway view of the starter motor and solenoid assembly. In the automobile starter, the solenoid causes a gear attached to the motor to mesh with the teeth on the flywheel as the starter motor begins to rotate. This coupling is done by the solenoid shift lever (shown in Figure 2). The solenoid shift lever is activated by the movement of the solenoid plunger. This happens when current in the solenoid coil pulls the plunger into the core. The plunger also acts to make direct electrical contact. This means that very high current can flow from the battery through the motor windings.

Several other common uses of a solenoid are found in the following:

Electric Doorbells —The solenoid plunger strikes the tone bars that set off the musical chimes.

Washing Machines —The solenoid plunger moves the levers that shift the transmission into different tub speeds or different washing actions.

Electric Typewriters —The solenoid works with the "daisy" print-wheel element in the printing process.

Electric Stapling Guns —The solenoid plunger is the main device that forces out the staples.

Power-operated Valves —The solenoid plunger moves the linkage that opens and closes the valves.

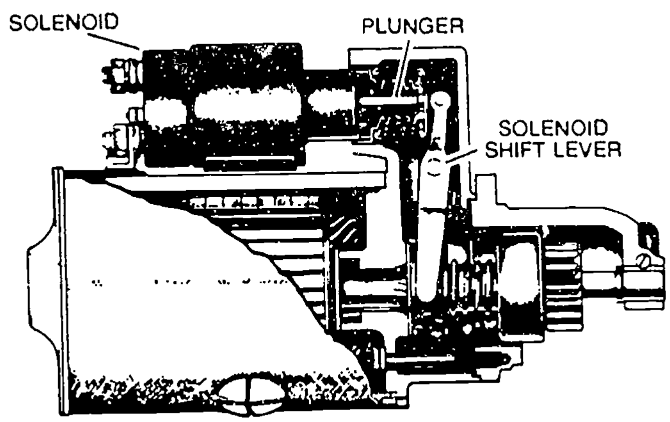


Fig. 2 Cutaway view of starter motor with solenoid.

LABORATORY

EQUIPMENT

Power supply
Solenoid, 12-V to 24-V DC operation with 2" to 4" stroke
Multimeters, one VOM and one DMM
Spring scale, 0 to 9 oz (0 to 250 gm)
Small-capacity slotted weight set with weight hanger
String
Switch, SPST type
Support stand with 3 clamps, 2 hook collars and support rod
Two pulleys
Ruler

PROCEDURES

In this lab, you'll set up a solenoid with a plunger as part of an electrical circuit. You'll measure both the ***pulling*** force and the ***holding*** force of the solenoid. You'll have a chance to learn how the solenoid force is related to the solenoid voltage and current.

Initial Setup

Assemble the apparatus as shown in Figure 3. (Do not add any weights to the weight hanger at this time.) Note carefully how the multimeters are connected. Follow the ***safety procedures*** you learned in Lab 1E1 for connecting electrical circuits. Trace through the completed circuit —as you learned in Lab 2E1—to make sure the connections are correct. Check with your teacher before proceeding.

Part 1: *Determining the Solenoid Holding Force*

1. With the power supply switch in the OFF position and the output voltage control set to "minimum," plug the three-prong power cord into a bench outlet.
2. Turn the power supply and multimeters ON.
3. Close switch S_1.
4. By pulling down on the sting above the solenoid, lower the plunger all the way into the solenoid body. (Hold on to the string if the "pull" of the weight hanger is large enough to cause the plunger to come back out.)

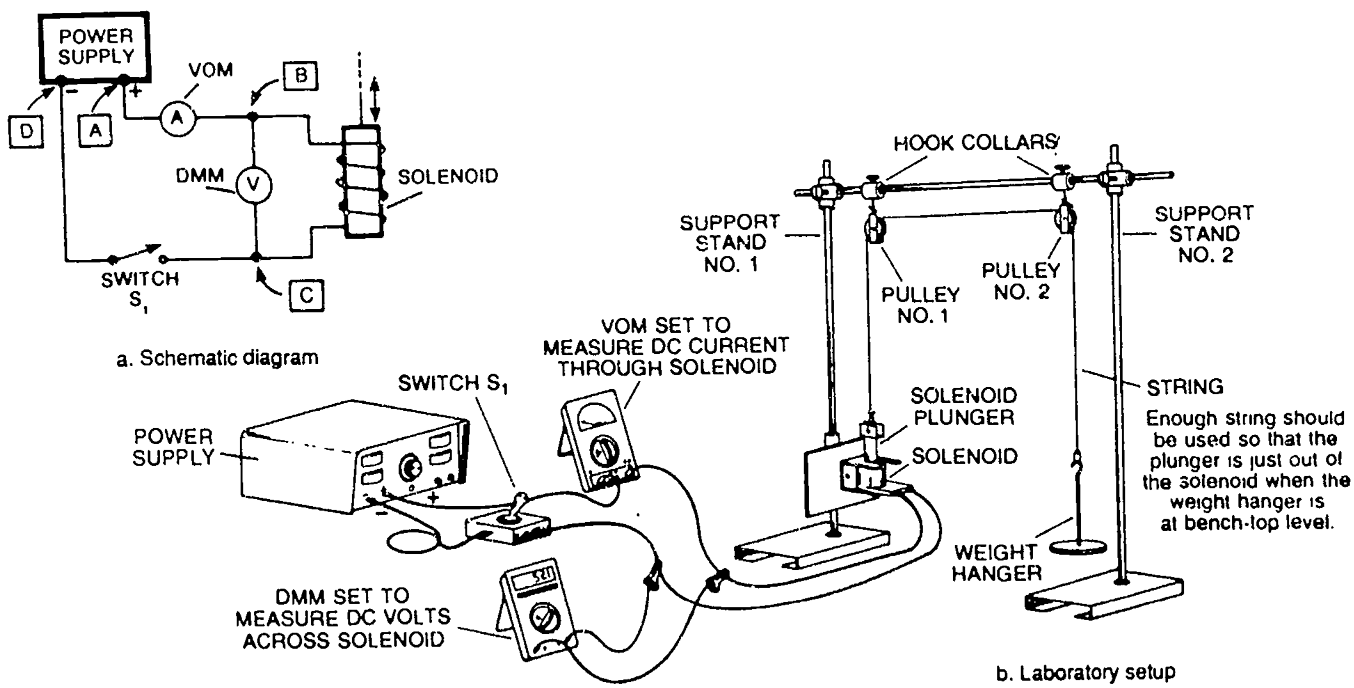


Fig. 3 Lab setup #1.

5. Slowly increase the output voltage control of the power supply until the plunger ***remains*** in the solenoid. (Holding force of solenoid is now greater than pulling force of weight hanger.)
6. *Trial 1:* With the plunger held in place by the solenoid, add weight in small increments to the weight hanger. Continue adding weights to the weight hanger until the plunger is pulled free of the solenoid. Note current and voltage readings when this happens.
7. Record the ***total*** weight in grams (hanger plus weights) that is needed to pull the plunger free. Record in Data Table 1, where shown. Convert the hanging weight in grams (gmw) to a holding force in newtons. Follow this example:

$$50\ \cancel{\text{gmw}} \times \frac{1\ \cancel{\text{kgw}}}{1000\ \cancel{\text{gmw}}} \times \frac{9.8\ \text{N}}{\cancel{\text{kgw}}} = 0.49\ \text{N}$$

8. Record current and voltage, at the time plunger is pulled free, in Data Table 1.
9. *Trials 2 and 3*: Increase the voltage across the solenoid by 4 volts and repeat Steps 4 through 7. Do this until you reach 12 volts across the solenoid. Record values in Data Table 1.
10. Open Switch S_1. Turn output voltage control to minimum.

DATA TABLE 1

Trial No.	Voltage Across Solenoid (V)	Current Through Solenoid (A)	Grams Weight on Hanger (gm)	Holding Force on Plunger (N)
1				
2				
3				
4				

OPTIONAL

Part 2: Determining the Solenoid Pulling Force

1. Remove the plunger from the solenoid. Mark the plunger every centimeter or so, beginning from the end that goes into the solenoid. This is shown in Figure 4.

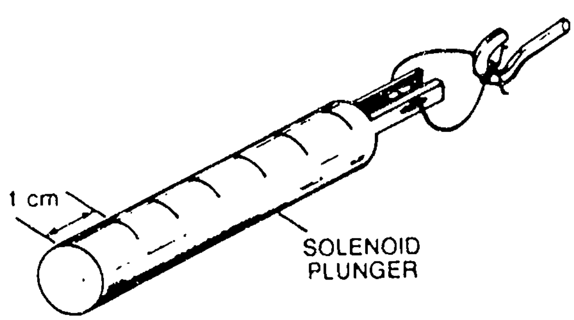


Fig. 4 Marked plunger.

2. Remove the weight hanger from the string. Place another clamp on support stand #2. Tie the free end of the string to the clamp. Insert a spring scale between the string and the plunger. See Figure 5.
3. Loosen the end of the string tied to the clamp described in Step 2. Pull on the string until the plunger hangs freely over the solenoid. Adjust the vertical alignment so that the plunger can slide into and out of the solenoid easily.
4. Adjust the scale on the spring balance to read zero with the plunger hanging from the balance. (If you're not sure how to make this adjustment, see your teacher.) Your lab setup should now look like Figure 5.
5. Use the clamp on support stand #2 to provide just enough slack in the string so that the plunger is about half-way into the solenoid. Now gently raise the plunger and spring scale by pulling on the string. Raise the plunger so that it is near the top of the solenoid.

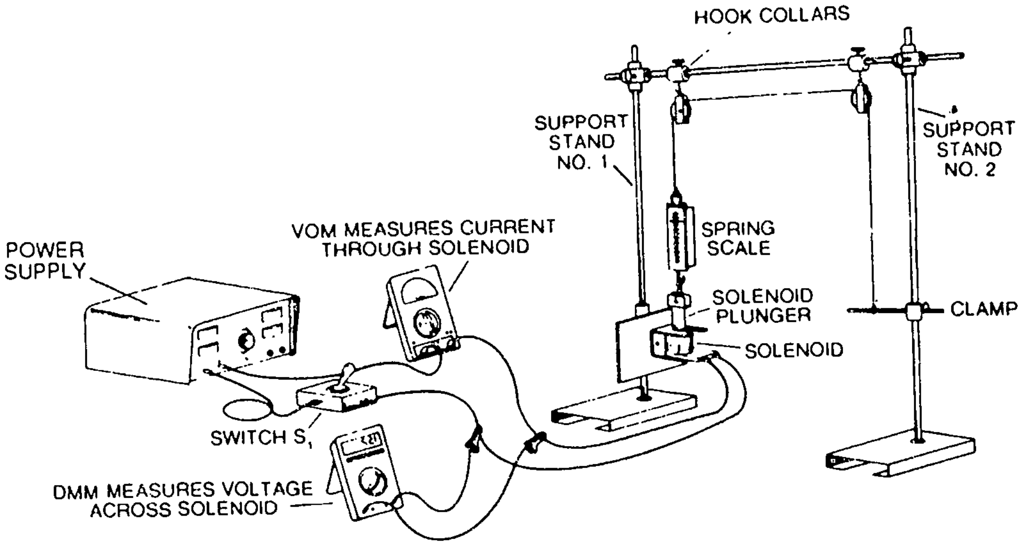


Fig. 5 Lab setup #2.

6. Close switch S_1. Adjust the output voltage control for a reading of 6 V DC on the DMM.
7. Now raise or lower the plunger so that the 1-cm mark is just level with the top of the solenoid. Read the spring scale. Record this in Data Table 2 as the pulling force, under the column labeled "1 cm" and in the row labeled "6 volts." Change the scale reading in *grams* to force in newtons. Here's an example of how to do this for a 50-gram weight (50 gmw):

$$(50\ \cancel{\text{gmw}})\left(\frac{1\ \cancel{\text{kgw}}}{1000\ \cancel{\text{gmw}}}\right)\left(\frac{9.8\ \text{N}}{1\ \cancel{\text{kgw}}}\right) = 0.49\ \text{N}$$

8. On the VOM, read the current flowing through the solenoid. Record current in Data Table 2 under the "current measurement" column in the 6-volt row.
9. Lower the plunger and the spring scale to the 2-cm mark on the plunger. Read and record the force in newtons in Data Table 2.
10. Follow the same procedure for each of the remaining marks on the plunger. Fill in the Data Table as you go. Continue this procedure until the plunger is suddenly pulled into the solenoid. Note the plunger depth at which this happens in the Data Table.
11. Open Switch S_1. Raise the plunger out of the solenoid.
12. Close Switch S_1. Increase the voltage across the solenoid to 10 volts as indicated on the DMM.
13. Repeat Steps 7-10 and record measurements in the Data Table.
14. Open Switch S_1. Raise the plunger out of the solenoid. Turn OFF the power supply.

DATA TABLE 2

Voltage Across Solenoid	Current Through Solenoid (A)	Pulling Force on Plunger at Depth of:				
		1 cm	2 cm	3 cm	4 cm	5 cm
Trial 1: 6 volts		N	N	N	N	N
Trial 2: 10 volts		N	N	N	N	N
Depth of plunger when it is pulled completely into solenoid:		At 6 volts: ________cm At 10 volts: ________cm				

WRAP-UP

1. Examine Data Table 1. Based on the recorded values of *holding force* and *voltage* applied to the solenoid, answer the following questions.
   a. What happens to the holding force as the solenoid voltage increases?
   b. When the solenoid voltage doubles, does the holding force double—or more than double?
   c. Would you say that the holding force varies linearly or nonlinearly with the applied voltage?
2. Examine Data Table 2. Based on the recorded values of *pulling force* and *plunger depth*, answer the following questions.
   a. What happens to the force with which the solenoid pulls on the plunger as more and more of the plunger moves into the solenoid?
   b. Is the relationship between pulling force and plunger depth linear or nonlinear? Explain.
3. What happens to the pulling force at a given plunger depth—when the solenoid voltage is increased?

Student Challenge

1. For a solenoid, describe how you would measure the *electrical work in*. What are some problems you would face?
2. Describe how you would measure the *mechanical work done* by the solenoid. What are some problems you would face?

Review

1. ***View and discuss the video, "Work in Electrical Systems."***
2. ***Review the Objectives and the Main Ideas of this subunit.***
3. ***Your teacher may give you a test over Subunit 3, "Work in Electrical Systems."***

Measuring Resistance in Air Filters

Lab 4F2

LAB OBJECTIVES

When you've finished this lab, you should be able to do the following:

1. *Measure the pressure drop across filter sections in air ducts.*
2. *Measure the pressure difference across a set of standard restrictor plates. Develop a calibration curve of pressure difference versus restriction.*
3. *Show that increased contamination of filters causes increased resistance to airflow and decreases flow rate.*

LEARNING PATH

1. *Preview the lab. This will give you an idea of what's ahead.*
2. *Read the lab. Give particular attention to the Lab Objectives.*
3. *Do lab, "Measuring Resistance in Air Filters."*

MAIN IDEAS

- *Dirty filters increase resistance in air-handling systems. Therefore, dirty filters decrease flow rate.*
- *The relationship between resistance, pressure difference and flow rate can be shown in an air-handling system that has filter sections.*

Did you ever wonder why ducts in a large air-conditioning or heating system are of different sizes along the airflow path? Did you ever wonder why these ducts have long, sweeping curves when a sharp, 90° bend would be much more compact? This lab will help you discover the answers.

Conditioned air that's been cooled or heated and then filtered (Figure 1) moves at various speeds through the ductwork. Speed control allows the air to move into and out of areas without causing drafts or excessive noise. Ductwork size changes at different points. Different-sized ducts are used to make sure that the proper volume of air can pass through the ducts without an increase or decrease in speed and, at the same time, maintain streamlined flow. The fan that circulates the air creates enough pressure to overcome duct resistance in the system and give proper flow rates.

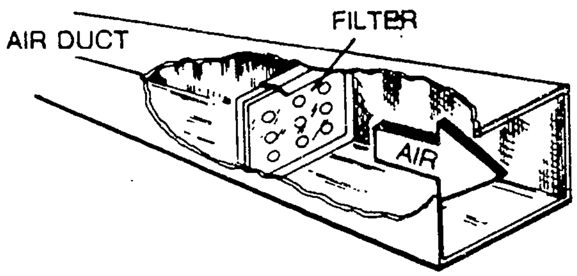


Fig. 1 Air filter.

This lab shows the effect of resistance in a fluid system. It will show you how different amounts of resistance in a fluid system change pressure and flow rate along the system's flow path.

LABORATORY

EQUIPMENT

Airflow assembly with 12-V DC fan orshop vac suction hose
Slant-tube water manometer, or
U-tube water manometer, with minimum 1-meter arms
Standard restrictor set
Assorted filter sections (clean and dirty)
DC power supply, 20 V, 10 A
Support stand, rods, and clamps

PROCEDURES

Part A: *Laboratory Setup*

1. Set up the apparatus, as shown in Figure 2. Be sure power supply is OFF and fan is NOT RUNNING.
2. With the voltage setting on the power supply set on ***minimum***, turn the power supply ON. Gradually increase voltage setting until fan begins to operate—usually around 4 volts. Then increase voltage to a value in the range of 6 to 8 volts. Your system will now be operating at maximum airflow through—and minimum pressure drop across—the intake platform. (***Note***: For a voltage setting of 6-8 volts, fan speed will cause a pressure drop across the intake platform (no restrictions) of about 0.5 to 0.75 inch H_2O, measured with either the U-tube or slant-tube manometer. With the ***maximum*** restrictor plate on the platform, pressure drop across the plate will read about 2 inches H_2O.)
3. Read the U-tube manometer or slant-tube manometer for the pressure drop Δp across the ***unrestricted*** intake platform. Record that value as Δp_0 on your data sheet.
4. Turn the power supply OFF. DO NOT CHANGE THE VOLTAGE SETTING. Then proceed with the calibration of the airflow device (see Part B).

Part B: *Calibration of Airflow Device*

1. Figure 3 shows a set of airflow-restrictor plates and a filter section. Restrictor plates are placed at the top of the airflow column (as indicated in Figure 2) to control the amount of air flowing through the device. Each plate is labeled with a percentage rating. A 90% plate means that—with the plate in place—the opening of the airflow tube is 90% of the full value without the plate.

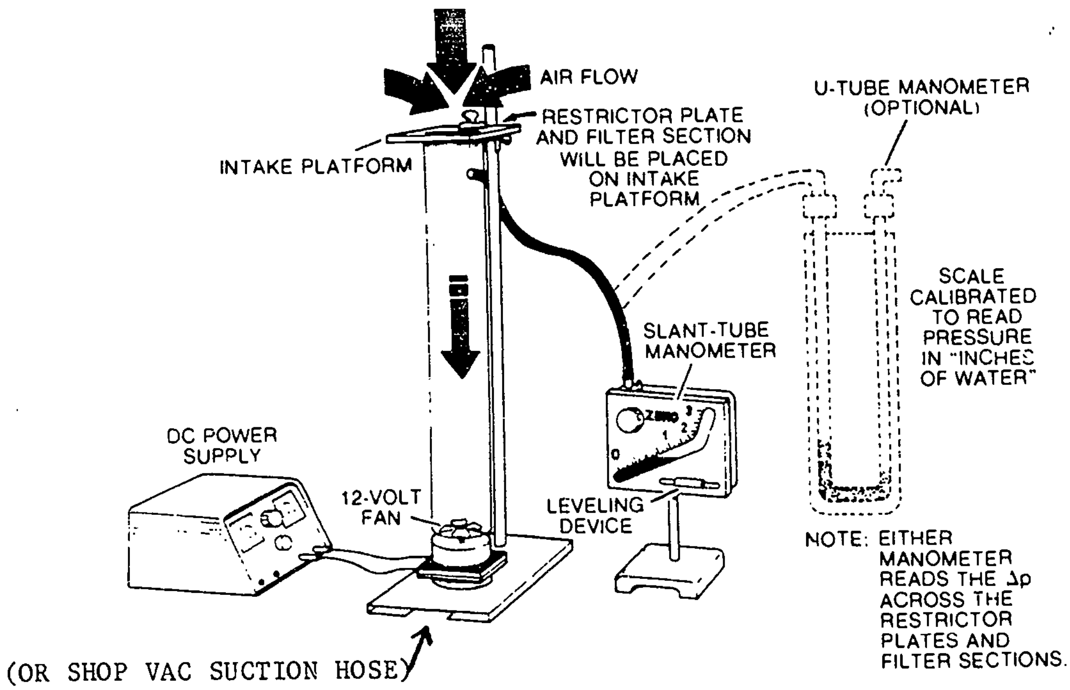


Fig. 2 Lab setup.

2. Place the 90% restrictor plate over the intake of the airflow device. Turn the power supply ON with voltage at SAME SETTING as in Step 2 of Part A.
3. Read the value of the pressure reading (Δp) on the manometer. Record in Data Table 1 with appropriate units. This reading gives the pressure drop (pressure difference) across the restrictor plate.
4. With the power supply ON and voltage setting UNCHANGED, successively replace the restrictor plate in use with the next smaller restrictor plate. Record each pressure reading (Δp) opposite the correct restrictor plate value, in Data Table 1. DO NOT CHANGE VOLTAGE SETTING VALUE FROM THAT ESTABLISHED in Step 2 of Part A.

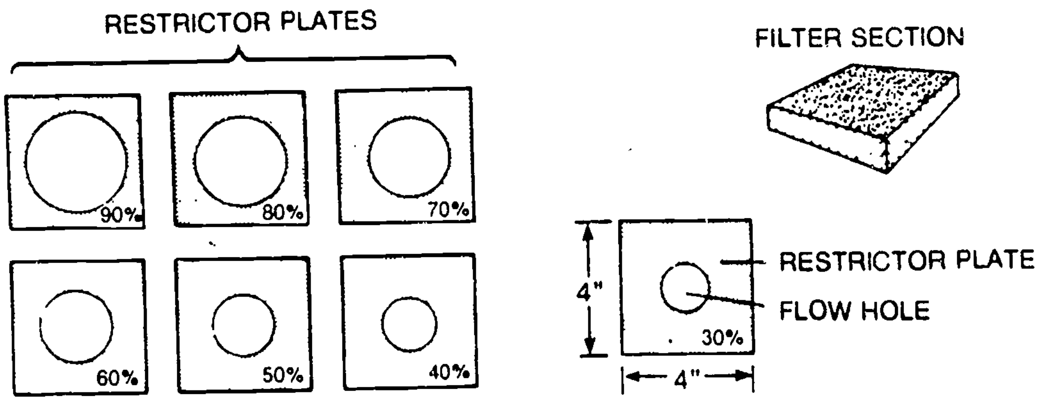


Fig. 3 Restrictor plate and filter section.

DATA TABLE 1. CALIBRATION DATA

Restrictor Plate Value	Δp Across Plate (in. of H_2O)	Restrictor Plate Value	Δp Across Plate (in. of H_2O)
90%		50%	
80%		40%	
70%		30%	
60%		20%	

Part C: *Airflow Restriction Caused by Dirty Filters*

1. Remove the last restrictor plate used. Place a ***clean filter*** section on the intake platform. Ensure that the voltage setting on the power supply is ***UNCHANGED***.
2. Read the pressure reading (Δp) in appropriate units. Record in Data Table 2.
3. Remove the clean filter section. Replace successively with several dirty filter elements. (One filter may be moderately dirty; the other may be so dirty it's almost clogged.) Read and record pressure readings (Δp) in Data Table 2 for each dirty filter section used. (Do not change voltage setting on the power supply!)

DATA TABLE 2. FILTER RESTRICTION

Filter	Δp Across Filter (in. of H_2O)
Clean	
Dirty #1	
Dirty #2	

Calculations

If your setup used:

- a slant-tube manometer, go to Step 2 of the Calculations.
- a U-tube manometer with English measure calibration (inches of H_2O), go to Step 2 of the Calculations.
- a U-tube manometer with SI measure calibration (cm or mm of H_2O), go to Step 1 of the Calculations.

1. Convert each Δp measure in Data Tables 1 and 2 and (Δp_0) of Procedure Step 3, Part A from SI to English units.
   a. For "cm of H_2O" to "inches of H_2O" use:

$$(\Delta p \text{ in cm } H_2O) \times \left(\frac{1 \text{ inch}}{2.54 \text{ cm}}\right) = \Delta p \text{ in inches } H_2O$$

   b. For "mm of H_2O" to "inches of H_2O" use:

$$(\Delta p \text{ in mm } H_2O) \times \left(\frac{1 \text{ inch}}{25.4 \text{ mm}}\right) = \Delta p \text{ in inches } H_2O$$

2. Since Δp_0 may not have been a zero value for either the U-tube or slant-tube manometer, determine the Δp caused by restrictor plates and filter elements as follows:
   a. (Δp from Data Table 1) $-$ Δp_0 = Δp across restrictor plate
      Record in Data Table 3.
   b. (Δp from Data Table 2) $-$ Δp_0 = Δp across restrictor plate
      Record in Data Table 4.

DATA TABLE 3. CALIBRATION DATA, CALCULATED Δp

Restrictor Plate Value	Δp Across Plate (in. of H_2O)	Restrictor Plate Value	Δp Across Plate (in. of H_2O)
90%		50%	
80%		40%	
70%		30%	
60%		20%	

DATA TABLE 4. CALCULATED Δp FILTERS

Filter	Δp Across Filter (in. of H_2O)
Clean	
Dirty #1	
Dirty #2	

3. Use Data Table 3 and a grid like that shown in Figure 4 (on the next page) to plot Δp values versus restrictor plate percentages. Plot a point for each restrictor plate and corresponding pressure difference (Δp). After completing this task, you should have plotted eight points. A ninth point for 0-pressure difference under no restriction—100% of open—may be added.
4. Draw a single, "best-fit" line from "zero" (100% open, 0 inches of H_2O) through the remaining eight points.

WRAP-UP

After you've completed all procedures, use your graph (Figure 4) to do the following:

1. On the Δp axis of the graph, locate the pressure difference point (Δp) measured for the clean air filter. Place a straightedge ***horizontally*** across the graph, starting from this point. Mark where the straightedge crosses the graphed line. Now, turn the straightedge to a ***vertical*** position. Line it up on the point marked on the graph line. Follow the straightedge down to the restriction (bottom) axis. Read the % value of the restriction where the straightedge crosses the axis. Record the value.
   Restriction of clean filter = _____% of open.
2. Use the same process to find the amount of restriction for each dirty filter section. Record your values.
   Restriction: Dirty Filter #1 = _____% of open.
   Restriction: Dirty Filter #2 = _____% of open.

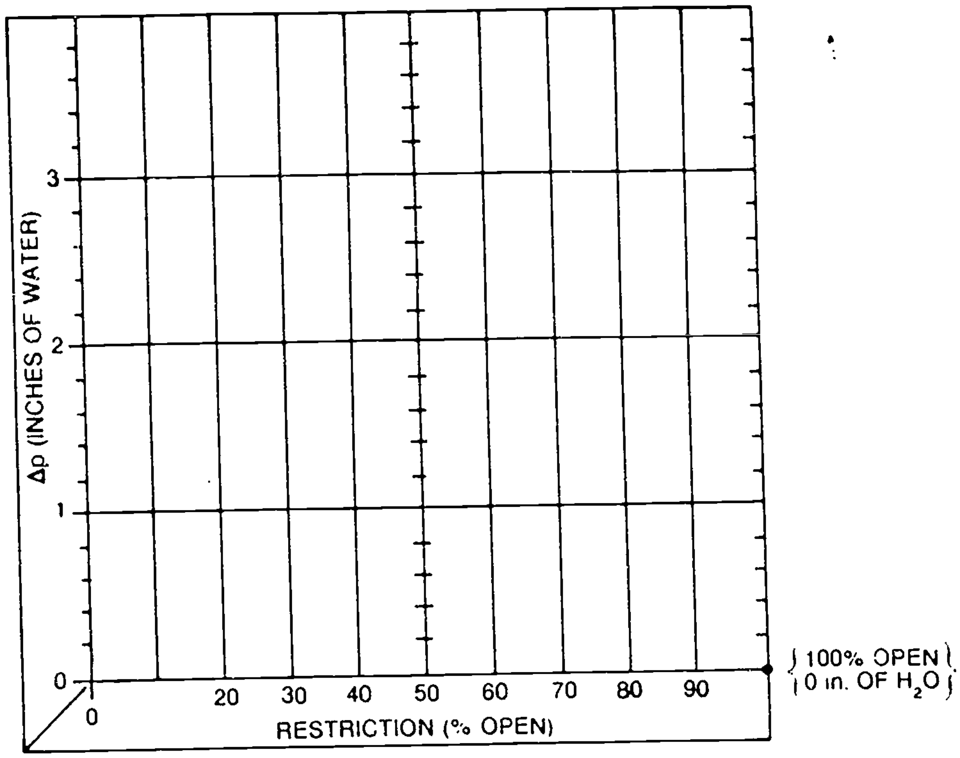


Fig. 4 Graph: Δp versus restriction.

Now answer these questions:

a. Which filter section is the dirtier?
b. How do you know which filter section is the dirtier?
c. How does a clogged filter affect the flow of fluid (air) in an air-handling system?
d. Why was it important NOT TO CHANGE THE INITIAL VOLTAGE SETTING while making the pressure difference readings (Δp) across the restrictor plates and the filter sections?

3. From your graph, estimate the pressure difference for a restriction that is 75% open.

Review

1. ***View and discuss the video, "Resistance in Fluid Systems."***
2. ***Review the Objectives and Main Ideas of this subunit.***
3. ***Your teacher may give you a test over Subunit 2, "Resistance in Fluid Systems."***

Streamlining Shapes to Reduce Air Drag

Lab 4M2

LAB OBJECTIVES

When you've finished this lab, you should be able to do the following:

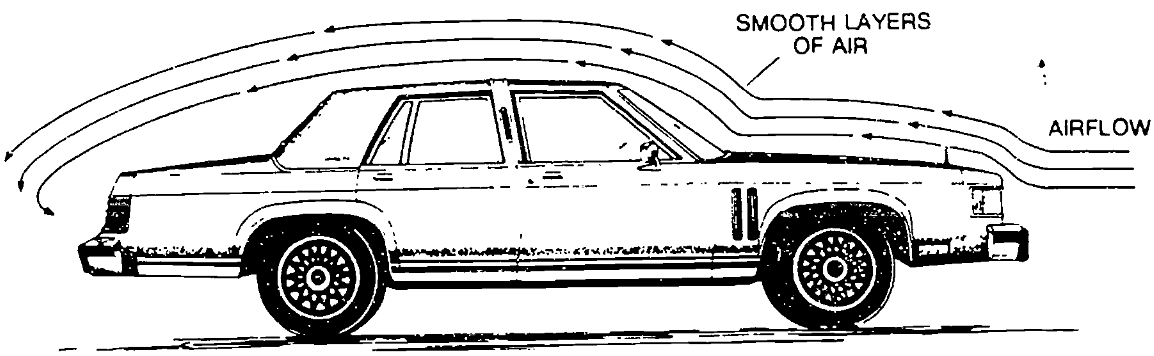
1. ***Measure the drag force on two or three objects of different shapes.***
2. ***Prepare a graph that shows how drag force depends on airflow speed for each of the objects.***

LEARNING PATH

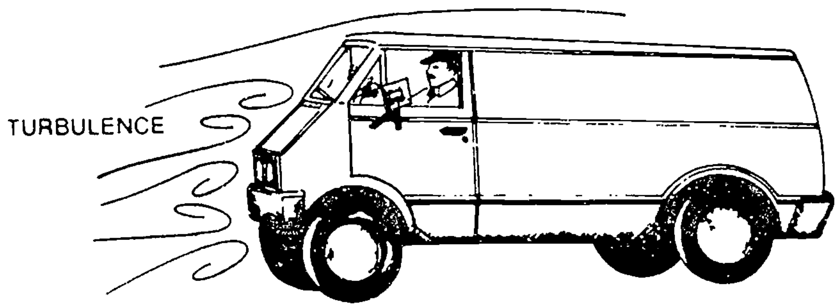
1. ***Preview the lab. This will give you an idea of what's ahead.***
2. ***Read the lab. Give particular attention to the Lab Objectives.***
3. ***Do lab, "Streamlining Shapes to Reduce Air Drag."***

MAIN IDEAS

- ***Fluid drag is related to the shape of the object that's moving through a fluid.***
- ***Drag force depends on the speed of fluid flowing past the object.***
- ***At moderate speeds, fluid turbulence is small. At high speeds, turbulence is large and is the main factor that causes fluid drag.***



a. Streamlined car



b. Unstreamlined van

Fig. 1 Streamlined shapes have less drag.

Streamlining the shape of an object can reduce drag force as the object moves through a fluid. If the object's shape is chosen properly, the fluid moves past the object in smooth layers. See Figure 1a. This is called "streamlined flow."

If the object's shape is blunt in the direction of movement, turbulence is set up. See Figure 1b. Turbulence destroys smooth, streamlined flow and increases drag. With increased drag more force and energy are required to keep the object moving at a certain speed—and energy costs money. Engineers and technicians design the shapes of moving objects so that drag forces are reduced.

When an object moves through a fluid, such as air or water, the streamlined flow pattern is related to the shape and speed of the object. If the object gently divides the fluid and allows flow around its shape without mixing the fluid layers, there will be little, if any, turbulence. If abrupt mixing of fluid layers occurs, each fluid layer will "bump" into other layers. This causes a disruption of the layers. Turbulence results.

For example, streamlined automobiles (Figure 1a) use less energy (gas) to move through the air than square-shaped vans (Figure 1b). The same result extends to bicycles, swimmers, motorcycles, boats, aircraft and rockets—including the space shuttle. In each case, a streamlined shape reduces drag.

In this lab, you'll measure the drag force caused by air flowing past objects of different shapes. Objects will vary from a blunt, flat shape to a streamlined, cone-like shape. In each case, the object will be suspended from a spring scale. As the air moves by, drag force will cause the spring scale to stretch. The amount of stretch measured on the scale is an indication of the drag force.

You should find that the same airflow rate causes a lower drag force on streamlined shapes than on blunt shapes. You should also find that increasing flow rates results in increasing drag force.

LABORATORY

EQUIPMENT

Airflow assembly with 12-V DC fan or shop vac suction hose
Three assorted drag objects, all with same diameter equal to approximately 60% of airflow-assembly tube ID
DC power supply, 20 V, 10 A
Spring scale, 8-oz (2.5 N) or 16-oz (5-N) capacity
Support stand, rods, and clamps
Monofilament line

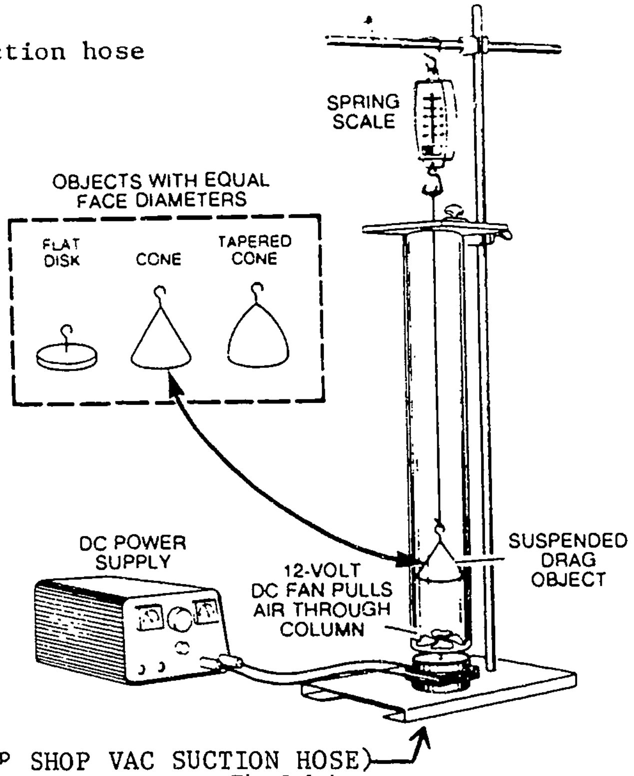


Fig. 2 Lab setup.

PROCEDURES

1. Set up the airflow apparatus and power supply as shown in Figure 2. Be sure power supply is OFF before plugging it in.
2. Calibrate the spring scale so that it reads zero when suspended above the airflow column with no object attached.
3. With the power supply OFF (fan is NOT RUNNING) attach the flat disk object to the free end of the line tied to the spring scale. Make sure object is centered in the airflow column.
4. Turn the power supply ON, with voltage selector on zero volts. Gradually turn the voltage up to 8 volts. If the fan is working properly, as the voltage is increased, the fan will speed up and cause increased airflow past the test object. The drag force on the test object will cause the spring scale to extend and indicate a force reading.
5. Read the force indicated on the spring scale and record value in the appropriate area in the Data Table.
6. Gradually increase the voltage in one-volt steps to 12 volts. At each voltage setting (9, 10, 11, and 12 volts) read the force on the spring scale and record the value in the Data Table.
7. Turn the power supply OFF. Replace the flat disk test object with the cone-shaped object. Repeat Steps 4 through 6.

▲***CAUTION: Do not exchange test objects while fan is running. If you drop the test object you will ruin fan blades.***

DATA TABLE: DRAG FORCE DUE TO AIRFLOW PAST TEST OBJECT

Test Object	Voltage Applied to Fan				
	8 V	9 V	10 V	11 V	12 V
Disk Shape					
Cone Shape					
Optional Shape (See your teacher.)					

67

Calculations

1. The spring scale gave you the ***drag-force*** reading directly. The Data Table provides a record of drag force (spring scale reading) versus flow rate (proportional to voltage applied to fan).
2. For the row in the Data Table labeled "Disk Shape," graph the drag force (F_d) against the relative airflow (indicated by the voltages applied to the fan). See graph in Figure 3. Place a point on the graph for each set of corresponding values—drag force and airflow number. You should have five points when you finish.

   Note: Your teacher may help you set up the best vertical scale for the drag force (F_d). What you finally choose will depend on the highest value of F_d measured—at the highest flow speed. The highest flow speed corresponds to the maximum voltage applied to the fan—probably 12 volts.
3. Draw a smooth line through the five points. Label the curve "disk-shaped object."
4. Repeat Steps 2 and 3 for the cone-shaped object. Label the line "cone-shaped object."
5. Repeat Steps 2 and 3 for the tapered-cone object or the optional shape you made. Label the line "optional shape."

WRAP-UP

1. Are the smooth lines drawn for each object on the graph straight? Or do the lines curve upward at higher speeds (higher voltages)?
2. Is there a sudden change in the slope of any of the graphs drawn as the flow rate increases? If so, what does this mean? (***Hint:*** Refer to discussion that goes with Figure 4-16 in text.)
3. Which of the shapes—according to your graph—shows the least amount of drag?
4. Which of the shapes is the most streamlined? Explain your answer.

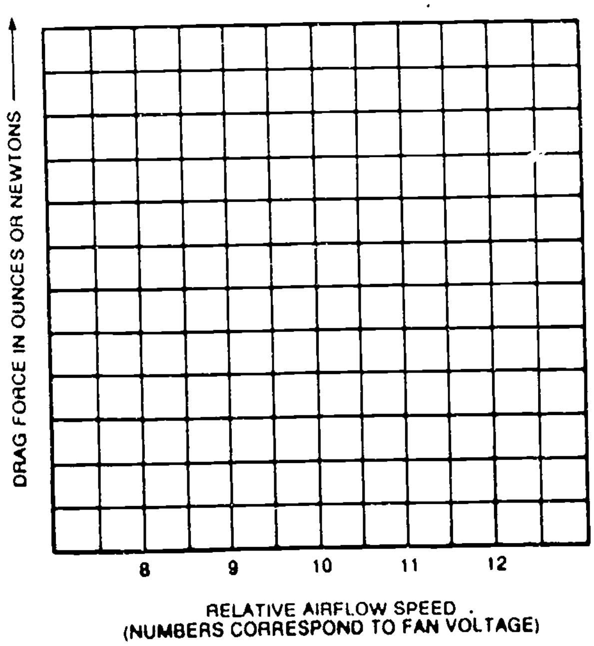


Fig. 3 Graph for plotting drag force against airflow speed.

Student Challenge

1. If you have access to small toy cars, you may want to suspend them one at a time in the airflow chamber and measure the drag force at different airflow speeds. How does the drag force for "block" shapes (vans) compare to the drag force for more streamlined shapes (racing cars)? How does the drag force for any one car change as the airflow speed increases?
2. What happens to your "gas mileage" when you increase the speed of your car from 30 mph to 60 mph? Identify two things that cause your car to use more gas at higher speeds.
3. Does surface finish on an object affect airflow over it? If so, in what way?
4. Why aren't the shapes of space-exploration satellites streamlined?

Review

1. ***View and discuss the video, "Resistance in Mechanical Systems."***
2. ***Review the Objectives and Main Ideas of the print materials in this subunit.***
3. ***Your teacher may give you a test over Subunit 1, "Resistance in Mechanical Systems."***

Measuring the Potential Energy of a Spring

Lab 5MF1

LAB OBJECTIVES

When you've finished this lab, you should be able to do the following:

1. ***Compress a spring by applying a known amount of force. Then measure the change in length of the spring caused by the applied force.***
2. ***Determine the spring constant for a spring.***
3. ***Calculate the elastic potential energy stored in a compressed spring.***

LEARNING PATH

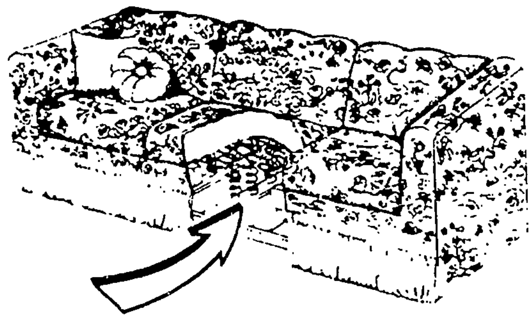
1. ***Preview the lab. This will give you an idea of what's ahead.***
2. ***Read the lab. Give particular attention to the Lab Objectives.***
3. ***Do lab, "Measuring the Potential Energy of a Spring."***

MAIN IDEAS

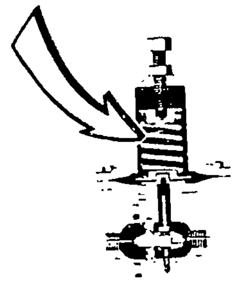
- ***Every spring has a spring constant. The spring constant tells you how much force is needed to stretch or compress a spring by a unit length—such as an inch or a centimeter.***
- ***When a force is applied to a spring, and work is done to stretch it or compress it, the work done is stored in the spring as elastic potential energy.***
- ***The stored potential energy in a "loaded" spring (one that's stretched or compressed) can be recovered to do useful work like moving levers, applying force to pressure rollers, and opening or closing a door.***

70

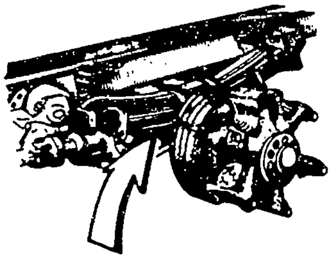
Springs are useful mechanical devices that help us store and retrieve energy with ease. For example, springs are found in items such as sofas, gas-pressure regulators—and in the suspension systems of virtually all transportation vehicles. See Figure 1.



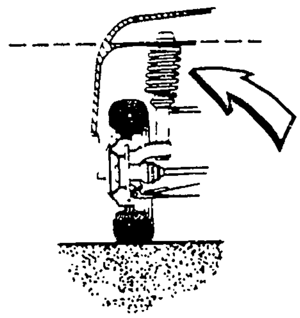
a. Springs in sofa



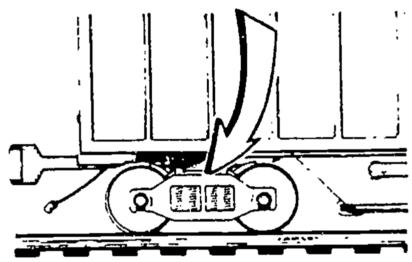
b. Springs in a gas-pressure regulator valve



c. Springs in a truck suspension



d. Springs in an automobile suspension

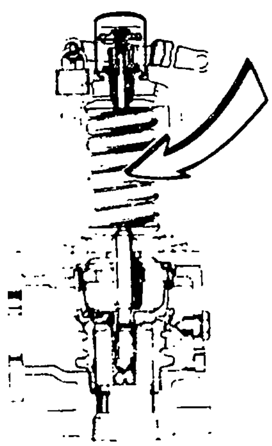


e. Springs in a boxcar suspension

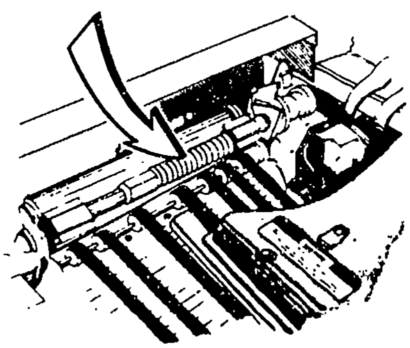
Fig. 1 Common uses of springs.

WHAT ARE SOME TECHNICAL APPLICATIONS OF SPRINGS?

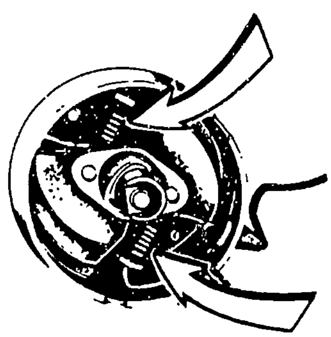
Technicians work with springs in many devices. Pressure-relief or safety valves have springs, as shown in Figure 2a. Springs are used in copying machines to hold a specific tension on rollers. (See Figure 2b.) As a technician, you may be required to adjust, check, or replace the mechanism in which a certain spring is used. Understanding how springs work, what a spring constant is, and how much energy is stored in springs can help you do your job better.



a. Springs in safety valve



b. Springs in copy machine



c. Springs in auto distributor

Fig. 2 Technical uses for springs.

LABORATORY

In this lab, you'll measure the force required to compress a spring. You'll also find the amount of potential energy stored in the compressed spring.

EQUIPMENT

Spring test assembly (vendor supplied or "home made")
Small weight set, total 1 kg
Small weight hanger, 50-g type
C-clamp
Ruler (12 in., with centimeter scale)

PROCEDURES

1. Set up your apparatus as shown in Figure 3, depending on which assembly you have. The procedure Steps 2, 3 and 4 that follow are applicable to either assembly #1 or #2.

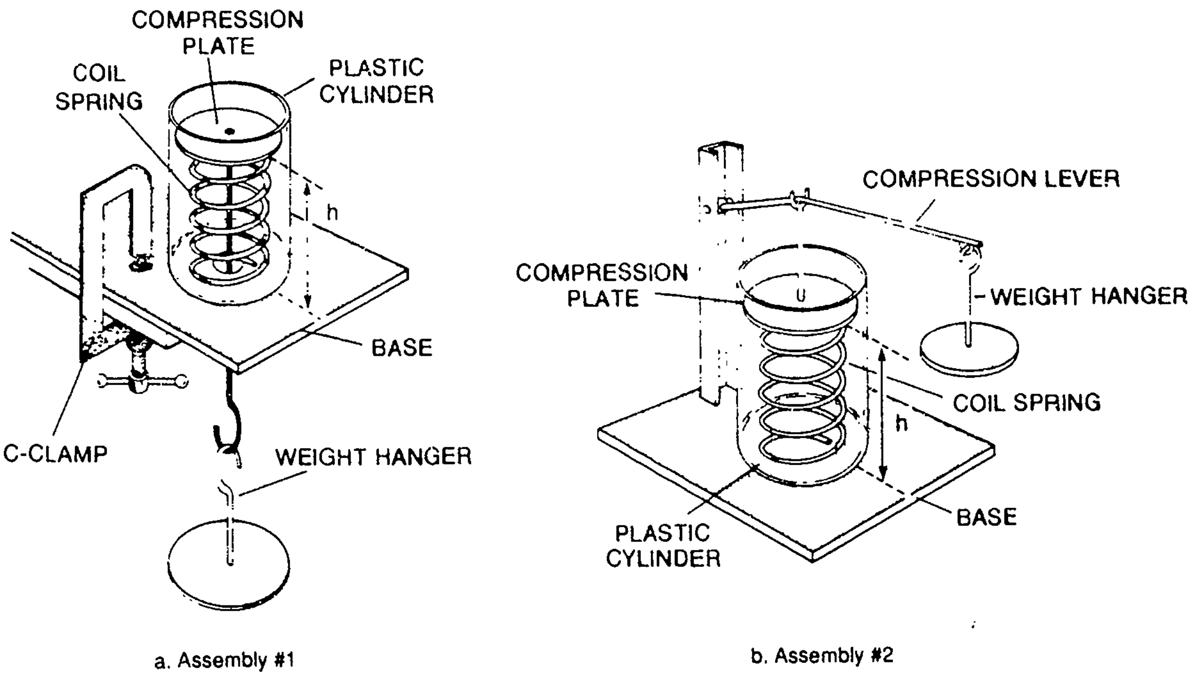


Fig. 3 Lab setup.

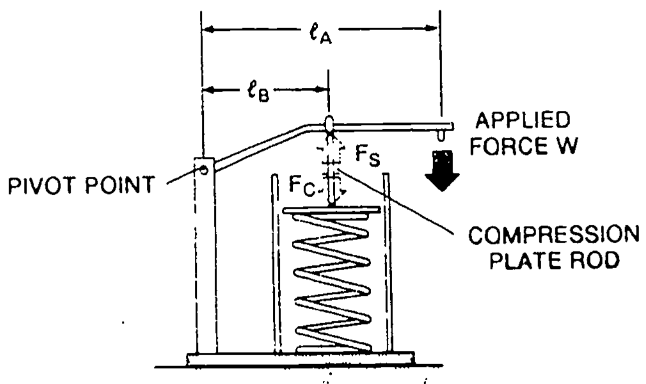
2. With the weight hanger attached, measure the initial height (h) of the uncompressed spring. (***Note:*** Since the weights you'll use in this lab are in SI units, length measures should also be in SI units.) The height (h) should be measured from the ***top*** surface of the base (Figure 3) to the **bottom** surface of the compression plate. Record this value in your Data Table in Column C, Row 1 (see Data Table on the next page).
3. Place a 50-gm mass on the weight hanger. Record this mass in Column A, Row 2. Record the height of the spring, from the base to the bottom surface of the compression plate, in Column C, Row 2.
4. Select four to five additional masses from the slotted-weight set. Add one mass at a time. For each mass added, measure and record in Column A the total mass hung on the weight hanger. Also, record in Column C of the Data Table the height of the spring from the base.

72

DATA TABLE

Column	A	B	C	D	
Row	Mass placed on assembly (g)	Force acting on spring (N)	Height h of spring (cm)	Spring compression d (cm)	(m)
1			(Initial height)		
2					
3					
4					
5					
6					
7					

5. If your lab equipment is the type shown in Figure 3a (assembly #1), go to Step 1 of the *Calculations* section. If your equipment is the type shown in Figure 3b (assembly #2), go to the next step—Step 6.
6. Measure the perpendicular distance (ℓ_A in Figure 4) from the vertical to the point on the lever where the weight hanger is hung from the lever pivot. Measure the perpendicular distance (ℓ_B in Figure 4) from the compression-plate rod to the lever pivot point. Record these lengths. Now proceed with the *Calculations*.



F_C = COMPRESSION FORCE

F_S = SPRING FORCE

$F_C = F_S$

ℓ_A = ______ cm

ℓ_B = ______ cm

Fig. 4 Force diagram for assembly #2.

Calculations

Part A: *Developing Working Data*

1. Calculate the spring compression (d) for each row of the Data Table. To do this, use the equation:

$$d = \left\{ \begin{matrix} \text{Uncompressed} \\ \text{Spring Height} \end{matrix} \right\} - \left\{ \begin{matrix} \text{Spring Height (h)} \\ \text{Due to Compression} \end{matrix} \right\}$$

73

The uncompressed spring height is the initial height recorded in Row 1 of Column C. Substitute the value of "h" from rows 2 through 7 in the second term in the equation for d. Record the result of each calculation in the corresponding row of Column D.

2. Convert centimeter units to meter units in Column D. To do this use the equation:

$$(\text{Length in cm}) \times \left(\frac{1\ \text{m}}{100\ \text{cm}}\right) = (\text{Length in Meters})$$

3. Convert the mass units recorded in Column A to force units. To do this, use the equation:

$$(\text{Mass in gm}) \times \left(\frac{1\ \text{kg}}{1000\ \text{gm}}\right) \times \left(9.8\frac{\text{m}}{\text{sec}^2}\right) = \text{Force in } \frac{\text{kg}\cdot\text{m}}{\text{sec}^2} \text{ or N}$$

Substitute the mass value for Rows 2 through 7 in the equation above. Record the result of each calculation, in the corresponding row of Column B, in units of newtons.

Note: If you're using assembly #1 skip to Step 5. (You can do this because the compression force (F_C) is equal to the value of the force recorded in Column B.) If you're using assembly #2, complete Step 4.

4. The compression force (F_C), which compresses the spring in Trials 2 through 7, equals the hanging weight (force recorded in Column B) multiplied by the number determined by dividing ℓ_A by ℓ_B.

Therefore, F_C = (Hanging weight in N) $\times \left(\frac{\ell_A}{\ell_B}\right)$. Use this formula to find the compression force (F_C) for Trials 2 through 7. Record each value of F_C in a chart like the one below.

TRIAL

	2	3	4	5	6	7
F_C (in N)						

Note: Trial 2 (here) corresponds to Row 2 of the Data Table.

5. Plot the compression force (F_C) versus spring compression (d) on a graph as shown in Figure 5. Do this for Trials 2 through 7. The vertical axis represents force in newtons (N). The horizontal axis represents spring compression in meters (m). Be sure to label the axis lines correctly for the quantity and units used. You should have six plotted points.

6. Draw the "best" straight line through the six points plotted on the graph.

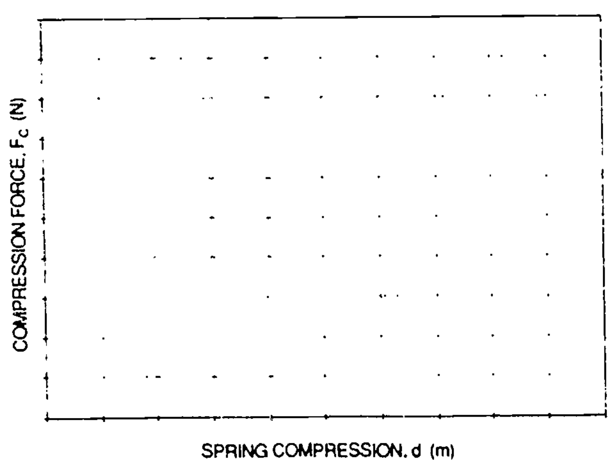
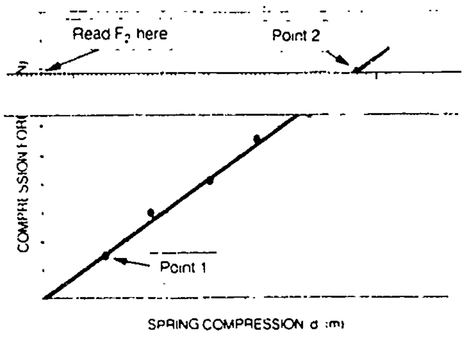


Fig. 5 Graph of compression force (F_C) versus the spring compression (d).

Part B: *Determining the Spring Constant*

1. Determine the spring constant (k) for the spring. To do this, select two points ***on*** the line drawn in Step 6, Part A, of Calculations. Point 1 should be close to the origin of the graph. Point 2 should be near the other end.

2. Place a ruler on the graph so that its edge is *parallel to the horizontal axis* and passes through Point 2, as shown in the figure here. Read the value of F_C where the ruler edge intersects the vertical axis. Record this value as F_2: F_2 = _____ N.



3. Move the ruler down so that its edge is parallel to the horizontal axis and passes through Point 1. Read the value of F_C where the ruler edge intersects the vertical axis. Record this value as F_1: F_1 = _____ N.

4. Now turn the ruler so that its edge is *parallel to the vertical axis* and passes through Point 2. Read the value of d where the ruler edge intersects the horizontal axis. Record this value as d_2: d_2 = _____ m.

5. Move the ruler to the left so that its edge is parallel to the vertical axis and also passes through Point 1. Read the value of d where the ruler edge intersects the horizontal axis. Record this value as d_1: d_1 = _____ m.

6. Substitute the values in Steps 2 through 5 in the equation below:

$$k = \frac{F_2 - F_1}{d_2 - d_1}$$

$$k = \left(\frac{[\quad\quad] - [\quad\quad]}{[\quad\quad] - [\quad\quad]}\right) \frac{N}{m}$$

$$k = \_\_\_\_\_ \ N/m$$

Part C: *Determining the Potential Energy Stored in the Spring*

1. The potential energy in the spring is given by the equation:

$$E_p = \tfrac{1}{2} kd^2$$

where: k = spring constant in N/m (determined in Step 6 above)
d = spring compression in m (see Column D of Data Table, for Trials 2 through 7)
E_p = potential energy in N·m (J) stored in the spring

Calculate the potential energy (E_p) stored in the spring for each compression (d) recorded in Column D of the Data Table.

Calculate as follows:

$$E_p = \tfrac{1}{2} kd^2$$

$$E_p = \tfrac{1}{2} (\text{k from Step 6}) \times (\text{d from Row 2, Column D})^2$$

$$E_p = \tfrac{1}{2} (\_\_\_\_\_ \ N/m)(\_\_\_\_\_ \ m)^2$$

$$E_p = \_\_\_\_\_\_\_\_\_\_ \ N{\cdot}m, \text{ or } J$$

Record this value in a chart like the one shown on the next page.

2. Repeat the previous calculations for E_p for each compression (d) in Rows 3 through 7 of the Data Table. Record your values for E_p in the following chart.

POTENTIAL ENERGY STORED IN COMPRESSED SPRING

	2	3	4	5	6	7
Spring compression, d (m)						
Potential energy stored in spring, $E_p = \frac{1}{2} kd^2$ (J)						

WRAP-UP

1. Did the potential energy stored in the spring increase or decrease as more weight was added to the weight hanger?
2. How did the potential energy stored change with spring compression (d) as the spring was compressed more and more? That is, when the spring was compressed twice as much, did the potential energy stored double or quadruple?
3. Based on the force constant for this spring, would you describe it as a "stiff" or a "soft" spring compared to the following:
   a. The coil spring of an automobile, where k = 4500 N/m
   b. The spring of a ball-point pen, where k = 22 N/m

Student Challenge

For assembly #2 (Figure 3) explain why the force of compression (F_C) is determined by multiplying the hanging weight (w) by the ratio ℓ_A/ℓ_B.

76

Electrical Transformers

Lab 7E1/7E2

LABORATORY OBJECTIVES

When you've finished this lab, you should be able to do the following:

1. ***Use a voltage transformer to step down input voltage.***
2. ***Use a voltage transformer to step up input voltage.***
3. ***Find the ideal and actual electrical advantage of a transformer.***
4. ***Find power in, power out—and the operating efficiency of a simple transformer.***

LEARNING PATH

1. ***Preview the lab. This will give you an idea of what's ahead.***
2. ***Read the lab. Give particular attention to the Lab Objectives.***
3. ***Do lab, "Electrical Transformers."***

MAIN IDEAS

- ***An electrical transformer is a "force" transformer that increases or decreases input voltage.***
- ***Ideal electrical advantage of an electrical transformer is determined by the ratio of wire turns on the output coil to input coil.***
- ***Actual "mechanical" advantage of an electrical transformer equals the ratio of V_{out}/V_{in}. Actual electrical advantage is usually less than the ideal electrical advantage because of circuit resistance and core losses.***
- ***When an electrical transformer is used to step up voltage, it's called a "step-up transformer."***
- ***When an electrical transformer is used to step down voltage, it's called a "step-down transformer."***

You're being affected by electrical and electronic devices even while you read this page. What kind of light is falling on these words? Chances are, it isn't sunlight. The clothes you're wearing probably were made with the help of an electrically powered machine—right down to the shoes on your feet. The food you'll eat at your next meal probably was processed by an electrically powered machine. And your food may have been cooked electrically as well.

Even a self-sufficient hermit, living off the land, usually finds a way to get electricity. Electricity has become a basic necessity of modern life. Manufacturing depends upon electricity. Word processing and other forms of communication depend on electricity and electrical devices.

77

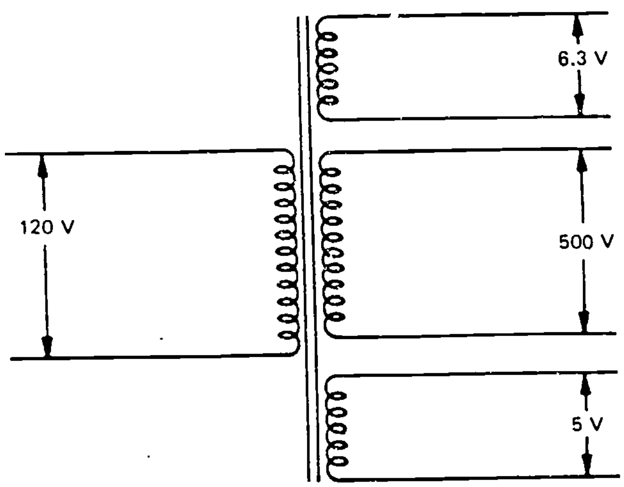
The list goes on and on. Therefore, technicians must know how to maintain, troubleshoot and repair electrical devices.

In the "guts" of most types of electrical devices, you'll find electrical transformers. Transformers are used in televisions to step up the voltage that operates the picture tube and to step down the voltage that operates the audio portion of the TV set. Transformers are also used in radios, tape players, turntables, doorbells, fluorescent lights, automotive ignition systems, lasers, and radio transmitters.

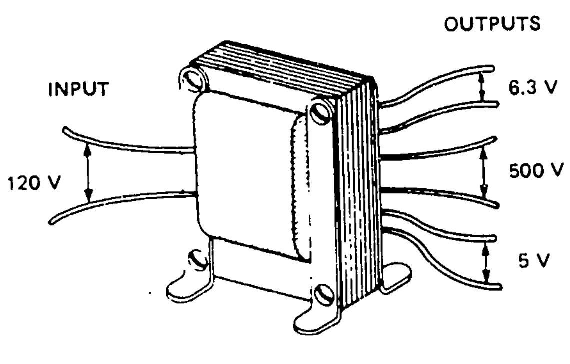
You've learned that a transformer is made of two separate coils of wire wrapped around a metal core. You've learned also that a ***step-up*** transformer has more coils (turns of wire) in the secondary (output) coil than in the primary or (input) coil. You know that a ***step-down*** transformer has fewer coils in the secondary than in the primary.

However, there are some transformers, called "multi-tap transformers," that have more than one "secondary" coil. A multi-tap transformer can be thought of as a multiple-output transformer. This transformer is used when a single input voltage—but more than one output voltage or current—is required. A television uses a transformer to step up and step down the voltage for different parts of the TV set. Figure 1 shows a transformer that has more than one secondary coil. As before, the number of turns in each secondary coil compared to the number of turns in the primary coil determines if that "tap" is a step-up or step-down tap.

Another common type of transformer is an ***isolation*** transformer. This transformer has the ***same*** number of turns in the secondary and primary coils. Some types of circuits use AC and DC voltage at the same time. Figure 2 shows an example of a circuit that uses an isolation transformer. Transformers can change only AC voltage and current. That means an isolation transformer can be used to isolate DC voltage and current signals. The isolation transformer then allows AC signals to go from primary to secondary but blocks any DC signals in the primary.



a. Schematic



b. Pictorial

Fig. 1 Multiple-tap transformer.

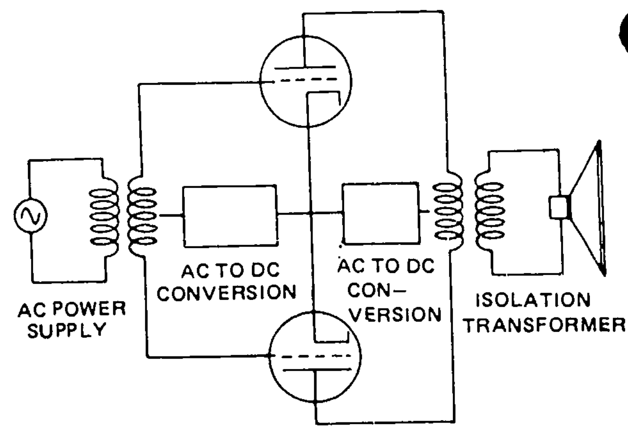


Fig. 2 Isolation transformer used to isolate DC voltage from AC voltage.

There's another good use for the isolation transformer. It can protect sensitive electronic equipment—such as computers—from sudden voltage spikes. The isolation transformer allows line-frequency signals to pass. But rapid- and short-duration spike pulses are safely reduced.

For this lab, you'll use an electrical transformer to step up and step down input voltage. You'll measure power in and power out. Then you'll find the efficiency of each transformer.

LABORATORY

EQUIPMENT

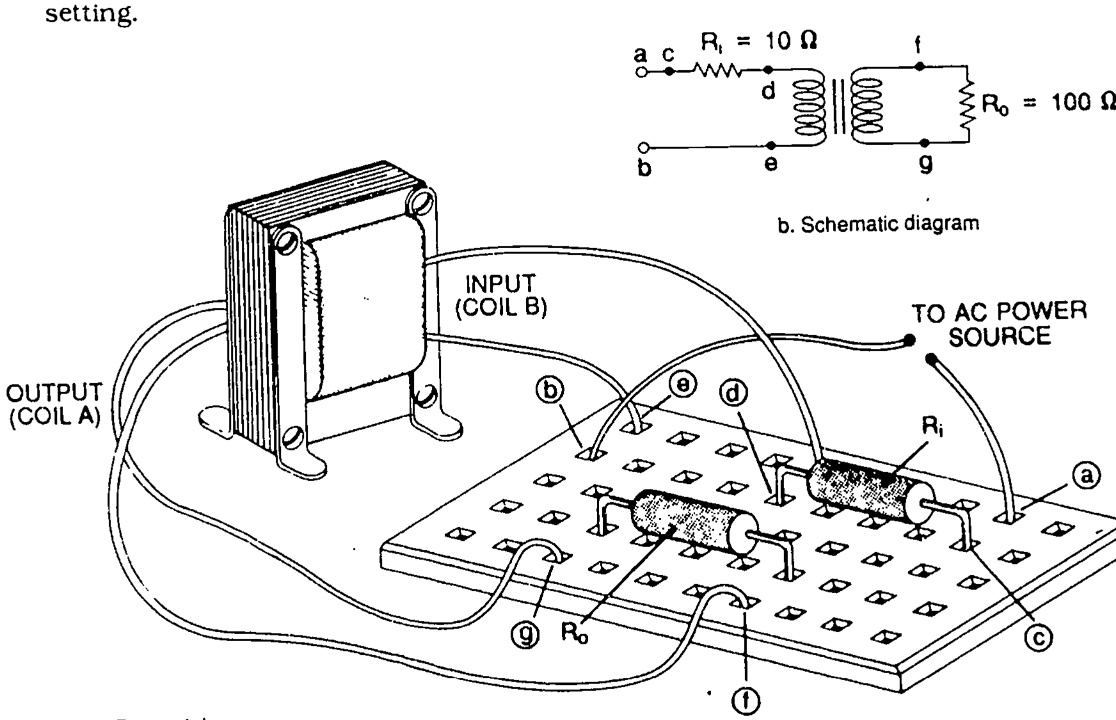
Transformer assembly with n_o/n_i ratio known (vendor supplied)
Variable AC power source, 0-25 V AC
Digital multimeter (DMM), with probes, 10 A, 0.1 mV
Solderless breadboard
Hookup wire, minimum 22 AWG
Load resistors, two, for example, 10 Ω and 100 Ω, 5 watts or higher

PROCEDURES

Part 1: *Testing a Voltage Step-down Transformer*

In the following procedures, we'll refer to the coil with the lesser number of turns as coil A; the other is coil B. (Number of turns for each coil to be provided by your teacher.)

1. First, use the transformer to "step down" the voltage. To do this, let coil B act as the input (primary) and coil A (secondary) as the output.
2. Connect the wires from coils A and B and the two resistors, R_o and R_i, to the solderless breadboard as shown in Figure 3. Study both the pictorial diagram (3a) and the schematic diagram (3b) to be sure your connections are correct.
3. Connect points "a" and "b" on the solderless breadboard to the AC power source. See Figure 3. Be sure power supply is OFF.
4. Connect a DMM between points "c" and "e." See Figure 3. Adjust the DMM to read AC volts. Select the smallest range that will read 10 volts.
5. Now turn the AC power source ON. Adjust the voltage so that the DMM across points "c" and "e" registers 10 volts. (This means that there's a 10-volt drop across the input resistor $[R_i]$ and coil B.) Leave the AC power source at this setting.



a. Pictorial diagram

Fig. 3 Lab setup.

6. Move the leads of the DMM across points "d" and "e" to measure the voltage across the input coil B. Read this voltage. Record in Row 1 of Data Table 1, under column "V_i."
7. Next, use the DMM to measure the voltage across coil A (output) between points "f" and "g." Read this voltage. Record in Row 2 of Data Table 1, under column "V_o."
8. Use the DMM to measure the voltage across resistor R_i, between points "c" and "d." Call this reading "V_R-in." Record in Row 1 of Data Table 1. (This measurement will allow us to find the input current.)
9. Turn the AC power source OFF.

Part 2: *Testing a Voltage Step-up Transformer*

1. To use the transformer to step up voltage, switch the connections of coils A and B. Connect the ends of coil A between points "d" and "e" on the breadboard and the ends of coil B between points "f" and "g." Now coil A is the input, or primary, coil. Coil B is the output, or secondary, coil.
2. Turn the output control of the AC power source to a "minimum" setting. Then turn source ON. Adjust the AC power source so that the DMM—connected across points "c" and "e"—now measures 5 volts. ***Note:*** Do not exceed 5 volts, else you may overload R_o.
3. Now connect the DMM leads across points "d" and "e." Measure the voltage drop across input coil A. Read the indicated voltage. Record in Row 2 of Data Table 1, under column "V_i."
4. Move the DMM leads to points "f" and "g" to measure the output voltage across coil B. Read the indicated voltage. Record in Row 2 of Data Table 1, column "V_o."
5. Move the DMM leads to points "c" and "d." Measure the voltage drop across resistor "R_i." Call this "V_R-in." Record in Row 2 of Data Table 1.
6. Turn the AC power source OFF.

DATA TABLE 1

Row No.	Primary Coil (input)	Secondary Coil (output)	Input Voltage V_i (volts)	Output Voltage V_o (volts)	Voltage Across R_i, V_R-in (volts)
1	B	A			
2	A	B			

Calculations

1. Calculate the turns-ratio n_o/n_i for the two types of transformers ***from the data of Data Table 1.***

   Row 1 Data: Step-down transformer.

   $$\left(\frac{n_o}{n_i}\right)_1 = \frac{(V_o)}{(V_i)} = \frac{(\quad)}{(\quad)} = \_\_\_.$$

   Row 2 Data: Step-up transformer.

   $$\left(\frac{n_o}{n_i}\right)_2 = \frac{(V_o)}{(V_i)} = \frac{(\quad)}{(\quad)} = \_\_\_.$$

2. Find the current in each coil of Data Table 1. Use the equation: $I = V/R$ where $R_o = 100$ ohms, $R_i = 10$ ohms (or whatever resistance values you used), and V = voltage across each resistor.

Row 1 Data: Step-down transformer.

$$I_i = \frac{V_R\text{-in}}{R_i} = \frac{(\quad V)}{10\ \Omega} = \_\_\_\ A$$

$$I_o = \frac{V_o}{R_o} = \frac{(\quad V)}{100\ \Omega} = \_\_\_\ A$$

Row 2—Data: Step-up transformer.

$$I_i = \frac{V_R\text{-in}}{R_i} = \frac{(\quad V)}{10\ \Omega} = \_\_\_\ A$$

$$I_o = \frac{V_o}{R_o} = \frac{(\quad V)}{100\ \Omega} = \_\_\_\ A$$

3. Find the input and output power to the transformer assembly, for each row of Data Table 1. Then find the efficiency of the transformer.

   Row 1 Data: Step-down transformer.

   $$P_{in} = V_i \times I_i = \_\_\_\ W$$

   $$P_{out} = V_o \times I_o = \_\_\_\ W$$

   $$\text{Eff} = \frac{P_o}{P_i} \times 100\,\% = \_\_\_\ \%$$

   $$\text{Eff} = \frac{(\quad)}{(\quad)} \times 100\,\% = \_\_\_\ \%$$

   Row 2 Data: Step-up transformer.

   $$P_{in} = V_i \times I_i = \_\_\_\ W$$

   $$P_{out} = V_o \times I_o = \_\_\_\ W$$

   $$\text{Eff} = \frac{P_o}{P_i} \times 100\,\% = \frac{(\quad)}{(\quad)} \times 100\% = \_\_\_\ \%$$

4. Find the power loss for each transformer assembly.

   Row 1 Data: Step-down transformer.

   $$P_i - P_o = P_{loss} = (\_\_\_) - (\_\_\_) = \_\_\_\ W$$

   Row 2 Data: Step-up transformer.

   $$P_i - P_o = P_{loss} = (\_\_\_) - (\_\_\_) = \_\_\_\ W$$

WRAP-UP

Use the data from Data Table 1, and the results of the *Calculations* you've just completed to complete Data Table 2. For the entry labeled "Turns Ratio" enter the ratio based on the vendor/teacher-supplied data, ***not*** that obtained in Step 1 of *Calculations.*

DATA TABLE 2

Input or Primary Coil	Output or Secondary Coil	Transformer Type (Step-up or step-down)	Turns Ratio n_o/n_i (Ideal)	Voltage Ratio V_o/V_i	Current Ratio I_o/I_i	Power			Eff %
						In	Out	Loss	
B	A								
A	B								

Conclusions

1. Compare the turns ratio n_o/n_i determined in Step 1 of Calculations with the true ratio for the transformer assembly (provided by your teacher) and listed in Data Table 2. Do the two ratios agree for either the step-up or step-down transformer arrangement? Explain—why or why not.
2. What is the ***ideal*** "electrical advantage" of the step-down transformer you used? Of the step-up transformer?
3. What is the ***actual*** "electrical advantage" of the step-down transformer? Of the step-up transformer?
4. How did the current ratio (I_o/I_i) compare with the voltage ratio (V_o/V_i) for each transformer?

Student Challenge

1. You are to "drive" an AC motor that requires 15 volts and 1 ampere of current with the transformer you used. Would you use the step-down or step-up arrangement if 30 volts AC were available for input voltage to the transformer?
2. Suppose that the transformer is 85% efficient. For the same situation as described above, how much current would be needed on the input side to ensure that the motor did indeed receive 15 watts of power (that is, 15 volts × 1 amp)?
3. The resistors R_o and R_i are rated around 5 watts each. What precautions should you take when adjusting the AC power supply to ensure that you will not overload the resistors and possibly burn them out?

Review

1. ***View and discuss the video, "Force Transformers in Electrical Systems."***
2. ***Review the Objectives and the Main Ideas of the print materials in this subunit.***
3. ***Your teacher may give you a test over Subunit 4, "Force Transformers in Electrical Systems."***

82

Force Transformers: The Hydraulic Jack

Lab 7F1

LABORATORY OBJECTIVES

When you've finished this lab, you should be able to do the following:

1. ***Recognize that a hydraulic jack combines a simple lever and a hydraulic force transformer.***
2. ***Assemble an apparatus that tests the principles of a hydraulic jack.***
3. ***Find the mechanical advantage of a hydraulic jack.***
4. ***Measure the input work and output work of a hydraulic jack. Find the jack's efficiency.***

LEARNING PATH

1. ***Preview the lab. This will give you an idea of what's ahead.***
2. ***Read the lab. Give particular attention to the Lab Objectives.***
3. ***Do lab, "Force Transformers: The Hydraulic Jack."***

MAIN IDEAS

- ***A force transformer changes a small force applied over a certain distance to a larger force applied over a smaller distance.***
- ***The hydraulic jack is a useful force transformer that amplifies (or increases) force.***
- ***The ideal mechanical advantage of a hydraulic jack equals the ratio of input displacement to output displacement.***
- ***The actual mechanical advantage of a hydraulic jack equals the ratio of output force to input force.***

A hydraulic jack is a powerful force transformer. It's made of a simple, second-class lever and a hydraulic force transformer.

A hydraulic jack is used to lift heavy objects such as cars, trucks, buses, earth-moving equipment and aircraft. When a house is moved from one location to another, hydraulic jacks are needed to lift the structure from its foundation.

Even in the early 1900s, hydraulic jacks provided the force needed to lift and move a massive structure. For instance, Western Electric Company in Indianapolis, Indiana, wanted to move its 10-story home office building to another site. This office building was located in the heart of the city.

Movers used hydraulic jacks to lift the building from its foundation. Then, more than 1000 specially designed wheels were attached to the bottom of the building. Hydraulic jacks were then used to help move the building onto a street, down the street, around a corner, down another street and onto its new foundation.

Hydraulic jacks are made in many shapes and sizes. Each jack has a safety limit—or the amount of force it can safely apply. These jacks are usually made to be used in either a vertical or a horizontal position. In this lab, you'll explore several technical details about hydraulic jacks.

LABORATORY

EQUIPMENT

Hydraulic jack assembly, ½- to 1 ½-ton capacity, with pressure gage (1000-lb/in² capacity)
Spring scale, 5-lb (20-N) or 25-lb (100-N) capacity
Vernier caliper
Ruler (12 in., with centimeter scale)

PROCEDURES

Part 1: *Familiarization*

1. Examine the hydraulic jack. Read all instructions printed on the label fastened to the jack. Then answer these questions:
   a. What type of working fluid is used in the hydraulic jack?
   b. Are there applications in which the jack can't be used? If so, what are they?
   c. What is the rated load-limit of the jack?
   d. How many different mechanical force transformers make up the jack? Identify them.

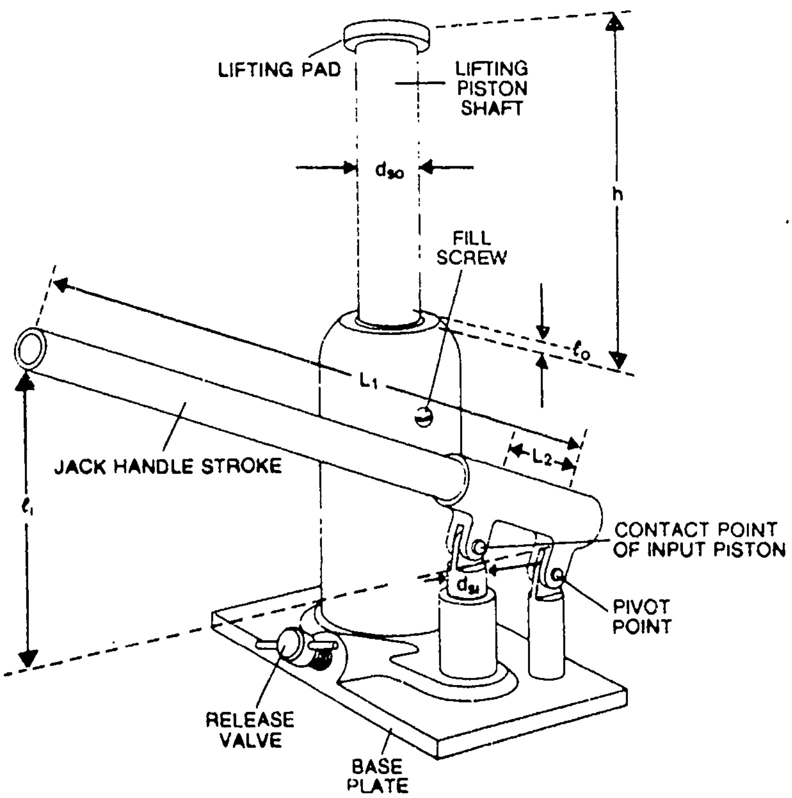


Fig. 1 Hydraulic jack dimensions.

2. Make some basic measurements. Use a ruler and a vernier caliper to measure each quantity listed in Data Table 1. Figure 1 identifies these parts. If you are unable to measure any one of these, see your teacher.

DATA TABLE 1

Diameter of: Input piston shaft	d_{si} =	________
Output piston shaft	d_{so} =	________
Distance end of jack handle moves for one complete stroke	ℓ_i =	________
Length of measure:		
From jack handle to pivot point	L_1 =	________
From pivot point to contact point of input piston	L_2 =	________
Height (maximum) of lifting piston shaft	h =	________

3. Open the release valve. Push the lifting piston to the bottom of its travel.

Part 2: *Operation and Testing*

1. Assemble the pressure stage, if necessary. Install the hydraulic jack, as shown in Figure 2a. Once you've finished the assembly, your lab setup should look like Figures 2b and 2c. Refer to Figure 2 as you complete the following steps.

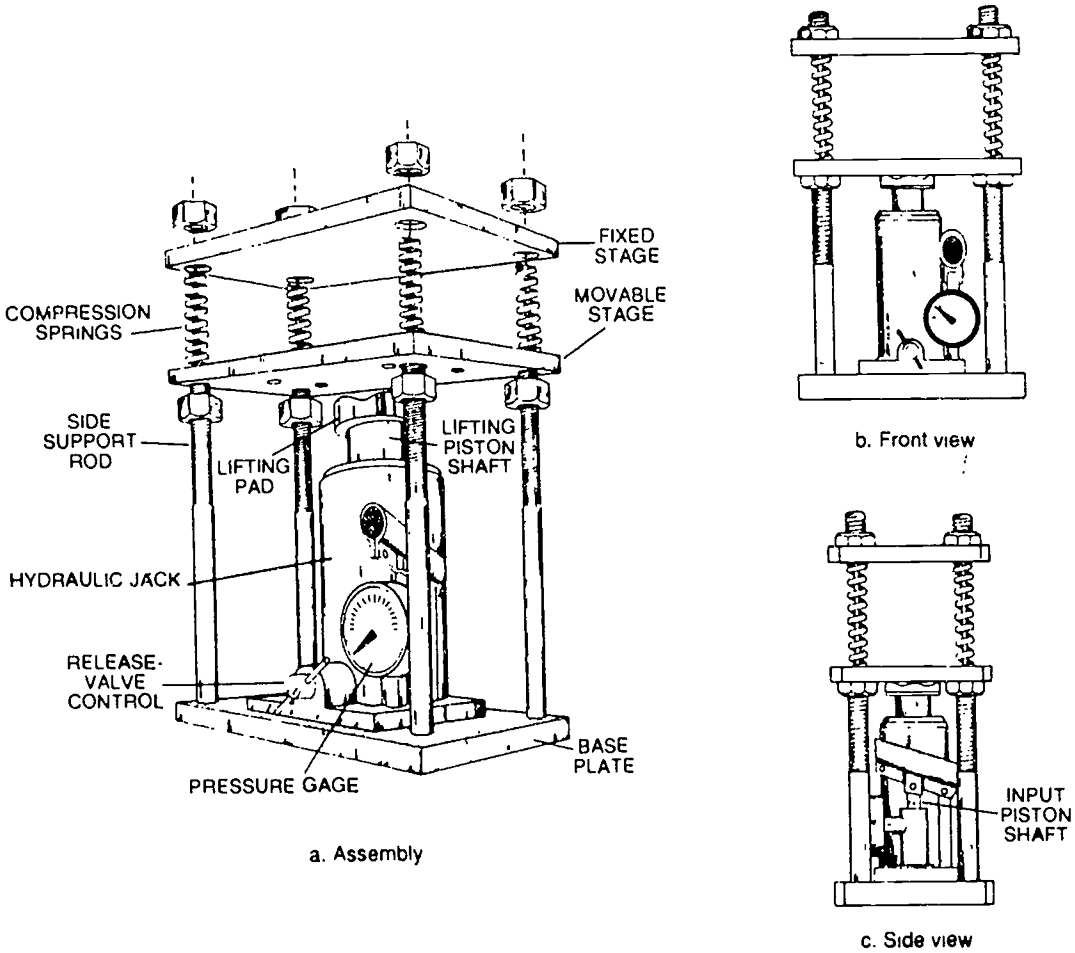


Fig. 2 Pressure stage and hydraulic jack.

85

2. Adjust the movable and fixed stages to be parallel. Make sure the four springs between the stages are compressed no more than 1/16 inch.
3. Situate the jack so that its lifting pad is centered with respect to the movable stage.
4. Close the release valve. Insert the jack handle. Raise the handle to full elevation. Push down on the handle until the lifting pad ***touches*** the bottom of the movable stage and the pressure gage begins to register. Remove the jack handle.
5. Measure the distance (d_o) between the ***bottom surface*** of the fixed stage and the ***top surface*** of the movable stage. Record (to the nearest 1/16 inch or nearest millimeter) under "Distance Between Stages" in Data Table 2.
6. Read the pressure gage. Record as p_o under "Pressure Gage Reading" of Data Table 2.
7. Reinsert the jack handle and move it to the top of its stroke. Put a spring balance on the end farthest from the pivot of the lever.
8. Pull down on the spring balance so that the handle moves down at a slow and steady rate. Try to keep the spring balance pulling in a direction perpendicular to the jack handle. Note the reading on the spring balance near midstroke.
9. Operate the jack handle for 4 more complete strokes, so that a total of 5 strokes are completed since the original d_o and p_o readings. Record the "average" spring balance reading near midstroke as F_1, then measure the stage separation d_1 (after 5 strokes) and pressure gage reading p_1 (after five strokes). Record in Data Table 2 in row labeled "After 5 strokes."
10. Repeat this sequence of five additional strokes, recording the measured values of d, p and F in Data Table 2. Continue until the Data Table has been filled (a total of 8 sets of readings)—or until the pressure gage reaches 700 lb/in^2.
11. Remove the jack handle. Open the release valve.

DATA TABLE 2

	Readings	Distance Between Stages	Pressure Gage Reading	Input Force from Spring Balance
1	Initial	d_o =	p_o =	
2	After 5 strokes	d_1 =	p_1 =	F_1 =
3	After 10 strokes	d_2 =	p_2 =	F_2 =
4	After 15 strokes	d_3 =	p_3 =	F_3 =
5	After 20 strokes	d_4 =	p_4 =	F_4 =
6	After 25 strokes	d_5 =	p_5 =	F_5 =
7	After 30 strokes	d_6 =	p_6 =	F_6 =
8	After 35 strokes	d_7 =	p_7 =	F_7 =

Calculations

For the following calculations, refer to Data Table 3. It's important to remember that five complete strokes were made from row to row in Data Table 2.

1. Figure the distance of travel for the output piston for five stroke intervals. This distance equals the change in "Distance Between Stages" of successive readings. Record your answer in the space, "Lifting Piston Travel," in Data Table 3.
2. Calculate and record the "Average Pressure" (p_{av}) for each set of five complete strokes. Pressure average is found by taking half the sum of the pressures before and after each set of five readings—as indicated in Data Table 3.
3. Calculate the total distance moved by the input force for every 5 strokes of work. This distance is $5 \times \ell_i$, where ℓ_i is the value recorded in Data Table 1. This value is the same throughout, so record it in all rows of Data Table 3 under "Input Force/Travel."

DATA TABLE 3

	Lifting Piston Travel	Average Pressure P_{av}	Input Force Travel $(5 \times \ell_i)$	Average Input Force
1				
2	$d_0 - d_1 =$	$\frac{p_0 + p_1}{2} =$		$\frac{F_0 + F_1}{2} =$
3	$d_1 - d_2 =$	$\frac{p_1 + p_2}{2} =$		$\frac{F_1 + F_2}{2} =$
4	$d_2 - d_3 =$	$\frac{p_2 + p_3}{2} =$		$\frac{F_2 + F_3}{2} =$
5	$d_3 - d_4 =$	$\frac{p_3 + p_4}{2} =$		$\frac{F_3 + F_4}{2} =$
6	$d_4 - d_5 =$	$\frac{p_4 - p_5}{2} =$		$\frac{F_4 + F_5}{2} =$
7	$d_5 - d_6 =$	$\frac{p_5 - p_6}{2} =$		$\frac{F_5 - F_6}{2} =$
8	$d_6 - d_7 =$	$\frac{p_6 - p_7}{2} =$		$\frac{F_6 - F_7}{2} =$

4. Determine the "Average Input Force," taking half the sum of the Input Forces before and after each set of five strokes. Record in the corresponding column of Data Table 3.
5. Figure the input work. Multiply the "Input Force Travel" by the "Average Input Force,"—that is, the last two columns of Data Table 3. Record the "Work In" (W_i) for readings 2 through 8 (or to the end of data taken, whichever comes first) in Data Table 4.

87

6. Calculate and record in Data Table 4 the volume of oil moved in the lifting piston for each reading in Data Table 3, as follows:

$$\Delta V = A \times \Delta d$$

where: ΔV = volume of oil moved in cylinder

A = πr^2 (area of circular surface of lifting piston—ask your teacher for this data)

Δd = height of oil column moved, that is, the lifting piston travel from Data Table 3

7. Copy the "Average Pressure" data from Data Table 3. List it in the correct column, reading by reading, in Data Table 4.
8. Find the output work (W_o). Multiply the "Average Pressure" (p_{av}) by the fluid volume moved (ΔV) for each listing in Data Table 4. Record the answer in the column labeled "Work Out." This is the work done to compress the springs.
9. From Data Table 4 and the equation,

$$\text{Eff} = \frac{\text{Work Out}}{\text{Work In}} \times 100\%$$

find the percentage "Efficiency" for each reading and enter in Data Table 4.

DATA TABLE 4

Readings	Work In (W_i)	Volume Moved (ΔV)	Average Pressure (p_{av})	Work Out (W_o)	Efficiency (%)
2					
3					
4					
5					
6					
7					
8					

WRAP-UP

1. The hydraulic jack is made up of a simple lever and a hydraulic force transformer.
   a. What's the ideal mechanical advantage of the lever? (See Data Table 1.)
   b. Is the lever a first-class, second-class or third-class lever? Why?
   c. What's the ideal mechanical advantage of the hydraulic force transformer?
   d. What's the ***overall*** ideal mechanical advantage of the hydraulic jack (lever + hydraulic transformer)?
2. Are the efficiencies found for the hydraulic jack reasonable? How could you increase the efficiency?

Student Challenge

1. Why were you instructed in Step 8 of Part 2 of the *Procedures*, "to pull down on the spring balance so that the handle moves at a slow and steady rate?"
2. If you worked for a company that built the apparatus shown in Figure 2, would you need to know about spring constants? Why or why not?

Math Skills Laboratory

MATH ACTIVITIES

Activity 1: **Working with Vectors—Part 1**
Activity 2: **Working with Vectors—Part 2**
Activity 3: **Substituting in Formulas**

MATH SKILLS LAB OBJECTIVES

When you complete these activities, you should be able to do the following:

1. *Distinguish between a scalar and a vector quantity.*
2. *Produce a scale drawing of a given vector at a given angle from a reference system.*
3. *Determine the actual magnitude and direction of a vector from its given scale drawing.*
4. *Add vectors that act in the same direction.*
5. *Add vectors that act in opposite directions.*
6. *Add vectors that act at any angle with each other.*
7. *Substitute in the formula for torque ($T = F \times L$) and calculate a torque, given values for the force (F) and the lever arm (L).*

LEARNING PATH

1. *Read the Math Skills Lab. Give particular attention to the Math Skills Lab Objectives.*
2. *Study Examples A through F.*
3. *Work the problems.*

ACTIVITY 1

Working with Vectors—Part 1

EQUIPMENT

For this activity, you'll need the following:

A ruler (both English and SI)
A protractor

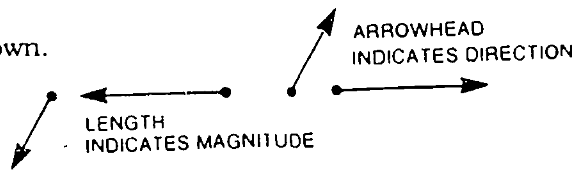
A quantity that's fully specified by measuring its magnitude (size) is called a ***"scalar."*** Examples of scalar quantities are:

(TEMPERATURE)	a.	Yesterday was very sunny and **85°.**
(TIME)	b.	It took me ***40 minutes*** to complete my homework.
(LENGTH)	c.	Tom is ***6 feet*** tall.
(CAPACITY or VOLUME)	d.	This recipe calls for ***3 cups*** of flour.
(AMOUNT OF MONEY)	e.	I paid ***$12.00*** for that record album.
(SPEED)	f.	I could not go more than ***55 miles per hour.***

A quantity that's fully specified by indicating both its magnitude and direction is called a "vector." Some examples of vector quantities are:

(DISPLACEMENT)	a.	He works ***5 miles south*** of here.
(FORCE)	b.	Dave had to ***push*** the car for ***1200 feet to the corner gas station.***
(VELOCITY)	c.	I was traveling ***40 mph eastward*** on Rt 103 when I saw the accident.

Vectors are represented by arrows, as shown.



The length of the arrow determines the magnitude of the quantity. The head of the arrow points in the direction that the force is acting.

Example A: *Drawing Vectors to Scale*

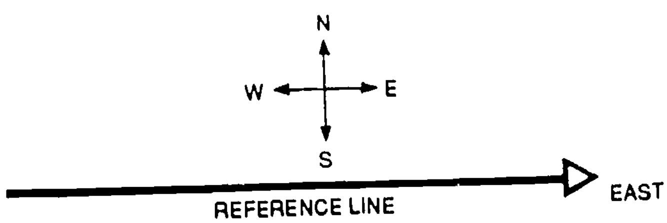
Given: A pencil, protractor and piece of paper.

Find: A scale to draw a 50-lb force at 40° north of east.

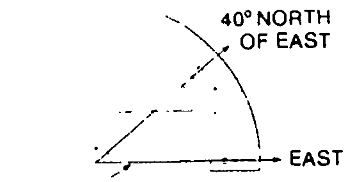
Solution: Step 1: Select a convenient scale, such as 1 cm = 10 lb. (That is, 1 centimeter (cm) on the drawing represents 10 lb of actual magnitude.) We can show the scale by the following representation:

1 cm = 10 lb ***2 cm = 20 lb***

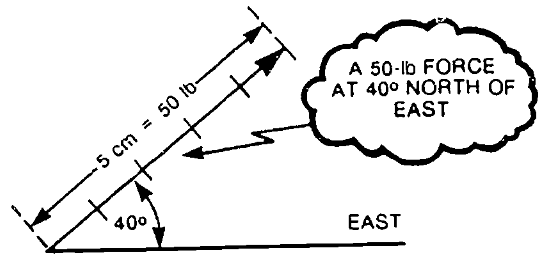
Step 2: Draw the reference line. In this case, a horizontal line is used to designate the east direction.



Step 3: Using a protractor, draw a 40° angle, north of east.



Step 4: The scale indicates that 1 cm = 10 lb. Thus, the scale drawing for the 50-lb force must be 5 cm long. Use the ruler to mark the 5-cm segment on the vector drawn.



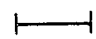
Example B: *Drawing Vectors to Scale*

Given: Reference line, protractor and pencil.

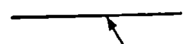
Find: A 15-lb force 70° above the reference line.

Solution: Step 1: Select a convenient scale, such as the following:

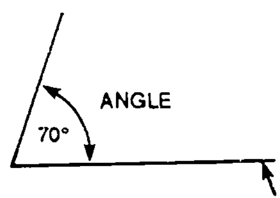
½ inch = 5 lb;



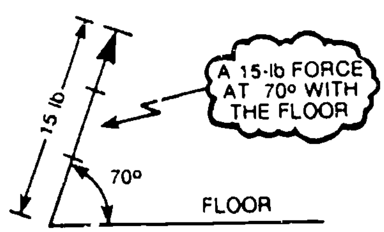
Step 2: Draw the frame of reference. (In this case, a straight line will represent the floor.)



Step 3: Use a protractor to draw a 70° angle, using the floor as the 0° reference line.



Step 4: Since the scale indicates that ½ inch on the paper represents 5 lb of actual force, the 15-lb force must be represented by a segment 1.5 inches long. Use a ruler to mark the 1.5-inch segment on the vector drawn.*

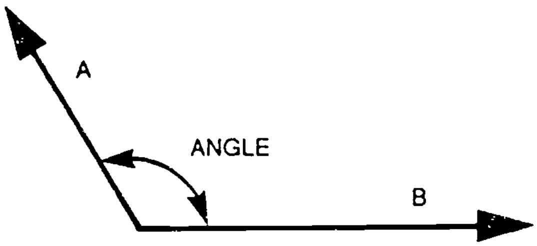


***NOTE:** Because printing this book changes the size of some illustrations, your ruler may not give you measurements that are exactly the same as the one in your book.

91

PRACTICE EXERCISES FOR ACTIVITY 1

1. On a separate sheet of paper. make a scale drawing of a 24-lb force acting along a line 20° above the floor.
2. Given the scale drawing below. determine the actual magnitude of vector A and vector B. Measure the angle formed between them.



SCALE: ½ in. = 20 lb

ACTIVITY 2

Working with Vectors—Part 2

Adding two vectors simply means to replace the two vectors with a single one that will accomplish the same result. The single vector is called the ***resultant***. The rules for the addition of vectors can be classified as follows:

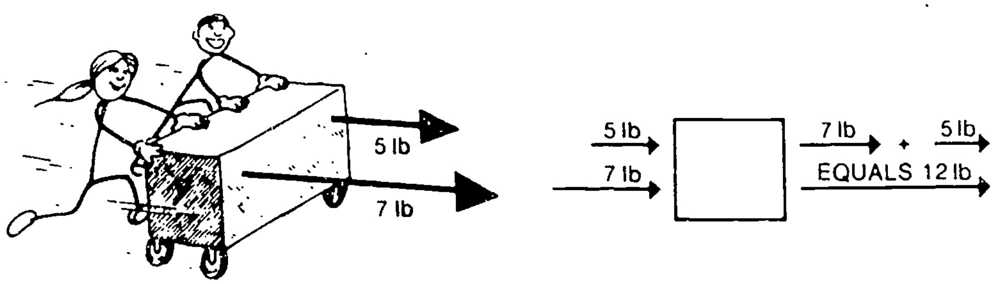
Rule 1: When two (or more) forces are acting at the same point in the same or opposite direction. the resultant can be found by performing a simple arithmetic addition.

Example C: ***Adding Vectors in Line***

Given: John and Sue are pushing the cart with a force of 5 lb and 7 lb. respectively. in the same direction (to the right).

Find: The magnitude and direction of the resultant.

Solution: To find the magnitude of the resultant. add 5 lb + 7 lb = 12 lb. Since both vectors were to the right. the resultant must be to the right.



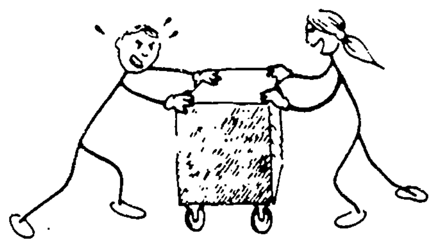
Example D: ***Adding Vectors in Line***

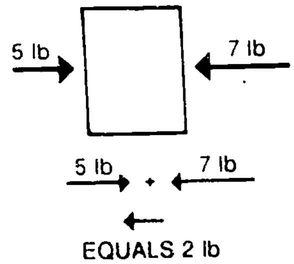
Given: John is pushing to the right with 5 lb of force on an object. Sue is pushing to the left with 7 lb of force.

Find: The magnitude and direction of the resultant.

Solution: To find the resultant, we add the forces acting in opposite directions, as shown in the following diagram.

92





5 lb (right) + 7 lb (left) = 2 lb (left)

Rule 2: When the angle between the vectors is other than 0° (same direction) or 180° (opposite direction), we must use the graphical method of addition (scale drawing method).

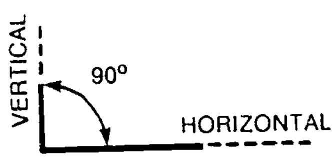
Example E: ***Adding Vectors Not in Line***

Given: Two forces, one 3 lb and the other 4 lb, pull on an object. The angle between them is 90°.

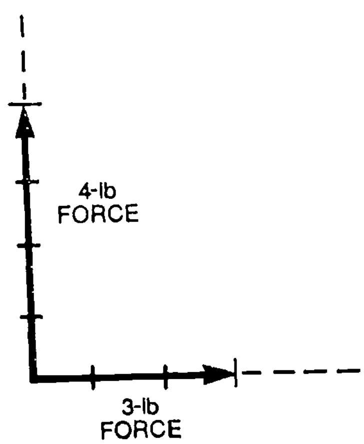
Find: The magnitude and direction of the resultant vector.

Solution: Step 1: Select a convenient scale: 1 cm = 1 lb.

Step 2: Draw an angle of 90°. (The sides of the angle give us the direction of the forces.)

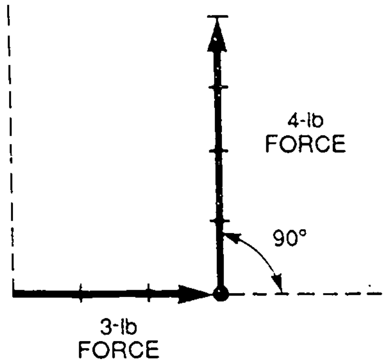


Step 3: Since our scale is 1 cm = 1 lb, the 3-lb force will be 3 cm in length along one of the lines of direction. (It doesn't matter which one, but let's choose the horizontal line.) The 4-lb force will be 4 cm long along the other line of direction (the vertical line). Draw the vectors.

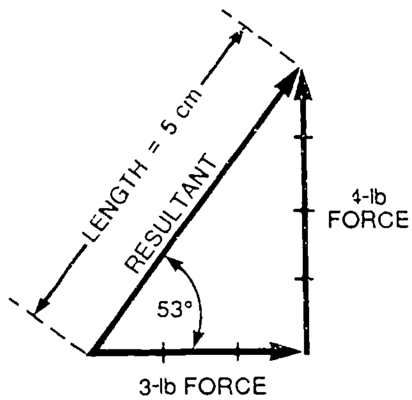


93

Step 4: Now redraw the 4-lb force with its tail at the head of the 3-lb force, at 90° to the 3-lb force, as shown.



Step 5: Draw a straight line connecting the tail of the 3-lb force to the head to the 4-lb force. This line is the resultant of the 3-lb and 4-lb force.



Step 6: Lay a ruler along the length of the resultant. Measure its length. In this problem, it should be close to 5 cm. Since the scale we're using is 1 cm = 1 lb, the 5-cm length must represent a 5-lb force. Thus, the magnitude of the resultant vector is equal to 5 pounds.

Step 7: Measure the angle between the 3-lb force and the resultant vector with a protractor. The result is about 53°.

Step 8: The magnitude and direction of the resultant of a 3-lb force and a 4-lb force at right angles to each other is a 5-lb force acting at an angle of 53° "up" from the 3-lb force.

PRACTICE EXERCISE FOR ACTIVITY 2

A force of 16 N and a force of 24 N are acting on an object at the same point. Find the magnitude and direction of the resultant for each of the three cases that follow:

***Case A:** when the two forces act in the same direction to the right.*

***Case B:** when the two forces act in opposite directions, 24 N to the right, 16 N to the left.*

***Case C:** when the two forces are at right angles to one another, 16 N to the east and 24 N to the north.*

ACTIVITY 3

Substituting in Formulas

A ***formula*** is an equation that relates certain things to each other. Usually, the formula is expressed in letters and numbers, rather than words. An example of a formula is $T = F \times L$. We have learned that this is an expression for torque (T) in terms of applied force (F) and lever arm (L). There are many other formulas.

Substituting in a formula is straightforward. All you need to do is write down the formula. substitute a given number for its appropriate symbol. and then combine the numbers (multiply, add, subtract, etc.). as the formula indicates. BE SURE TO KEEP TRACK OF THE UNITS THAT GO WITH THE NUMBERS.

Example F: *Torque on a Bolt*

Given: A mechanic tightens a bolt by applying a force of 10 pounds to the end of a wrench that is 24 inches long.

Find: The torque applied to the bolt.

Solution: Step 1: Write down the formula for torque. Identify the symbols.

$T = F \times L$

where: T = torque (lb·ft)
F = force (lb)
L = lever arm (ft)

Step 2: Identify what is given in the problem.

$F = 10$ lb
$L = 2$ ft (that is. 24 inches)

Step 3: Substitute in the formula.

$T = F \times L$
$T = 10 \text{ lb} \times 2 \text{ ft}$

Step 4: Complete the indicated multiplication.

$T = 10 \text{ lb} \times 2 \text{ ft}$
$T = (10 \times 2)\ (\text{lb·ft})$
$T = 20$ lb·ft*

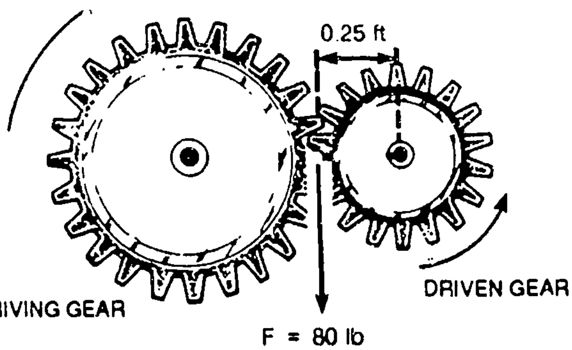
Thus. the torque wrench applies a force of 20 lb·ft to the bolt.

*Notice that the correct answer contains both a number (20) and a unit (lb·ft).

PRACTICE EXERCISES FOR ACTIVITY 3

Problem 1: How much torque is produced by a torque wrench that tightens a nut when the applied force is 20 lb and the lever arm is 1.5 ft?

Problem 2: Find the torque exerted on the driven gear by the teeth of the driving gear in the diagram shown here.



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Math Skills Laboratory

MATH ACTIVITY

Using Formulas to Calculate Temperature

MATH SKILLS LAB OBJECTIVES

When you complete this activity, you should be able to do the following:

1. ***Use a formula to calculate the Fahrenheit temperature, given the Celsius temperature.***
2. ***Use a formula to calculate the Celsius temperature, given the Fahrenheit temperature.***

LEARNING PATH

1. ***Read the Math Skills Lab. Give particular attention to the Math Skills Lab Objectives.***
2. ***Study Examples A and B.***
3. ***Work the problems.***

ACTIVITY

Using Formulas to Calculate Temperature

MATERIALS

For this activity, you'll need a hand calculator.

Given any temperature T°C on the Celsius scale, the corresponding temperature T°F on the Fahrenheit scale is found from the formula that follows:

$$T°F = \tfrac{9}{5}\,(T°C) + 32° \qquad \textit{Equation 1}$$

Given any temperature T°F on the Fahrenheit scale, the corresponding T°C on the Celsius scale is found from the formula:

$$T°C = \tfrac{5}{9}\,(T°F - 32°) \qquad \textit{Equation 2}$$

The examples that follow show how to use the two formulas to convert from Celsius to Fahrenheit and from Fahrenheit to Celsius. Study the examples. Make sure you understand all of the steps in each solution. You may want to check the calculations with your calculator.

Example A: Changing Celsius Temperature to Fahrenheit Temperature

Given: Computer equipment must not become overheated. The temperature of rooms where expensive mainframe computers are used is kept at 20°C.

Find: Fahrenheit temperature equal to 20°C.

Solution: This problem requires that you change from a Celsius temperature (20°C) to a Fahrenheit temperature. Therefore, you use the formula given by Equation 1:

$$T°F = \frac{9}{5}(T°C) + 32°$$

where: T°C = known Celsius temperature
T°F = unknown Fahrenheit temperature to be found

Step 1: Write down the formula as follows:

$$T°F = \frac{9}{5}(T°C) + 32°$$

Step 2: Substitute 20° for T°C in the formula

$$T°F = \frac{9}{5}(20°) + 32°$$

Step 3: Multiply $\frac{9}{5}$ times 20°. (Use your calculator.) You should get 36°. Substitute this in the equation:

$$T°F = 36° + 32°$$

Step 4: Add as indicated. (Use your calculator.) The final answer should be:

$$T°F = 68°F.$$

You have just shown, using a formula, that a temperature of 20°C is equal to a temperature of 68°F.

Example B: Changing Fahrenheit Temperature to Celsius Temperature

Given: Normal body temperature on the Fahrenheit scale is 98.6°F.

Find: Normal body temperature on the Celsius scale.

Solution: This problem requires that you change from a Fahrenheit temperature to a Celsius temperature. Therefore, you use the formula given by the equation:

$$T°C = \frac{5}{9}(T°F - 32°)$$

where: T°F = known Fahrenheit temperature
T°C = unknown Celsius temperature to be found

Step 1: Write down the formula as follows:

$$T°C = \frac{5}{9}(T°F - 32°)$$

Step 2: Substitute 98.6° for T°F in the formula:

$$T°C = \frac{5}{9}(98.6° - 32°)$$

Step 3: Perform the subtraction indicated in the parentheses. Use your calculator. Substitute your result back into the formula. You should get:

$$T°C = \frac{5}{9}(66.6°)$$

Step 4: Use your calculator to determine the value of T°C = $\frac{5}{9}$ (66.6°). You should get 37°.

Step 5: Write down the final answer as:

$$T°C = 37°C.$$

You have just shown, using a formula, that 98.6°F is equal to 37°C.

PRACTICE EXERCISES

In the following problems, you'll use Equation 1 or Equation 2. Read each problem carefully. Decide which formula to use. Then solve for the unknown by substituting in the formula.

Problem 1: A thermostat on an automobile engine is calibrated to "open" and allow engine fluid to circulate through the radiator when the fluid temperature reaches 180°F. What is this temperature equal to on the Celsius scale?

Problem 2: The temperature of a hot summer day, in a non-air-conditioned shop, reaches 36.7°C. What is this temperature equal to on the Fahrenheit scale?

Problem 3: A 5W motor oil does not become too viscous (heavy) even at temperatures as low as 5°F. What is this temperature equal to in degrees Celsius (°C)?

Problem 4: A thermocouple that measures the temperature of molten aluminum has a temperature indicator gage that's graduated in a Fahrenheit scale as well as a Celsius scale. The aluminum in the vat is at a temperature of 694°C, as shown by the gage. If the Fahrenheit scale had been read instead, what would the reading be in degrees Fahrenheit (°F)?

Problem 5: A nurse at a hospital emergency room tells Mrs. Nakamura that her baby has a temperature of 103°F. Mrs. Nakamura is a visitor from Japan and only understands the meaning of temperatures expressed in degrees Celsius. What is her baby's temperature in degrees Celsius (°C)?

Problem 6: What is the ***temperature difference*** in Celsius degrees if the temperature difference bewteen two cities is 78 Fahrenheit degrees? (***Note***: This problem involves a temperature difference, rather than a temperature, so we're working with Fahrenheit degrees (F°) and Celsius degrees (C°) and the relationship 1 C° = $\frac{9}{5}$ F°, or 1 C° = 1.8 F°.)

Math Skills Laboratory

MATH ACTIVITIES

Activity 1: Reviewing Examples of Potential Energy Problems

Activity 2: Solving Problems That Involve Energy and Work in Mechanical and Fluid Energy Systems

MATH SKILLS LAB OBJECTIVES

When you complete these activities, you should be able to do the following:

1. *Rearrange the equation for gravitational potential energy, $E_p = mgh$, to solve for mass (m), gravitational constant (g), or height (h).*
2. *Rearrange the equation, $E_p = \frac{1}{2} kd^2$, to solve for a spring constant (k) or the distance (d) a spring extends or compresses.*
3. *Rearrange the equation for a spring constant, $k = F/d$, to solve for force (F) applied to the spring, or the distance (d) the spring extends or compresses.*
4. *Substitute correct numerical values and units in energy equations. Solve the equations for a numerical value with the proper units.*

LEARNING PATH

1. *Read the Math Skills Lab. Give particular attention to the Math Skills Lab Objectives.*
2. *Study Table 1 and Equations 1, 2 and 3.*
3. *Work the problems.*

ACTIVITY 1

Reviewing Examples of Potential Energy Problems

MATERIALS

For this activity, you'll need a calculator.

In Subunit 1, you learned about two types of energy: (1) ***gravitational potential energy*** and (2) ***elastic potential energy.***

Knowing about each type of energy is important. As a technician, you'll be working with machines that use these types of energy to do work. Each type of energy influences the way a machine is designed. Technicians must understand the way a machine is designed if they want to modify or repair the machine properly.

During classroom discussions, you learned some general methods of storing potential energy. You also learned that stored potential energy can be converted to do work. Activity 1 of this math lab explains methods that can be used to solve technical problems. In Activity 2, you'll solve some problems similar to those a technician might have to solve.

Let's look at the relationship of the various physical quantities in the gravitational potential energy equation and the elastic potential energy equation.

$$\begin{matrix}\text{Gravitational} \\ \text{Potential Energy}\end{matrix} = \text{Mass} \times \begin{matrix}\text{Gravitational} \\ \text{Constant}\end{matrix} \times \text{Height}$$

This relationship helps you find the value of one physical quantity if you know the value and units of the other two physical quantities. The relationship is often written with symbols rather than words, as follows.

$$E_p = mgh = wh$$ ***Equation 1***

where: E_p = gravitational potential energy
m = mass
g = gravitational constant
w = weight
h = height

Equation 1 describes potential energy of an object in terms of the object's mass (m), the gravitational constant (g) and height (h) above a reference level.

Equation 2 describes potential energy in terms of the properties of the material. These are the material's elastic spring constant and the length a spring extends or compresses.. This equation can be written as follows.

$$\begin{matrix}\text{Elastic} \\ \text{Potential Energy}\end{matrix} = \tfrac{1}{2} \times \begin{matrix}\text{Spring} \\ \text{Constant}\end{matrix} \times \begin{pmatrix}\text{Length of} \\ \text{Movement}\end{pmatrix}^2$$

This relationship helps you find the value of one physical quantity if you know the value and units of the other physical quantities. The relationship is often written with symbols rather than words, as follows.

$$E_p = \tfrac{1}{2} kd^2$$ ***Equation 2***

where: E_p = elastic potential energy
k = spring constant
d = length of stretch or compression

Table 1 sums up the units used with each of the physical quantities given in Equations 1 and 2. Study Table 1. Compare the units in each system.

TABLE 1. TYPICAL POTENTIAL ENERGY UNITS

		System of Units English	System of Units SI
Equation 1: $E_p = mgh = wh$	E_p	ft·lb	N·m
	w (or mg)	lb	N
	m	—	kg
	g	ft/sec^2	m/sec^2
	h	ft	m
Equation 2: $E_p = \frac{1}{2} kd^2$	E_p	ft·lb or in·lb	N·m or N·cm
	k	lb/ft or lb/in.	N/m or N/cm
	d	ft or in.	m or cm
	d^2	ft^2 or in^2	m^2 or cm^2

Now let's look at the physical quantities that determine the elastic spring constant of a material.

$$\text{Elastic Spring Constant} = \frac{\text{Force Applied to Spring}}{\text{Distance Spring is Extended or Compressed}}$$

This relationship is written with symbols as follows:

$$k = \frac{F}{d} \qquad \textit{Equation 3}$$

where: k = elastic spring constant of the material
F = force applied to extend or compress the spring
d = displacement of spring during extension or compression

LET'S REVIEW UNITS!

Use Table 1 to answer the following questions. Fill in the blank with the correct word of words.

a. In the English system, ***gravitational potential energy*** is measured in units of ____ (ft·lb, N·m).

b. In the English system, the ***elastic spring constant*** is measured in units of ____ (lb/in., N/cm).

c. In the gravitational potential energy equation, ***height*** has units of ____ (ft, m) in SI units.

d. In the English system of units, the ***weight quantity*** (mg) is measured in ____.

101

PRACTICE EXERCISES FOR ACTIVITY 1

Problem 1: The gravitational potential energy that an object has at some position equals the gravitational force acting on the object times the vertical distance the object is raised above the reference point.

Given: A construction elevator raises an 800-pound load of bricks from the ground to the third floor of the building. 24 feet above the ground.

Find: The potential energy of the load of bricks when the elevator reaches the third floor.

Solution: This problem involves gravitational potential energy. so let's use Equation 1.

$$E_p = mgh, \text{ or } E_p = wh \text{ (since } w = mg)$$

where: mg = 800 lb (weight of bricks in English units)
h = 24 ft (height from ground to third floor)

$$E_p = w \times h$$
$$E_p = 800 \text{ lb} \times 24 \text{ ft} = (800 \times 24)(\text{ft} \times \text{lb})$$
$$E_p = 19.200 \text{ ft·lb}$$

This is the potential energy gained by the bricks with reference to the ground.

If the bricks gain 19.200 ft·lb of potential energy due to their position 24 ft above the ground. at least that much work (19.200 ft·lb) was done to raise the bricks to that height. This is an example of the relationship of stored potential energy and work done. Since machines are not 100% efficient. *more than* 19.200 ft·lb of energy was used by the machine to raise the bricks to the third floor. That's because the machine had to overcome friction while it did the work.

Problem 2: Elastic potential energy in a spring is the energy stored in the spring when the spring is stretched or compressed.

Given: A newspaper printing machine uses a set of rollers to feed paper through the machine. The rollers are held firmly against the paper by a spring. The spring exerts a force of 100 pounds when it is compressed 4 inches beyond its unstretched length.

Find:
a. The spring constant (k) that the maintenance technician should specify when ordering a spare replacement.
b. The amount of work done to compress the spring 4 inches.

Solution: a. The value of k equals the force applied to the spring divided by the distance the spring stretches or compresses. In equation form, this is written as

$$k = \frac{F}{d} \qquad \text{(Equation 3)}$$

where: k = spring constant
F = 100 lb
d = 4 in.

Solve for k.

$$k = \frac{F}{d} = \frac{100 \text{ lb}}{4 \text{ in.}} = \left(\frac{100}{4}\right)\left(\frac{\text{lb}}{\text{in.}}\right)$$

$$k = 25 \text{ lb/in.}$$

The spring constant for this particular spring is 25 lb/in. Therefore, the technician would ask for a spare replacement of the proper dimensions with a spring constant of 25 lb/in.

b. The elastic potential energy stored in a deformed spring is equal to the work required to deform the spring. Elastic potential energy, in equation form (Equation 2) is:

$$E_p = \tfrac{1}{2} kd^2$$

where: $k = 25$ lb/in. (from Part a)
$d = 4$ in.

$$E_p = \tfrac{1}{2}\left(25\ \frac{\text{lb}}{\text{in.}}\right)(4\ \text{in.})^2$$

$$E_p = \tfrac{1}{2}(25 \cdot 16)\left(\frac{\text{lb}}{\cancel{\text{in.}}} \times \text{in}^{\cancel{2}}\right) \quad \text{(Cancel units.)}$$

$$E_p = 200\ \text{in}\cdot\text{lb}$$

$$E_p = 200\ \cancel{\text{in}}\cdot\text{lb} \times \frac{1\ \text{ft}}{12\ \cancel{\text{in.}}} \quad \text{(Change units from in}\cdot\text{lb to ft}\cdot\text{lb.)}$$

$$E_p = 16.7\ \text{ft}\cdot\text{lb}$$

The work done to compress the spring 4 inches is 16.7 ft·lb. Therefore, the spring has 16.7 ft·lb of elastic potential energy stored in it.

Problem 3: The work done to stretch a spring equals the elastic potential energy stored in the spring while the spring is deforming.

Given: Five hundred inch-pounds (500 in·lb) of work is done in stretching a spring with a spring constant of 40 lb/in.

Find:
a. The distance the spring is stretched.
b. The force applied to stretch the spring.

Solution: a. This problem involves elastic potential energy, so let's use Equation 2, $E_p = \tfrac{1}{2} kd^2$, where $k = 40$ lb/in. and $E_p = 500$ in·lb.

To isolate d, first isolate d^2 by multiplying both sides of the equation by $(2/k)$.

$$E_p\left(\frac{2}{k}\right) = \tfrac{1}{\cancel{2}}\cancel{k}d^2 \times \left(\frac{\cancel{2}}{\cancel{k}}\right) \quad \text{(Cancel 2's and k's on right side of equation.)}$$

$$E_p\left(\frac{2}{k}\right) = d^2 \quad \text{(Simplify.)}$$

$$d^2 = E_p\left(\frac{2}{k}\right) \quad \text{(Rearrange equation with } d^2 \text{ isolated on the left.)}$$

$$d^2 = \frac{500\ \text{in}\cdot\text{lb} \times 2}{40\ \text{lb/in.}} \quad \text{(Substitute in numbers. Solve for } d^2\text{.)}$$

$$d^2 = \left(\frac{1000}{40}\right)\left(\text{in}\cdot\cancel{\text{lb}} \times \frac{\text{in.}}{\cancel{\text{lb}}}\right) \quad \text{(Cancel lb units.)}$$

$$d^2 = 25\ \text{in}^2$$

Take the square root of each side of the equation to obtain d.

$$d = \sqrt{25\ \text{in}^2} = 5\ \text{in.}$$

Thus the spring was stretched a distance of 5 inches.

103

b. The equation for the spring constant is $k = F/d$ where $k = 40$ lb/in. and $d = 5$ in. (from Part a).

Solving the equation $k = F/d$ for F (by rearranging and isolating F) gives:

$$F = k \times d$$

$$F = 40 \frac{\text{lb}}{\text{in.}} \times 5 \text{ in.}$$

$$F = (40 \times 5)\left[\frac{\text{lb}}{\cancel{\text{in.}}} \times \cancel{\text{in.}}\right] \quad \text{(Cancel units.)}$$

$$F = 200 \text{ lb}$$

The force applied to the spring is 200 lb.

ACTIVITY 2

Solving Practical Problems That Involve Energy and Work in Mechanical and Fluid Energy Systems

MATERIALS

For this activity, you'll need a calculator.

Note: You've used one type of hydraulic accumulator in Lab 4F1. The following problem involves an accumulator. (You'll learn more about accumulators in Lab 5MF2.)

Problem 4: Given: A hydraulic accumulator spring has a spring constant of $k = 200$ lb/in. The spring is compressed 6 inches. The work done to compress the spring equals the potential energy stored in the spring.

Find:

a. The potential energy (E_p) stored in the spring when the spring is compressed 6 inches—in units of in·lb and ft·lb.

b. The force required to compress the spring 6 inches. (Remember: $k = F/d$ or $F = k \times d$.)

Solution:

Check the units of the solution with the units of Table 1. Are the units correct? For each problem in the Math Skills Lab, you should compare the units of the solution to the units of Table 1. Doing this will help you make sure the solution units are correct.

Problem 5: Given: Sara is a technical sales representative for a company that makes material-conveying systems. One of those systems uses a vacuum to move material from one place to another.

Sara has been talking with a production manager. The production manager is searching for a way to transfer 1000 lb of plastic pellets from a shipping container to a hopper that's 50 ft above the floor. Sara believes this work can be done with a vacuum system. She knows that the potential energy the pellets gain while being moved up to the hopper can be used to determine how much work the vacuum system must do.

Find:

a. The potential energy of the pellets in the storage hopper.

b. The work that the vacuum system must do.

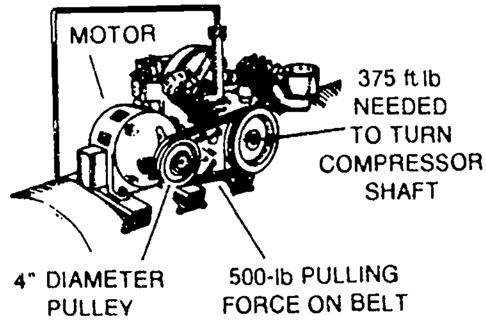
Solution:

Don't forget to compare the units obtained in your solutions to those listed in Table 1.

Student Challenge

The following problems review some concepts you have already learned. You may find it useful to refer to the equations given in Table 5-5 at the end of the summary for Unit 5.

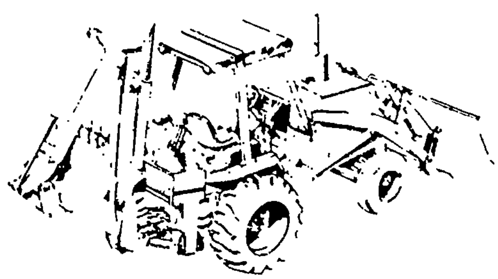
Problem 6: Given: You and another technician have installed a new electric motor on an air compressor. The motor is equipped with a 4-inch drive belt pulley. With that pulley, the motor produces 500 pounds of pulling force on the belt. The motor turns the belt in a counterclockwise direction. A torque of 375 foot-pounds is required to turn the drive shaft of the air compressor.



Find: The diameter of the pulley that is attached to the shaft of the air compressor. ***Hint:*** Remember that the diameter is 2 times the radius. The radius is the lever arm of the pulley.

Solution:

Problem 7: Given: The drawing at the right shows a hydraulically operated machine that's used to dig holes. The force required for either bucket to dig into the ground is 12,000 lb. The maximum pressure that can be developed in the hydraulic system is 1800 lb/in^2 (psi).



Find: Will a 3-in.-diameter hydraulic cylinder develop the needed digging force?

Solution:

Math Skills Laboratory

MATH ACTIVITY

Solving "Force" Transformer Problems for Fluid Systems

MATH SKILLS LAB OBJECTIVES

When you complete these activities, you should be able to do the following:

1. ***Solve and interpret "force" transformer problems for fluid systems.***
2. ***Relate ideal mechanical advantage to ratio of piston face areas (or diameters) on input and output sides of the transformer.***
3. ***Relate actual mechanical advantage to ratio of forces (or pressures) on input and output sides of the transformer.***

LEARNING PATH

1. ***Read the Math Skills Lab. Give particular attention to the Math Skills Lab Objectives.***
2. ***Work the problems.***

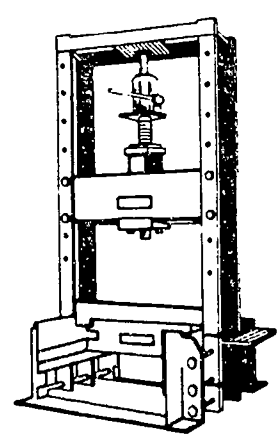
ACTIVITY

Solving "Force" Transformer Problems for Fluid Systems

In this lab, you'll work problems that involve "force" transformers in fluid systems. The problems involve fluid pressure intensifiers, fluid jacks and cylinders.

To solve these problems, refer to the formulas in Table 7-4, "Force Transformer Formulas for a Hydraulic Jack," and Table 7-5, "Force Transformer Formulas for a Pressure Booster."

Problem 1: Given: Shop Press, Inc., makes presses like the one in this drawing. This press uses a hydraulic jack to apply force to parts that are being put together and taken apart. In fluid systems, pressure is constant throughout the volume containing the fluid. This means that "pressure input" equals "pressure output" in a hydraulic jack. The ideal mechanical advantage of a hydraulic jack can be stated as:



Shop press

$$\text{IMA} = \frac{F_o}{F_i} = \frac{A_o}{A_i}$$

(Suppose the input pump piston of the hydraulic jack shown in the drawing has a surface area of 1.77 in^2.)

Find:
a. Surface area of the output piston face when a 50-pound input force causes the output piston of the jack to raise a 600-pound load.
b. The diameter of the output piston when a 50-pound input force moves a 600-pound load.
c. The distance the load moves if the input piston moves 12 inches, under the conditions of b.

Solution:

Problem 2: Given: Century Construction Company has several hydraulically operated earth-moving machines. Ron Brown works as a hydraulics technician for the company. He's been asked to modify the hydraulic system of one of the machines. He'll replace a small hydraulic cylinder with a larger one. The new cylinder has a usable output piston face area of 10 in^2. The pump on this machine can provide 1500 psi of pressure in the fluid.

Find:
a. Maximum output force that can be exerted by the cylinder.
b. Output work done by the cylinder to move the cylinder rod out 1 ft against a load.
c. Input force supplied by the pump if the system's ideal mechanical advantage is 12.
d. Input work done by the pump (assuming there are no losses due to friction/resistance).

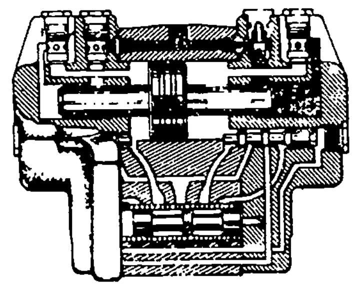
Solution:

Problem 3: Given: Carl Renchler is a machine repair technician for Harris Manufacturing. This company produces copper fittings. These fittings are used by plumbers and makers of heating and cooling equipment. Fitting ends are expanded so that tubes can be eased into the fittings and soldered into place. Fitting ends are expanded in a forming machine that's equipped with an air-to-water pressure booster. The pressure booster is usually operated at 125 psi air pressure. This produces a 20:1 ideal mechanical advantage.

Find:
a. The water pressure applied to the inside surface of the copper fitting.
b. The face area of the output piston if the input piston is 3 inches in diameter.

Solution:

Problem 4: Given: Kali-Alto Laboratories employs Kay Lewis as a standards lab technician. Part of Kay's job is to calibrate high-pressure hydraulic gages. An air-to-hydraulic pressure intensifier is used to pressurize the gages being tested and calibrated. The intensifier has a 3.5-inch-diameter input cylinder and a 0.5-inch-diameter output cylinder.



Intensifier

Find:

a. Maximum pressure available to test the gages if the air pressure is 100 psi.

b. Mechanical advantage of the pressure intensifier.

c. Overall mechanical advantage if the output pressure of the intensifier were connected to the input side of an identical pressure intensifier.

Solution:

Problem 5: Given: Power Systems makes a pressure booster that's used on the power brake system of some cars. One side of the pressure booster is linked to the intake manifold of a car's engine. When the engine runs, a vacuum forms on this side of the pressure booster. When the brake pedal is pushed down, atmospheric air pressure acts on the surface of the large piston. This increases the pressure available to push on the piston in the master cylinder of the hydraulic brake system. A research technician for this company might be asked to provide an answer to the following question.

Find: If the atmospheric pressure is 14.7 psi and the mechanical advantage of the booster is 12, what's the pressure applied to the piston of the master cylinder?

Solution:

Problem 6: Given: Williamsport Tower Company constructs and installs girder towers that support high-voltage electric power lines. These towers are very tall. They must be assembled "on site." Individual pieces of the tower are riveted together with a portable air-to-hydraulic rivet gun. The rivet gun is a pressure intensifier that uses a 50-psi air source.

Find:

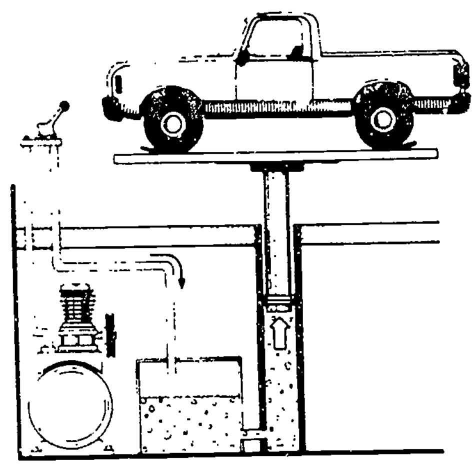
a. Mechanical advantage of the pressure intensifier when a 1-in^2 output piston pushes on a rivet with 600 lb of force.

b. Area of the piston on the air input side of the pressure intensifier.

Solution:

108

Problem 7: Given: The sketch with this problem shows a type of air-over-hydraulic lift used by automotive garages. In this example, the air compressor is connected to a hydraulic tank that has a cross-sectional area of 7 ft^2. The tank is connected to a hydraulic lifting cylinder. The cylinder piston has 1 ft^2 of face area in contact with the oil.



Find:

a. The ideal mechanical advantage of this device.

b. The force applied to a load by the movable piston if 100 psi of air pressure is applied to oil in the tank. Remember: 1 ft^2 = 144 in^2.

c. How far up the top of the lifting piston moves if the oil level in the large tank moves down one foot.

Solution:

109

PRINCIPLES OF TECHNOLOGY

PART THREE - LOGISTICS

After participation in a workshop on Principles of Technology, the teacher will be able to...

- Identify sources and write specifications to order equipment and supplies for a Principles of Technology program.
- Describe the mechanics and logistics for laboratory management, safety, inventory control, grading and other problems which arise during the planning, preparation and delivery for a Principles of Technology program.
- Describe Pennsylvania teacher certification requirements for Principles of Technology as they relate to teachers presently certified in Physics, General Science, and Industrial Arts\Technology Education.
- Provide an overview of Principles of Technology to students, parents, counselors, school administrators-board members, and persons in the community.

OUTCOME ACTIVITY GUIDE 5

1. Outcome

   Identify sources and write specifications to order equipment and supplies for a Principles of Technology program.

2. Method: Oral presentation, discussion and specification writing practice exercise

3. Resources and Material Needs:

   A. Information Sheets:

      IS-5 Equipment and Supplies
      IS-6 Laboratory Equipment
      IS-7 Equipment Sources
      IS-8 Specification Writing

   B. Vendor Catalogs

   C. Design Notes Supplement for Principles of Technology

4. Suggested Activities

   A. Using information sheets IS-5 to 7, make a presentation on the selection and ordering of equipment and supplies for a Principles of Technology program.

   B. Discuss purchasing procedures variations that exist in the districts represented by participants.

   C. Using information sheet IS-8 make a presentation on writing specifications.

   D. Distribute copies of vendor catalogs and have workshop participants write a sample specification for a major piece of equipment or lab furniture for a Principles of Technology program. After specifications have been written, have participants exchange and review each others specifications.

NOTE: Since Pennsylvania is a member state of the Principles of Technology consortium, Commonwealth school districts have the right to make unlimited copies of print and video material for in-school use. Print and video masters for making copies are available through instructional materials centers of local Intermediate Units. A copy authorization letter for Pennsylvania from AIT is included in information sheet IS-5.

Copies of these materials are also available at state consortium member prices. Copies can be purchased directly from AIT/CORD; a price listing and order form are included in information sheet IS-5.

EQUIPMENT AND SUPPLIES

The Principles of Technology teacher's responsibility includes the procurement of equipment and supplies necessary for lab activities. This is a big job as an initiating activity for the development of a new program. The start-up cost associated with equipping a Principles of Technology program is considered expensive.

The range of cost that has been estimated by CORD is between $3 to $5 thousand per lab work station for a fully equipped new program. The typical cost to equip the first year of a new Principles of Technology program with six lab work stations is approximately $18 to $25 thousand; for both years, approximately $32 to $45 thousand.

This cost can however be reduced by close to one-half if a student rotation system is used. In operation this works with two rotating groups of students with one group doing Lab 1, while the other group is doing Lab 2. After both groups are done, they rotate. The lab rotation system requires only one-half of the number of fully equipped lab work stations. Although this approach can not be used for all labs, it is effective for many and therefore should be considered.

To aid in the procurement process, a set of steps which can be followed as well as three separate equipment listings (organized by system needs, specific lab needs and teacher demonstration needs) have been prepared for your reference.

It is recommended that you conduct a preliminary review of these steps and inspect the related equipment listings prior to any formal action. Further, it is recommended that you develop a rough action plan and discuss this, in a preliminary fashion, with a department chairperson, supervisor and/or purchasing agent in your school district. This action may contribute to greater ease and efficiency in this endeavor than may be achieved otherwise.

Step 1. Order equipment catalogs from vendors. See listings of equipment sources.

Step 2. While waiting for your catalogs, review the equipment lists and the labs to gain a "feel" for the lab component of Principles of Technology.

Step 3. Divide the equipment list into three categories.

Category 1: Equipment on hand and available for use.
Category 2. Equipment needed, nonconsumable.
Category 3. Consumable supplies.

Step 4. If you're required to receive bids for all items above a certain dollar figure, you could subdivide Category 2 of Step 3.

Step 5. Carefully examine the items you initially placed in Category 1 of Step 3. Will each item really work? Is it compatible with other equipment which it will be connected to in the lab?

Step 6. Select specific items. Examine the items in Category 2 of Step 3. Naturally, you want the equipment to be rugged and flexible, yet economical. This is the tough part. One way to judge the level of flexibility and ruggedness needed is to look at several labs where that item is used.

If a piece of equipment is going to receive a high frequency of use, it may be best to consider investing in an industrial grade rather than a student grade of the same item; the industrial grade will be more rugged and last longer. Particular care should be given to writing detailed equipment specifications if a distinction of this type is going to be made.

Step 7. Write equipment specifications. See separate specification writing information sheet.

Step 8. Consider your equipment suppliers. What's their track record? What service after the sale do the provide? How do they handle damaged or defective items? Do they have someone who is technically knowledgeable about the items they offer (that you can contact)? Do they offer "package" deals? Do they give discounts for quantity?

Step 9. Submit your lists--and be ready to justify each item. You might consider sitting down with your school's purchasing director and seek his/her cooperation in not allowing the order to be based only on price. Be flexible on where the equipment item comes from, but don't compromise on the capabilities of the item.

All of these steps will be influenced by the purchasing procedures in each district as well as your experience. In many instances, you'll also be faced with making a decision or one or more of the following: (1) procuring materials in a disassembled kit form, (2) getting the materials completely assembled, or (3) fabricating some of the equipment items yourself or with the help of others. The first option provides economy, flexibility and potentially greater student involvement. The second option provides convenience, time savings, and minimal student frustration. The third option may apply to only selected items and although time consuming, it often results in high quality items, considerable cost savings and contributes to a sense of ownership. Your ability, and the dollars available will help you select the path you should take.

It should be noted the problem that teachers most frequently report is getting the lab equipment on time. Since the school's ordering system and the vendor delivery process will likely be time-consuming, lab equipment should be ordered as far as possible in advance of anticipated use.

PRINCIPLES OF TECHNOLOGY INSTRUCTIONAL MATERIALS

NOTE: Since Pennsylvania is a member state of the Principles of Technology consortium, Commonwealth school districts have the right to make unlimited copies of print and video material for in-school use. Print and video masters for making copies are available through instructional materials centers of local intermediate units. A copy authorization letter for Pennsylvania from AIT is included in information sheet IS-5.

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IS-5

AGENCY FOR INSTRUCTIONAL TECHNOLOGY

September 29, 1992

Sandra Mattson
Vocational Education
Temple University
Philadelphia, PA 19122

Dear Sandra,

In referance to your letter asking permission to copy materials from the Applied Communication and Principles of Technology series, as a consortium member of both series your state has the legal right to copy all components of both series.

If you have any further questions, please contact me.

Sincerely,

Connie Scott

Connie Scott
Customer Service and Sales

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To Sandra Mattson	From Connie Scott
Co. Temple Univ.	Co. AIT
Dept. Voc. - Educ.	Phone # 800-457-4509
Fax # 215-787-5154	Fax # 812-333-4278

110

Box A, Bloomington, Indiana 47402-0120 812-339-2203 800-457-4509 FAX 812-333-4218

APPLIED ACADEMICS

PRINCIPLES OF TECHNOLOGY

Principles of Technology is an applied technical physics course designed to prepare secondary students for technical careers. **Principles of Technology** uses hands-on laboratory activities alongside mathematics to apply practical science to the world of work.

Each of **Principles of Technology's** 14 units deals with one principle as it applies in the four energy systems — mechanical, fluid, thermal, and electrical.

Principles of Technology is a two-year, integrated course which combines the use of several instructional components to teach basic physics concepts.

The **Video Programs** introduce the subunits within each unit and demonstrate the role of physics concepts in the world of work. Each unit contains six video presentations which consist of a unit overview, application of principles in the mechanical, fluid, thermal, and electrical systems, and a unit summary.

The **Student Text** divides each unit into four subunits. Subunits apply the physics principle to the mechanical, fluid, thermal, and electrical systems. Each subunit is designed for six 50-minute lessons. Lessons one and two are intended for lecture/discussion. Lesson three is a math skills laboratory. Lessons four and five offer hands-on physics applications labs. Lesson six provides a unit review, including student exercises.

The **laboratory exercises** included in **Principles of Technology** apply physics principles to an industry setting. Students gain practice in setting up experiments and manipulating machines and formulas. Over 50 percent of class time is spent on such exercises.

The **Teacher's Guide** for each unit includes notes to the instructor, printed on the left side of the guide, with the corresponding student page printed on the right side of the guide. Explanations of more difficult passages, along with teaching paths and strategies, are included.

The **Student Resource Book** is a compilation of tables, charts, and reference matter from the 14 student units. It also includes eighteen preparatory math skills labs to assist those students who may require additional help in a particular area of math.

The 15-minute **Overview Video** provides an informativ[illegible]troduction to **Principles of Techn**[illegible] for parents, counselors, teachers, an[illegible] administrators.

The **Implementation Guide** is a "how-to" manual for teachers, counselors, and administrators introducing a **Principles of Technology** program. The guide provides information from case studies in which **Principles of Technology** was "field tested" and occupational information related to technical careers. Lab management information, facilities requirements, a lab equipment list, a dissemination guide, and suggestions for motivating students are also included.

✦ *Available from the Agency for Instructional Technology (AIT), 1-800-457-4509. School prices are based on state membership in the **Principles of Technology** consortium. Please contact **AIT** for non-consortium and non-school availability and pricing.*

Student Text
$2.55 per unit *(Before 7/1/92)*
$3.25 per unit *(Effective 7/1/92)*
$17.85 per year *(Before 7/1/92)*
$22.75 per year *(Effective 7/1/92)*

Teacher's Guide
$17.45 per unit *(Before 7/1/92)*
$23.50 per unit *(Effective 7/1/92)*
$122.15 per year *(Before 7/1/92)*
$164.50 per year *(Effective 7/1/92)*

Student Resource Book **$3.25**

Videos (VHS, 3/4", or Beta)
$75.00 per unit
$525.00 per year

Overview Video (VHS, 3/4", or Beta)
$40.00 each

Available from CORD:

Implementation Guide
PT367-3 **$40.00**

Year 1
Original edition, 1985 &
Revised edition, 1991
Both available

Unit 1: *Force*
Unit 2: *Work*
Unit 3: *Rate*
Unit 4: *[illegible]ance*
Unit 5: [illegible]
[illegible]

Year 2
Original edition, 19[illegible]
Now availabl[illegible]
Revised edition — *comb*[illegible]

Unit 8: *Momentum*
Unit 9: *Waves and Vibrations*
Unit 10: *Energy Convertors*
Unit 11: *Transducers*
Unit 1[illegible]
Unit 1[illegible]
Unit [illegible]

ORDER FORM

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Bill to:

Name/Title

School/Company

Address

City/State/Zip

Telephone ( )

Purchase Order No.

Ship to:

Name/Title

School/Company

*Address

City/State/Zip

Telephone ( )

**Please include street address only.*

Quantity	Item No.	Title	Amount
		SUB-TOTAL	
		Shipping & Handling	
		TOTAL AMOUNT	

Copy this form and mail to:

CORD
Attn: Material Sales
P.O. Box 21689
Waco, TX 76702-1689

OR

FAX a copy of this form to:
817-772-8972

Terms:

Due upon receipt of invoice.

Method of Payment:

__ Check enclosed.
__ Purchase order enclosed.
__ VISA __ MasterCard
Account No.
Exp. Date: Month Year

Shipping & Handling Instructions:

- Add 10% for shipping & handling if prepayment is desired.
- For all orders not prepaid, shipping & handling will be added to invoiced amount
- All orders will be shipped UPS unless packages exceed UPS weight and size limits. Packages that exceed UPS requirements will be consigned to a responsible motor freight carrier.

117

LABORATORY EQUIPMENT FOR

PRINCIPLES OF TECHNOLOGY

UNITS 1 - 7
MARCH 1991

This packet lists all the laboratory equipment items needed to complete the lab activities and teacher demonstrations in **Units 1 through 7** of ***Principles of Technology*** **(Second Edition).**

The packet is divided into the following sections:

I. ***Lab equipment list, sorted by the major systems.*** Each item is followed by a list of the labs where that item will be used. (Pages 1 - 6)

II. ***Lab equipment list for each of the 51 PT labs.*** Due to some polishing of descriptions and an attempt to use consistent names for items throughout, these lists may not identically match the lists given in the student texts. However, no significant differences exist. (Pages 7 - 23)

III. ***Demonstration equipment list for the teacher demonstrations.*** At the end of each unit's Teacher's Guide is a group of demonstrations that the teacher can perform, using a single lab setup, rather than several per class. Some of the items must be purchased in addition to the student's equipment, as indicated by an asterisk in this list. (Pages 25 - 32)

IV. ***A brief discussion about lab management, facilities, and laboratory equipment purchasing.*** (Pages 33 - 42)

V. ***A list of those vendors who support fully the official PT equipment specifications with comprehensive equipment offerings.*** This list is for informational purposes only. No endorsement, approval, or other qualification is intended or implied with regard to the relative merits of suppliers, their equipment, or services. (Pages 43 - 46)

VI. ***A cost comparison worksheet.*** You can make copies of this worksheet to assist you in securing the *PT* equipment in a cost-effective manner. (Page 47)

I. *Principles of Technology* Lab Equipment (Listed by major systems)

Each item here is listed under one of the following major systems: Mechanical, Fluid, Electrical, Thermal, or Miscellaneous. The quantity listed for each item (if more than one) is the maximum that will be needed at *one lab station* for any one lab during the first year. Following each item is a list of the lab activities where the item will be used. For example, the first item below, the *small weight hanger* is a mechanical-system type of item that will be used in Labs 2M1, 2E2, 5MF1, 6F2, 7M2, and 7M3.

Units 1 through 7

MECHANICAL SYSTEM

Small weight hanger, 50-g type [2M1, 2E2, 5MF1, 6F2, 7M2, 7M3]
Small weight set, total 1 kg [2M1, 2E2, 5MF1, 6M2, 6F2, 7M2, 7M3]
Large weight hanger, 1-kg type [1M1, 1M2, 2M1, 2M2, 2E1, 6M1]
Large weight set, total 10 kg [1M1, 1M2, 2M1, 2M2, 2F1, 2E1, 4M1, 6M1, 7M1]
50-100 small, identical objects (e.g. screws, nails, washers, etc.) [3M1]
Drag objects, three assorted types, all with same diameter equal to approximately 60% of airflow-assembly tube ID [4M2]
Pulley, set, including 2 single-sheave, 1 double-sheave, 1 triple-sheave, and 1 metal single-sheave pulleys [2M1, 2M2, 2E1, 2E2, 6M1, 6F2, 7M2]
Pulley attachment for DC motor [3M1, 3M2, 5MF4]
Soap, liquid dish-washing type [4M1]
Rags or paper towels to clean up soap [4M1]
Solid wooden block, 4" × 4" × 2", with same texture on all faces, with eye hook or other attachment point on one 4" × 2" face [4M1]
Spring scale, 5-lb (20 N) or 25-lb (100-N) capacity [2M2, 4M1, 7M1, 7F1]
Spring scale, 8-oz (2.5 N) or 16-oz (5-N) capacity [2M1, 2E2, 4M2, 7M2]
Spring scale, three, 25-lb (100-N) capacity [1M2, 2M1]
Triple-beam balance [3M1, 4M1, 5T1, 5T2]
Spring, coil type [1M1]
Steel plate, 4" × 6" × ¼", flat with one side smooth, the other side rough, with attachment points on one edge [4M1]
Steel plate, 6" × 18" × ¼", flat [4M1]
Stroboscope [3M2, 5MF3, 5MF4, 6M2, 7M4]
Come-along winch [7M1]
Conveyor belt apparatus [3M1, 3M2]

1.20

Friction-strap apparatus (attached to flywheel assembly housing) [6M2]
Screw and disk assembly [7M2]
Spur-gear train assembly (assembled or unassembled) [7M3]
Worm-and-wheel gear train [7M3]
Flywheel assembly with safety enclosure (flywheel should be a solid disk, ***not*** a spoked wheel) [5MF4, 6M2]
Rubber sleeve attachment for DC motor [6M2]
Spring test assembly (vendor supplied or "home made") [5MF1]
Stepped belt-drive assembly, with cogged motor pulley, equipped with safety enclosure [7M4]
Cogged-pulley attachment for DC motor [7M4]
Winch assembly [2M2]

FLUID SYSTEM

Compressed air supply (for example, air tank, with pressure gage and shutoff valve, about 6-gallon capacity, charged to 100 psi) [3F2, 4F1, 5MF3, 5E2, 6F2, 7F2]
Pressure regulator, 0 to 30 psi [4F1, 5MF3, 5E2, 6F2, 7F2]
Air cylinders with coupling slug:
First cylinder: 1 ⅛-in. diameter × 6-8-in. stroke
Second cylinder: ¾-in. diameter × 6-in. stroke [2F1, 7F2]
DC-powered water pump, vane-type, self-priming, with connecting hoses [2F2, 3F1, 6F1]
Air motor [5MF3, 5E2, 6F2]
Stirring attachment for air motor and container with splash shield [5MF3]
Hand-operated pressure/vacuum pump [1F2, 3F2]
Liquid mixtures to include: tap water; isopropyl alcohol; 25% mixture of RV antifreeze (propylene glycol used in Recreational Vehicles); and 50% mixture of RV antifreeze [1F1]
Plexiglass collection column, 2" ID × 24" long, with waterproof tray [3F2]
Schedule 40 PVC pipe, two 18-in. sections, with connectors to fit into water pump and pressure gage tees [6F1]
Sheet-metal or vinyl channel (trough), 2 ½-ft long with a 1-in., V-notch weir at one end and a hose coupling at the other end [3F1]
Standard restrictor set [4F2]
Assorted filter sections (clean and dirty) [4F2]
Beaker, two, 250-ml capacity, Pyrex [1F1, 1T1, 1T2, 4T2]
Beaker, two, 600-ml capacity, Pyrex [4T2, 5T1, 5T2]
Beaker, two, 1000-ml capacity, Pyrex [2F2, 3F1]
Beaker tongs [1T1, 1T2, 5T1, 5T2]
5-gallon plastic container, two [2F2, 3F1, 6F1]
Funnel [4T2, 5MF2]

Large fluid reservoir with porthole on side, near bottom [5MF2]
Metal container, approximately 2-quart capacity (local acquisition) [4T2]
Ordinary plastic-type drinking straw (8" × 3/16") [1F1]
Differential pressure gage, zero center *(−15 in. H_2O to +15 in. H_2O)* with air-chamber assembly [1F2, 3F2]
Pressure gage, two, compound type, 15 mm Hg vacuum to 30 psi pressure, with connecting tee [2F1, 4F1, 5MF2, 5MF3, 5E2, 6F1, 6F2, 7F2]
Rotameter, 50 to 450 SCFH [4F1, 5E2, 6F2]
Pocket-type hydrometer with colored balls [1F1]
Scaled hydrometer (heavy liquids), 12-in. long, scale 1.000-2.000 in 0.01 div [1F1]
Scaled hydrometer (light liquids), 12-in. long, scale 0.700-1.000 in 0.01 div [1F1]
Hydrometer jar, four, approximately 1 ½" diameter, 10" high [1F1]
Slant-tube water manometer [4F2]
U-tube water manometer, with minimum 1-meter arms [1F2, 4F2]
Light-weight floating object such as a weighted bobber [3F1]
Pipe tee, two [3F2, 6F1]
Bleeder valve with tee, two [2F1, 7F2]
Plastic tubing, approximately ¼" ID [1F2, 3F2, 4F1, 4F1, 5MF3, 5E2, 6F2, 7F2]
Plastic tubing: 5/16" OD × 10-ft length [4F1]
Tubing clamp, three [3F2]
Connectors for piping and hoses [6F1]
Connectors for plastic tubing [4F1, 5MF3, 5E2]
Airflow assembly with 12-V DC fan [4M2, 4F2]
Hydraulic jack assembly, ½- to 1 ½-ton capacity, with pressure gage (1000-lb/in² capacity) [7F1]
Hydraulic shock device (vendor supplied), including
 Schedule 40 PVC pipe
 Pipe tee with fitting for pressure gages, two
 Flow-control valves, two
 Accumulator assembly
 Support frame and rubber mallet
 Connector to fluid reservoir [5MF2]
Orifice-plate assembly [3F2]

ELECTRICAL SYSTEM

6-V dry-cell battery, three [1E1, 1E2, 3E1]
9-V transistor-type battery, two [1E1]
12-V wet-cell battery (optional) [1E1]
DC power supply, 20 V, 10 A [2F2, 2E1, 2E2, 3M1, 3M2, 3F1, 3E1, 3T1, 3T2, 4M2, 4F2, 4E1, 4E2, 4T1, 5MF4, 6M1, 6M2, 6F1, 6E2, 7M4]
AC power source, variable 0-25 V AC [7E1/7E2]

Oscilloscope, with probe [3E2]
Function generator [3E2]
Digital multimeter (DMM), with probes, 10 A, 0.1 mV [1T2, 2E1, 2E2, 3M1, 3M2, 3E1, 3T1, 3T2, 4E1, 4E2, 4T1, 4T2, 5MF4, 5E2, 6E2, 7E1/ 7E2]
Multimeter (Volt-Ohm-Milliampere or VOM) with probes, 10 A [1E1, 2E1, 2E2, 3E1, 4E1, 4E2, 5MF4, 5E2, 6E2]
Single-pole, single-throw (SPST) knife switch [1E2, 2E1, 2E2, 3E1, 4E1, 4E2, 5E2, 6M2, 6F1]
Double-pole, double-throw (DPDT) knife switch [3T1, 3T2, 4T1, 4T2, 5MF4]
Normally-open (NO) momentary-type switch [6M1]
DC permanent-magnet motor, nominally 0-12 V [2E1, 3M1, 3M2, 5MF4, 5E2, 6M1, 6M2, 6E2, 7M4]
Drum attachment for DC motor, approximately 1-in. OD [2E1, 6M1]
Coupling device for motor shafts (e.g., plastic tubing) [5E2, 6E2]
Lamp, two, 6 V, type 40 [1E2, 6E2]
Miniature screw base for lamp, two [1E2, 6E2]
Heater filament or a high-wattage (minimum 200 W) lamp [3E1]
Screw-in base for heater filament or high-wattage lamp [3E1]
Load resistor, two: 10 Ω and 100 Ω, 2 to 5 watts [5MF4, 5E2, 7E1/ 7E2]
Resistor (load), two: 10 Ω and 100 Ω, 2 to 5 watts [5MF4, 5E2, 7E1/ 7E2]
Resistor, six, ½ W, ±5% tolerance, assorted resistances to represent at least 6 of the 10 possible multiplier-bands [4E1, 4E2]
Banana plugs to connect thermocouple wire to DMM [1T2]
Hookup wire, minimum 22 AWG, with alligator clips [1E1, 1E2, 2E1, 2E2, 2E2, 3M1, 3E1, 4E1, 4E1, 5MF4, 5E2, 6M2, 6E2, 7E1/ 7E2]
Solderless breadboard [4E1, 4E1, 7E1/ 7E2]
Solenoid, 12-V to 24-V DC operation, nominally with 2" stroke [2E2]
Transformer assembly (vendor supplied) [7E1/ 7E2]
Watt-hour meter apparatus (vendor supplied or home built) [6E1]
User-provided appliances, such as corn-popper, blow-dryer, hot plate, etc. [6E1]

THERMAL SYSTEM

Hot plate, or
- Bunsen burner
- Wire gauze
- Ring
- Support stand, rods, and clamps [1T1, 1T2, 4T2, 5T1, 5T2]

Specific-heat sample set [5T2]
Aluminum cylindrical slug, 1" diameter, 3" long, to fit in hole of insulated lid [3T1, 3T2]
Aluminum cylindrical slug, ½" diameter, 3" long, to fit in hole of insulated lid [3T2]
Iron cylindrical slug, 1" diameter, 3" long, to fit in hole of insulated lid [3T2]

Insulation wrap for metal slugs [3T2]
Metalized tape (aluminum) [4T1]
Styrofoam cup, 16-24 oz capacity [5T1, 5T2]
Chromel/constantan thermocouple (Type E), two [1T2, 3T1, 3T2, 4T1, 4T2]
Mercury thermometer, blank (no scale) [1T1]
Mercury thermometer, two, dual scale [1T1, 1T2, 3T1, 3T2, 4T1, 4T2, 5T1, 5T2]
Thermometer clamp [5T2]
Thermal pipe assembly (one pipe insulated, one uninsulated), including four tapered rubber stoppers and two one-hole rubber stoppers to fit pipe [4T2]
Insulated chamber assembly, with
 Heat source (may be a power resistor, double-filament auto lamp, or a diesel glow plug)
 Insulated lid, with 1"-diameter hole
 Insulated lid, with ½"-diameter hole [3T1, 3T2, 4T1]
Insulation test samples to fit over heated chamber, five to six samples, each ½" thick (Test samples can be made of plywood, celotex, wallboard, ceiling tile, etc.) [4T1]

MISCELLANEOUS

Heavy-duty support stand [1M1, 1M2, 2M1, 2M2, 2E1, 6M1, 6F2, 7M1]
Support stand, rods, and clamps [1T1, 2M1, 2F1, 2E2, 3M1, 3F2, 4M2, 4F2, 5MF3, 5E2, 5T2, 6F2, 7M3, 7F2]
Hook collar, two [2M1, 2E2]
Ruler (12 in., with centimeter scale) [1M1, 1M2, 2F1, 2E2, 3M1, 4T1, 5MF1, 5E1, 7M4, 7F1]
Meterstick/yardstick, two [2M1, 2F2, 3F1, 7M1, 7M2, 7M3]
Steel rule [7M1, 7M2]
Vernier caliper [7M4, 7F1]
Bow caliper [5MF4]
Protractor [1M2, 7M1]
Stopwatch [2E1, 3M1, 3F1, 3F2, 4T2, 5MF4, 5E2, 6M1, 6F2, 6E1]
Cord, minimum 30-lb test [1M2, 2M1, 2M2, 2E1, 2E2, 6M1, 7M2]
Monofilament line [2M2, 4M2, 5T2, 7M3]
C-clamp, two [2M1, 2M2, 2F2, 2E1, 3M1, 4M1, 5MF1, 6M1, 6F2, 7M4]
Masking tape [2F2, 2E1, 3T2, 6F1]
Number-2 pencil [1T1, 5E1]
Wax crayon [3F1, 3F2]

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II. *Principles of Technology* Lab Equipment (Listed by individual laboratory)

Each lab is listed here, in order of occurrence in the text, with the equipment and quantities needed to perform that lab at *one lab station*. For example, to conduct Lab 1M1, a lab station would require a heavy-duty support stand, a coil-type spring, a large weight hanger, a large weight set, and a 12-in. ruler with a centimeter scale.

Frequently a vendor-supplied apparatus or assembly is listed that may have several components. The heavy-duty support stand is one such item. In Lab 1M1, for example, a hook attachment is needed to support the spring. See the illustrations accompanying each lab for details of the needed components.

Units 1 through 7

Lab 1M1

Heavy-duty support stand
Spring, coil type
Large weight hanger, 1-kg type
Large weight set, total 10 kg
Ruler (12 in., with centimeter scale)

Lab 1M2

Heavy-duty support stand
Spring scale, three, 25-lb (100-N) capacity
Large weight hanger, 1-kg type
Large weight set, total 10 kg
Cord, minimum 30-lb test, 24-in., 10-in., and 5-ft lengths
Protractor
Ruler (12 in., with centimeter scale)

Lab 1F1

Scaled hydrometer (heavy liquids), 12-in. long, scale 1.000-2.000 in 0.01 div
Scaled hydrometer (light liquids), 12-in. long, scale 0.700-1.000 in 0.01 div
Pocket-type hydrometer with colored balls

Hydrometer jar, four, approximately 1 ½" diameter, 10" high
Liquid mixtures to include: tap water; isopropyl alcohol; 25% mixture of RV antifreeze (propylene glycol used in Recreational Vehicles); and 50% mixture of RV antifreeze
Beaker, 250-ml capacity, Pyrex
Ordinary plastic-type drinking straw (8" × 3/16")

Lab 1F2

U-tube manometer, with minimum 1-meter arms
Differential pressure gage, zero center *(–15 in. H_2O to +15 in. H_2O)*
Hand-operated pressure/vacuum pump
Air-chamber assembly
Plastic tubing, approximately ¼" ID

Lab 1E1

Multimeter (Volt-Ohm-Milliampere or VOM) with probes, 10 A
6-V dry-cell battery, three
9-V transistor-type battery, two
12-V wet-cell battery (optional)
Hookup wire, minimum 22 AWG, with alligator clips

Lab 1E2

Digital multimeter (DMM), with probes, 10 A, 0.1 mV
6-V dry-cell battery
Lamp, two, 6 V, type 40
Miniature screw base for lamp, two
Single-pole, single-throw (SPST) knife switch
Hookup wire, minimum 22 AWG

Lab 1T1

Mercury thermometer, blank (no scale)
Mercury thermometer, dual scale
Ice and water mixture, approximately 200 ml

Hot plate, or
    Bunsen burner
    Wire gauze
    Ring
Beaker, two, 250-ml capacity, Pyrex
Beaker tongs
Support stand, rods, and clamps
Number-2 pencil

Lab 1T2

Chromel/constantan thermocouple (type E)
Banana plugs to connect thermocouple wire to DMM
Digital multimeter (DMM), with probes, 10 A, 0.1 mV
Ice and water mixture, approximately 200 ml
Hot plate, or
    Bunsen burner
    Wire gauze
    Ring
    Support stand, rods, and clamps
Beaker, two, 250-ml capacity, Pyrex
Beaker tongs
Mercury thermometer, dual scale

Lab 2M1

Pulley set, including single, double, and triple sheave pulleys
Cord, minimum 30-lb test
Meterstick/yardstick, two
For small scale setup:
    Support stand, rods, and clamps
    Small weight set, total 1 kg
    Small weight hanger, 50-g type
    Spring scale, 8-oz (2.5 N) or 16-oz (5-N) capacity
    Hook collar
    C-clamp
For larger scale setup:
    Heavy-duty support stand
    Large weight hanger, 1-kg type
    Large weight set, total 10 kg
    Spring scale, 25-lb (100-N) capacity

Lab 2M2

Winch assembly
Heavy-duty support stand
Single-sheave pulley, metal
Spring scale, 5-lb (20 N) or 25-lb (100-N) capacity
Large weight set, total 10 kg
Large weight hanger, 1-kg type
Cord, minimum 30-lb test
Monofilament line
C-clamp

Lab 2F1

Air cylinder, ¾" diameter × 6-in. stroke, with weight stage
Pressure gage, compound type, 15 mm Hg vacuum to 30 psi pressure, with connecting tee
Bleeder valve, with tee
Support stand, rods, and clamps
Large weight set, total 10 kg
Ruler (12 in., with centimeter scale)

Lab 2F2

DC-powered water pump, vane-type, self-priming, with connecting hoses
5-gallon plastic container, two
DC power supply, 20 V, 10 A
Hookup wire, minimum 22 AWG
Beaker, 1000-ml capacity, Pyrex
Meterstick/yardstick
Masking tape
C-clamp

Lab 2E1

DC permanent-magnet motor, nominally 0-12 V
Drum attachment for DC motor, approximately 1-in. OD
DC power supply, 20 V, 10 A
Hookup wire, minimum 22 AWG
Heavy-duty support stand

Digital multimeter (DMM), with probes, 10 A, 0.1 mV
Multimeter (Volt-Ohm-Milliampere or VOM) with probes, 10 A
Single-sheave pulley, metal
Large weight set, total 10 kg
Large weight hanger, 1-kg type
Stopwatch
Single-pole, single-throw (SPST) knife switch
Cord, minimum 30-lb test
C-clamp
Masking tape

Lab 2E2

Solenoid, 12-V to 24-V DC operation, nominally with 2" stroke
Spring scale, 8-oz (2.5 N) or 16-oz (5-N) capacity
Small weight set, total 1 kg
Small weight hanger, 50-g type
Single-sheave pulley, two
DC power supply, 20 V, 10 A
Hookup wire, minimum 22 AWG
Multimeter (Volt-Ohm-Milliampere or VOM) with probes, 10 A
Digital multimeter (DMM), with probes, 10 A, 0.1 mV
Single-pole, single-throw (SPST) knife switch
Support stand, rods, and clamps
Hook collar, two
Cord, minimum 30-lb test
Ruler (12 in., with centimeter scale)

Lab 3M1

Conveyor belt apparatus
DC permanent-magnet motor, nominally 0-12 V
Pulley attachment for DC motor
DC power supply, 20 V, 10 A
Hookup wire, minimum 22 AWG
Digital multimeter (DMM), with probes, 10 A, 0.1 mV
Stopwatch
Triple-beam balance
50-100 small, identical objects (e.g. screws, nails, washers, etc.)

Ruler (12 in., with centimeter scale)
Support stand, rods, and clamps
C-clamp, two

Lab 3M2

Conveyor belt apparatus
DC permanent-magnet motor, nominally 0-12 V
Pulley attachment for DC motor
DC power supply, 20 V, 10 A
Digital multimeter (DMM), with probes, 10 A, 0.1 mV
Stroboscope

Lab 3F1

Sheet-metal or vinyl channel (trough), 2 ½-ft long with a 1-in., V-notch weir at one end and a hose coupling at the other end
DC-powered water pump, vane-type, self-priming, with connecting hoses
DC power supply, 20 V, 10 A
Light-weight floating object such as a weighted bobber
5-gallon plastic container
Beaker, 1000-ml capacity, Pyrex
Stopwatch
Wax crayon
Meterstick/yardstick

Lab 3F2

Orifice-plate assembly
Plexiglass collection column, 2" ID × 24" long, with waterproof tray
Compressed air supply (for example, air tank, with pressure gage and shutoff valve, about 6-gallon capacity, charged to 100 psi)
Plastic tubing, approximately ¼" ID
Hand-operated pressure/vacuum pump
Differential pressure gage, zero center *(–15 in. H_2O to +15 in. H_2O)*
Tubing clamp, three
Pipe tee
Support stand, rods, and clamps
Stopwatch
Wax crayon

Lab 3E1

Heater filament or a high-wattage (minimum 200 W) lamp
Screw-in base for heater filament or high-wattage lamp
DC power supply, 20 V, 10 A
Multimeter (Volt-Ohm-Milliampere or VOM) with probes, 10 A
Digital multimeter (DMM), with probes, 10 A, 0.1 mV
6-V dry-cell battery, two
Single-pole, single-throw (SPST) knife switch
Hookup wire, minimum 22 AWG

Lab 3E2

Oscilloscope, with probe
Function generator

Lab 3T1

Insulated chamber assembly, with
- Heat source (may be a power resistor, double-filament auto lamp, or a diesel glow plug)
- Insulated lid, with 1"-diameter hole

Aluminum cylindrical slug, 1"-diameter, 3"-long, to fit in hole of insulated lid
Chromel/constantan thermocouple (type E), two
Mercury thermometer, dual scale
DC power supply, 20 V, 10 A
Digital multimeter (DMM), with probes, 10 A, 0.1 mV
Double-pole, double-throw (DPDT) knife switch

Lab 3T2

Insulated chamber assembly with
- Heat source (may be a power resistor, double-filament auto lamp, or a diesel glow plug)
- Insulated lid, with 1"-diameter hole
- Insulated lid, with ½"-diameter hole

Aluminum cylindrical slug, 1" diameter, 3" long, to fit in hole of insulated lid
Aluminum cylindrical slug, ½" diameter, 3" long, to fit in hole of insulated lid
Iron cylindrical slug, 1" diameter, 3" long, to fit in hole of insulated lid
Insulation wrap for metal slugs

Chromel/constantan thermocouple (type E), two
Mercury thermometer, dual scale
DC power supply, 20 V, 10 A
Digital multimeter (DMM), with probes, 10 A, 0.1 mV
Double-pole, double-throw (DPDT) knife switch
Masking tape

Lab 4M1

Large steel plate, 6" × 18" × ¼", flat
Small steel plate, 4" × 6" × ¼", flat, with one side smooth, the other side rough, with attachment points on one edge
Solid wooden block, 4" × 4" × 2", with same texture on all faces, with eye hook or other attachment point on one 4" × 2" face
Spring scale, 5-lb (20 N) or 25-lb (100-N) capacity
Large weight set, total 10 kg
Triple-beam balance
Soap, liquid dish-washing type
Rags or paper towels to clean up soap
C-clamp, two

Lab 4M2

Airflow assembly with 12-V DC fan
Three assorted drag objects, all with same diameter equal to approximately 60% of airflow-assembly tube ID
DC power supply, 20 V, 10 A
Spring scale, 8-oz (2.5 N) or 16-oz (5-N) capacity
Support stand, rods, and clamps
Monofilament line

Lab 4F1

Compressed air supply (for example, air tank, with pressure gage and shutoff valve, about 6-gallon capacity, charged to 100 psi)
Plastic tubing:
  ¼" OD: one 20-ft length, one 10-ft length, and two 6-in. lengths
  5/16" OD: one 10-ft length
  Other, approximately ¼" ID (for connections)
Rotameter, 50 to 450 SCFH

Pressure regulator, 0 to 30 psi
Pressure gage, compound type, 15 mm Hg vacuum to 30 psi pressure, with connecting tee
Connectors for plastic tubing

Lab 4F2

Airflow assembly with 12-V DC fan
U-tube water manometer, with minimum 1-meter arms, or Slant-tube water manometer
Standard restrictor set
Assorted filter sections (clean and dirty)
DC power supply, 20 V, 10 A
Support stand, rods, and clamps

Lab 4E1

Resistors, ½ W, ±5% tolerance, assorted resistance values to represent at least 6 of the 10 possible multiplier-band colors
Single-pole, single-throw (SPST) knife switch
DC power supply, 20 V, 10 A
Digital multimeter (DMM), with probes, 10 A, 0.1 mV
Multimeter (Volt-Ohm-Milliampere or VOM) with probes, 10 A
Solderless breadboard
Hookup wire, minimum 22 AWG

Lab 4E2

Resistors, ½ W, ±5% tolerance, assorted resistance values
Single-pole, single-throw (SPST) knife switch
DC power supply, 20 V, 10 A
Digital multimeter (DMM), with probes, 10 A, 0.1 mV
Multimeter (Volt-Ohm-Milliampere or VOM) with probes, 10 A
Solderless breadboard
Hookup wire, minimum 22 AWG

Lab 4T1

Insulated chamber assembly, with
    Heat source (may be a power resistor, double-filament auto lamp, or a diesel glow plug)
Insulation test samples to fit over heated chamber, five to six samples, each ½" thick
    (Test samples can be made of plywood, celotex, wallboard, ceiling tile, etc.)
DC power supply, 20 V, 10 A
Double-pole, double-throw (DPDT) knife switch
Chromel/constantan thermocouple (type E), two
Mercury thermometer, dual scale
Metalized tape (aluminum)
Digital multimeter (DMM), with probes, 10 A, 0.1 mV
Ruler (12 in., with centimeter scale)

Lab 4T2

Thermal pipe assembly (one pipe insulated, one uninsulated), including four tapered
    rubber stoppers and two one-hole rubber stoppers to fit pipe
Beaker, 250-ml or 600-ml capacity, Pyrex
Metal container, approximately 2-quart capacity (local acquisition)
Hot plate
Funnel
Mercury thermometer, dual scale
Chromel/constantan thermocouple (type E), two
Digital multimeter (DMM), with probes, 10 A, 0.1 mV
Double-pole, double-throw (DPDT) knife switch
Stopwatch

Lab 5MF1

Spring test assembly (vendor supplied or "home made")
Small weight set, total 1 kg
Small weight hanger, 50-g type
C-clamp
Ruler (12 in., with centimeter scale)

Lab 5MF2

Pressure gage, two, compound type, 15 mm Hg vacuum to 30 psi pressure
Funnel
Large fluid reservoir with porthole on side, near bottom
Hydraulic shock device (vendor supplied), including
- Schedule 40 PVC pipe
- Pipe tee with fitting for pressure gages, two
- Flow-control valves, two
- Accumulator assembly
- Support frame and rubber mallet
- Connector to fluid reservoir

Lab 5MF3

Compressed air supply (for example, air tank, with pressure gage and shutoff valve, about 6-gallon capacity, charged to 100 psi)
Pressure regulator, 0 to 30 psi
Air motor
Pressure gage, compound type, 15 mm Hg vacuum to 30 psi pressure, with connecting tee
Plastic tubing, approximately ¼" ID
Connectors for plastic tubing
Stirring attachment for air motor and container with splash shield
Stroboscope
Support stand, rods, and clamps

Lab 5MF4

Flywheel assembly with safety enclosure (flywheel should be a solid disk, ***not*** a spoked wheel)
DC permanent-magnet motor, nominally 0-12 V
Pulley attachment for DC motor
Double-pole, double-throw (DPDT) knife switch
DC power supply, 20 V, 10 A
Hookup wire, minimum 22 AWG
Load resistors, two: 10 Ω and 100 Ω, 2 to 5 watts
Multimeter (Volt-Ohm-Milliampere or VOM) with probes, 10 A
Digital multimeter (DMM), with probes, 10 A, 0.1 mV

Stroboscope
Stopwatch
Bow caliper

Lab 5E1

Pen or pencil
Ruler (12 in., with centimeter scale)

Lab 5E2

Compressed air supply (for example, air tank, with pressure gage and shutoff valve, about 6-gallon capacity, charged to 100 psi)
Air motor
Rotameter, 50 to 450 SCFH
DC permanent magnet motor, nominally 0-12 V
Coupling device for motor shafts (e.g., plastic tubing)
Support stand, rods, and clamps
Pressure regulator, 0 to 30 psi
Pressure gage, compound type, 15 mm Hg vacuum to 30 psi pressure, with connecting tee
Hookup wire, minimum 22 AWG
Load resistors, two: 10 Ω and 100 Ω, 2 to 5 watts
Multimeter (Volt-Ohm-Milliampere or VOM) with probes, 10 A
Digital multimeter (DMM), with probes, 10 A, 0.1 mV
Stopwatch
Single-pole, single-throw (SPST) knife switch
Plastic tubing, approximately ¼" ID
Connectors for plastic tubing

Lab 5T1

Styrofoam cup, 16-24 oz capacity
Mercury thermometer, dual scale
Beaker, 600-ml capacity, Pyrex
Hot plate
Triple-beam balance
Beaker tongs

Lab 5T2

Specific-heat sample set
Support stand, rods, and clamps
Thermometer clamp
Beaker, 600-ml capacity, Pyrex
Hot plate
Beaker tongs
Mercury thermometer, two, dual scale
Styrofoam cup, 16-24 oz capacity
Triple-beam balance
Monofilament line

Lab 6M1

DC power supply, 20 V, 10 A
DC permanent-magnet motor, nominally 0-12 V
Drum attachment for DC motor, approximately 1-in. OD
Large weight hanger, 1-kg type
Large weight set, total 10 kg
Heavy-duty support stand
Single-sheave pulley, metal
Normally-open (NO) momentary-type switch
C-clamp
Cord, minimum 30-lb test
Stopwatch

Lab 6M2

DC power supply, 20 V, 10 A
Stroboscope
DC permanent-magnet motor, nominally 0-12 V
Rubber sleeve attachment for DC motor
Flywheel assembly with safety enclosure (flywheel should be a solid disk, ***not*** a spoked wheel)
Friction-strap apparatus (attached to flywheel assembly housing)
Small weight set, total 1 kg
Single-pole, single-throw (SPST) knife switch (optional)
Hookup wire, minimum 22 AWG

Lab 6F1

DC power supply, 20 V, 10 A
DC-powered water pump, vane-type, self-priming, with connecting hoses
Pipe tee, two
Connectors for piping and hoses
Schedule 40 PVC pipe, two 18-in. sections, with connectors to fit into water pump and pressure gage tees
5-gallon plastic container, two
Pressure gage, two, compound type, 15 mm Hg vacuum to 30 psi pressure, with connecting tee
Single-pole, single-throw (SPST) knife switch (optional)
Masking tape

Lab 6F2

Compressed air supply (for example, air tank, with pressure gage and shutoff valve, about 6-gallon capacity, charged to 100 psi)
Air motor
Plastic tubing, approximately ¼" ID
Support stand, rods, and clamps
Pressure regulator, 0 to 30 psi
Pressure gage, compound type, 15 mm Hg vacuum to 30 psi pressure, with connecting tee
Rotameter, 50 to 450 SCFH
Heavy-duty support stand
Single-sheave pulley, metal
Small weight set, total 1 kg
Small weight hanger, 50-g type
C-clamp
Stopwatch

Lab 6E1

Watt-hour meter apparatus (vendor supplied or home built)
User-provided appliances, such as corn-popper, blow-dryer, hot plate, etc.
Stopwatch

Lab 6E2

DC power supply, 20 V, 10 A
Hookup wire, minimum 22 AWG
DC permanent-magnet motor, nominally 0-12 V
Coupling device for motor shafts (e.g., plastic tubing)
Multimeter (Volt-Ohm-Milliampere or VOM) with probes, 10 A
Digital multimeter (DMM), with probes, 10 A, 0.1 mV
Lamp, 6 V, type 40
Miniature screw base for lamp

Lab 7M1

Steel rule
Heavy-duty support stand
Large weight set, total 10 kg
Spring scale, 5-lb (20 N) or 25-lb (100-N) capacity
Come-along winch
Meterstick/yardstick
Protractor

Lab 7M2

Screw and disk assembly
Steel rule
Single-sheave pulley
Meterstick/yardstick
Spring scale, 8-oz (2.5 N) or 16-oz (5-N) capacity
Small weight set, total 1 kg
Small weight hanger, 50-g type
Cord, minimum 30-lb test

Lab 7M3

Spur-gear train assembly (assembled or unassembled)
Worm-and-wheel gear train
Small weight set, total 1 kg
Small weight hanger, 50-g type

Support stand, rods, and clamps
Meterstick/yardstick
Monofilament line

Lab 7M4

Stepped belt-drive assembly, with cogged motor pulley, equipped with safety enclosure
DC power supply, 20 V, 10 A
DC permanent-magnet motor, nominally 0-12 V
Cogged-pulley attachment for DC motor
Stroboscope
C-clamp, two
Vernier caliper
Ruler (12 in., with centimeter scale)

Lab 7F1

Hydraulic jack assembly, ½- to 1 ½-ton capacity, with pressure gage (1000-lb/in² capacity)
Spring scale, 5-lb (20 N) or 25-lb (100-N) capacity
Vernier caliper
Ruler (12 in., with centimeter scale)

Lab 7F2

Compressed air supply (for example, air tank, with pressure gage and shutoff valve, about 6-gallon capacity, charged to 100 psi)
Pressure regulator, 0 to 30 psi
Pressure gage, two, compound type, 15 mm Hg vacuum to 30 psi pressure, with connecting tee
Air cylinders with coupling slug:
First cylinder: 1 ⅛-in. diameter × 6-8-in. stroke
Second cylinder: ¾-in. diameter × 6-in. stroke
Support stand, rods, and clamps
Bleeder valve, two, with tees
Plastic tubing, approximately ¼" ID

Lab 7E1/ 7E2

Transformer assembly (vendor supplied)
Variable AC power source, 0-25 V AC
Digital multimeter (DMM), with probes, 10 A, 0.1 mV
Solderless breadboard
Hookup wire, minimum 22 AWG
Load resistors, two: 10 Ω and 100 Ω, 2 to 5 watts

III. *Principles of Technology* Demonstration Equipment (Listed by demonstration)

Most of the items below are part of the student lab equipment package. Only items with an asterisk need to be purchased or obtained to perform the demonstrations as detailed in the Teacher's Guide for each unit of *PT*.

Units 1 through 7

Demo 1DM

Spring scale, two, 5-lb (20 N) capacity
Meterstick/yardstick
* Vacuum-suction cups, two, with hooks
Cord, minimum 30-lb test
* Metal container, 1 gallon capacity, with handle (e.g. paint can)
* Socket fixture assembly
C-clamp, two
* Torque wrench
* Hose clamp, two, with hook (to attach to torque wrench handle)
Masking tape

Demo 1DF

* Flow indicator, to fit inline with plastic tubing
5-gallon plastic container
Large fluid reservoir with porthole on side, near bottom
Plastic tubing, approximately ¼" ID
Connectors for plastic tubing
Tubing clamp
* Heavy-duty lab jack
Stopwatch
Beaker, two, 1000-ml capacity, Pyrex

Demo 1DE

* 1 ½-V dry-cell lantern-type battery, two
  Multimeter (Volt-Ohm-Milliampere or VOM), two, with probes, 10 A
* Hookup wire, minimum 22 AWG, with alligator clips, three rolls with different insulation colors: red, black, and yellow
  Single-pole, single-throw (SPST) knife switch
  Resistor, between 20 and 60 Ω, ½ W, ±5% tolerance

Demo 1DT

* Thermal bar assembly, including
  Copper bar with 5 drilled holes,
  16-penny nail, five
  Paraffin wax
  Insulation shield
  Hot plate
* Thermal crayon
  Heavy-duty lab-jack

Demo 2DM

* Basketball
  Spring scale, 5-lb (20 N) capacity
  Solid wooden block, 4" × 4" × 2", with same texture on all faces, with eye hook or other attachment point on one 4" × 2" face
  Meterstick/yardstick
  Cord, minimum 30-lb test

Demo 2DF

5-gallon plastic container, two
DC-powered water pump, vane-type, self-priming, with connecting hoses
DC power supply, 20 V, 10 A
Meterstick/yardstick

Demo 2DE

Multimeter (Volt-Ohm-Milliampere or VOM), two, with probes, 10 A
Hookup wire, minimum 22 AWG
DC power supply, 20 V, 10 A
DC permanent-magnet motor, nominally 0-12 V
Drum attachment for DC motor, approximately 1-in. OD
C-clamp, two
Support stand, rods, and clamps
Pulley, single-sheave
Cord, minimum 30-lb test
Large weight hanger, 1-kg type
Large weight set, total 10 kg
Stopwatch

Demo 3DM

* Toy car, with windup or electric power
Stroboscope
Stopwatch
Meterstick/yardstick
DC power supply, 20 V, 10 A
DC permanent-magnet motor, nominally 0-12 V
* Disk attachment for DC motor, approximately 6-in. OD
Masking tape
C-clamp

Demo 3DF

5-gallon plastic container
Large fluid reservoir with porthole on side, near bottom
Plastic tubing, approximately ¼" ID
Tubing clamp
Stopwatch
Beaker, two, 1000-ml capacity, Pyrex
Triple-beam balance

Demo 3DE

Multimeter (Volt-Ohm-Milliampere or VOM) with probes, 10 A
Hookup wire, minimum 22 AWG, with alligator clips, three rolls with different insulation colors: red, black, and yellow
Single-pole, single-throw (SPST) knife switch
Oscilloscope, with probe
Function generator
6-V dry-cell battery, two
* Lamp, two, 12 V
* Miniature screw base for lamp

Demo 3DT

* Thermal bar assembly, including
  - Steel bar with 5 drilled holes
  - Copper bar with 5 drilled holes, two
  - 16-penny nail, eight
  - Paraffin wax
  - Insulation shield, four

Hot plate
* Thermal crayon
* Heavy-duty lab-jack, two

Stopwatch, two

Demo 4DM

Steel plate, 6" x 18" x ¼", flat
Spring scale, 25-lb (100-N) capacity
* Lead ingot, two, 1-lb, smooth-surfaced, with attachment point such as hook

Soap, liquid dish-washing type (or light motor oil)
Rags or paper towels to clean up soap

Demo 4DF

* Flow shroud assembly, including
  - Manometer connections,
  - Automotive air filter (sealed to assembly)
* Mylar strips (e.g., old cassette tape)

- * Vacuum cleaner
- Slant-tube water manometer
- * Confetti

Demo 4DE

- * Resistance demonstration assembly, including
  - Nichrome wire, 40 AWG, 1 m long
  - Copper wire, 40 AWG, 1 m long
  - Copper wire, 40 AWG, 4 m long
  - Copper wire, 34 AWG, 1 m long
- Digital multimeter (DMM), two, with probes, 10 A, 0.1 mV
- DC power supply, 20 V, 10 A
- Hookup wire, minimum 22 AWG

Demo 4DT

- * Thermal chimney assembly, including
  - Insulation strips, two types
  - Reversible temperature-indicator strip
  - Copper pipe
  - Aluminum foil
  - Double-back tape
- * Thermal crayon
- Support stand, rods, and clamps
- * Bunsen burner (or Fisher burner, or propane torch)

Demo 5DM

- * Pile-driving assembly, including
  - Acrylic tube
  - Styrofoam board
  - Roofing nails, 1 in. long
- Small weight hanger, 50-g type
- Small weight set, total 1 kg
- Monofilament line
- Masking tape
- Ruler (12 in., with centimeter scale)

Demo 5DF

Compressed air supply (for example, air tank, with pressure gage and shutoff valve, about 6-gallon capacity, charged to 100 psi)
Pressure regulator, 0 to 30 psi
Air motor
DC permanent-magnet motor, nominally 0-12 V
Coupling device for motor shafts (e.g., plastic tubing)
Lamp, 6 V, type 40
Miniature screw base for lamp
Plastic tubing, approximately ¼" ID
Support stand, rods, and clamps

Demo 5DE

* Strip-chart recorder, with optional voltage divider
6-V dry-cell battery
DC power supply, 20 V, 10 A
Variable resistor, 20 Ω
Single-pole, single-throw (SPST) knife switch
Resistor, six, ½ W, ±5% tolerance, assorted resistances to represent at least 6 of the 10 possible multiplier-bands
* Capacitor, non-electrolytic, 5 to 10 μF

Demo 5DT

* Fluid-flow pipe assembly, including
  PVC/iron pipe and fittings
  Thermocouple plug with Type-E thermocouple wire
* Strip-chart recorder
DC power supply, 20 V, 10 A
DC-powered water pump, vane-type, self-priming, with connecting hoses
5-gallon plastic container
Styrofoam cup, 16-24 oz capacity

Demo 6DM

Heavy-duty support stand
Large weight hanger, 1-kg type
Large weight set, total 10 kg

Pulley, metal single-sheave
Meterstick/yardstick
Masking tape
Stopwatch
Cord, minimum 30-lb test
* Dowel, 1-in. diameter × 6-in. long

Demo 6DF

Compressed air supply (for example, air tank, with pressure gage and shutoff valve, about 6-gallon capacity, charged to 100 psi)
Pressure regulator, 0 to 30 psi
Pressure gage, compound type, 15 mm Hg vacuum to 30 psi pressure
Air motor
Rotameter, 50 to 450 SCFM
Heavy-duty support stand
Small weight hanger, 50-g type
Small weight set, total 1 kg
Masking tape
Stopwatch
Cord, minimum 30-lb test
Pulley, metal single-sheave
Plastic tubing, approximately ¼" ID
Tubing clamp

Demo 6DE

DC power supply, 20 V, 10 A
Lamp, 6 V, type 40
Miniature screw base for lamp
Single-pole, single-throw (SPST) knife switch
Digital multimeter (DMM), two, with probes, 10 A, 0.1 mV
* Variable resistor, 10 kΩ
* Kilowatt-hour meter transparency
Hookup wire, minimum 22 AWG

Demo 7DML

* Assortment of levers (or transparencies depicting them), such as
  - Claw hammer
  - Nutcracker
  - Hydraulic jack
  - Paper cutter
  - Tongs
  - Wheelbarrow
  - Windshield wiper system
  - Wood screw
  - Wooden plank

Demo 7DMR

DC power supply, 20 V, 10 A
DC permanent-magnet motor, nominally 0-12 V
Stroboscope
Pulley, multiple-step
Support stand, rods, and clamps
Rubber sleeve attachment for DC motor

Demo 7DF

Hydraulic jack

Demo 7DE

AC power source, variable 0-25 V AC
* Transformer, 25 V AC step-down type

Digital multimeter (DMM), four, with probes, 10 A, 0.1 mV
* Power resistor, 50 Ω, 30 W, or
  - Light bulb, 40 W
  - Screw-in base for light bulb

143

VI. *Principles of Technology* Cost Comparison Worksheet

ITEM NO.	QUANTITY	VENDOR ________ CAT. NO.	UNIT PRICE	TOTAL PRICE	VENDOR ________ CAT. NO.	UNIT PRICE	TOTAL PRICE	NOTES OR COMMENTS

EQUIPMENT SOURCES

The following list if equipment suppliers and vendors is offered as assistance to you in modification, upgrading, or supplementing a Principles of Technology course. The primary vendors of PT equipment with respect to package deals head the list.

Vendor	*Contact Person*	
PRIMARY PT VENDORS		
Amatrol, Inc. P. O. Box 2697 Jeffersonville, IN 47131		812/288-8285
Brodhead-Garrett Co. 4560 E. 71st St. Cleveland, OH 44105	John Skulski	800/321-6730 303/722-2660
Energy Concepts, Inc. 3254 N. Kilbourn P. O. Box 14155 Chicago, IL 80214	Dick Gibbons Bruce Buehler	800/621-1247 800/437-9242
IES (Fab-Com) 3916 N. Harvard Oklahoma City, OK 73122	Jim Wilson, Jr.	800/678-7768 405/495-7252
Lab Volt Rep'd by Lab Technologies 64 Cedar St. Longmont, CO 80501	Gary Nelson Barron Farquhar	800/825-1111 303/449-2171 303/772-3527
New Science Technology, Inc. P. O. Box 431849 Houston, TX 77243		800/288-1150 713/468-1150
Sargent Welch Scientific Co. 7300 N. Linder Avenue P. O. Box 1026 Skokie, IL 60077		800/727-4368 312/676-0172
Technical Lab Systems, Inc. P. O. Box 218609 Houston, TX 77218		800/445-1088
TII Robotic Systems Div. of Modular Robotics, Inc. 428 S. Vermont St. Palatine, IL 60067	Jamie C. Smith	708/991-2636 800/451-2169

PRINCIPLES OF TECHNOLOGY **TEACHER TRAINING WORKSHOP**

W.W. GRAINGER, INC.
6901 Imperial Dr.
Waco, TX 76712
817/751-1415

Industrial Supply Wholesale

ROSS EQUIPMENT
7108 S. Alton Way, Bldg. A2
Englewood, CO 80112

Pneumatic/Hydraulic Equipment and Supplies

DWYER, INC.
P. O. Box 373
Michigan City, MN 46360
219/872-9141

Flow Measurements & Instrumentation

OMEGA ENGINEERING, INC.
One Omega Dr.
P. O. Box 4047
Stamford, CT 06907-0047
800/622-2378

Instrumentation for Flow, Strain, Temperature, Ph, and Computer Interfacing

PCB PIEZOTRONICS, INC.
3425 Walden Ave.
Depew, NY 14043-2495

Vibration Transducers

TRANS-TEK, INC.
P. O. Box 338
Ellington, CN 06029
203/872-8351

Linear-Variable-Differential-Transducers

COLE-PARMER INST. CO.
7425 N. Oak Park Ave.
Chicago, IL 60648
800/323-4340

Laboratory Instrumentation

U.S. PLASTICS CO.
1390 Neubrecht Rd.
Lima, OH 45801
800/537-9724

Plastic Items and Stock

STOCK DRIVE PRODUCTS
55 S. Denton Ave.
New Hyde Park, NY 11040
516/328-0200

Mechanical Components and Systems on a Miniature Scale

FISHER-TECHNIK, LEGO, CAPSULA
Rep'd by LAB TECHNOLOGIES
See LAB VOLTS above

Miniature Fluid, Mechanical, and Electro-Mechanical Systems

HOOVER BROTHERS
2050 Postal Way
P. O. Box 660429
Dallas, TX 75266-0420

Lab Furniture and Storage Systems

C & H SALES CO.
2176 E. Colorado Blvd.
P. O. Box 5356
Pasadena, CA 91117-9988
800/325-9465

Surplus Equipment, Transducers, Motors, Tools, Optics, Etc.

EDMUND SCIENTIFIC CO.
101 E. Gloucester Pike
Barrington, NJ 08007
609/547-3488

Surplus Equipment, Electronic and Optical

H & R CORP. (Herbach & Rademan)
401 E. Erie Ave.
Philadelphia, PA 19134-1187
215/426-1708

Surplus Electronic Equipment and Components

UNILAB, INC.
9102-I Industry Drive
P. O. Box 837
Manassas Park, VA 22111
703/330-1997

Electro-Mechanical Tech-Ed Curriculum and Equipment Packages for Science, Tech. and Elec.

ELECTRONIC COMPONENTS AND KITS

ALL ELECTRONICS CORP.
905 S. Vermont Ave.
P. O. Box 20406
Los Angeles, CA 90006

800/826-5432

CHANEY ELECTRONICS, INC.
P. O. Box 4116
Scottsdale, AZ 85271-3047

800/227-7312

CIRCUIT SPECIALISTS
P. O. Box 3047
Scottsdale, AZ 85271-3047

800/528-1417

DIGI-KEY CORPORATION
P. O. Box 677
Thief River Falls, MN 56701

800/344-4539

EDLIE ELECTRONICS
2700 Hempstead Turnpike
Levitown, NY 11756-1443

800/645-4722

PRINCIPLES OF TECHNOLOGY **TEACHER TRAINING WORKSHOP**

GRAYMARK, INC. P. O. Box 5020 Santa Ana, CA 92704	800/854-7393
KELVIN ELECTRONICS 7 Fairchild Ave. Plainview, NY 11803	800/645-9212
MOUSER ELECTRONICS P. O. Box 699 Mansfield, TX 76065	800/346-6873
NEWARK ELECTRONICS Arvada, CO (There are many locations across the U.S.)	303/423-7941
OMNITRON ELECTRONICS 770 Amsterdam Ave. New York, NY 10025	800/23-0826

TRANSDUCERS AND SENSORS

OMRON ELECTRONICS 1 E. Commerce Dr. Schaumburg, IL 60173	
The Hargis Co., Inc. 1205 Washington Ave. Waco, TX 76703	817/754-5667
THERMO-ELECTRIC CORP. Saddlebrook, NJ 07662	201/843-5800

MISCELLANEOUS RECOMMENDED RESOURCES

EQUIPMENT

Pump, Diaphragm (like ECI's)	Flojet Corporation
Pneumatic Equipment	Clipparad Instrument Lab, Inc. 7378 Colerain Road Cincinnati, OH 45239 513/521-4261
Flow Rate Sensor	Data Industrial Corp. 53 Portside Dr. Pocasset, MA 02559

155

Quick-Connect/Disconnect Fittings for Pneumaica (Ask for Cat 3528)	Parker Hannifin Corp. Brass Product Division 300 Parker Drive Otsego, MI 49087

FILMS and VIDEO TAPES

Los Alamos National Laboratory Motion Picture/Video Production Mail Stop D415 Los Alamos, NM 87545	Write for a catalog, a source of great no cost rental of sci/tech films.
Johnson Space Center Public Relations Houston, TX	Write for a catalog of great NASA films.

SOFTWARE

Electronic Workbench	(See Tech Lab Systems)
Pneumatic/Hydraulic Simulation	(See Tech Lab Systems)
Verniers Software - Timers, Graphing, Temperature Probes	Hearlihy and Company 714 Columbia Street Springfield, OH 45501
Modern School Supplies 1-800-243-2329	P.O. Box 958 Hartford, CT 06143
Shopware Educational Systems 1-800-487-3392	101 Hill Rd., Dept KL-4 Aberdeen, WA 98520-7302
Skills Bank Corp. 1-800-222-3681	15 Governor's Court Baltimore, MD 21207-2791
Vernier Software 1-503-297-5317	2920 SW 89th St. Portalnd, OR 97225

GENERAL PURPOSE-LOCAL SOURCES

ACE HARDWARE	Check Local Phone Book
GENERAL TRACTOR	"
K-MART	"
RADIO SHACK	"
SEARS-ROEBUCK	"
TRUE-VALUE HARDWARE	"
WESTERN AUTO	"

DONATIONS

PA utilty companies (PPL, PECO,etc.) can be contacted to request surplus equipment items.

SPECIFICATION WRITING

Local school district procedures must be followed in all purchases of supplies and equipment. Although these procedures will vary from district to district, two general categories usually exist. The category for small expenditures and/or supplies that are routinely used is fairly easy to deal with through: (1) direct purchase by the teacher from a designated district vendor, (2) a requisition and purchase order procedure or (3) a request from the districts warehouse or supplies "store".

The purchase of major equipment or other capital outlay in excess of a certain dollar amount requires considerably greater planning and attention to detailed procedures. The amounts of money involved are usually quite large, and the purchase results in a permanent addition to the school program; so mistakes must be avoided.

Purchasing procedures for capital outlay are usually clear and rigid, and they generally follow this order: (1) approval for the purchase must be obtained from the school principal or other authorized person, (2) the teacher writes a detained description (specifications) of the item needed, (3) the specifications are submitted for bids by vendors (usually three bids are required), (4) the lowest bidder is awarded the purchase order, and (5) the teacher accepts delivery of the item, verifies that it is correct and in good condition, and signs the invoice or delivery ticket.

Central to the success of this process is the specifications written, and the homework done by the specification writer. What you request or list in a specification will dictate what a vendor will bid on and ultimately determine what is eventually purchased for your Principles of Technology program.

The specifications should provide a complete set of details and the conditions of sale for each item to be purchased. Without this information the vendor will not be able to understand, with any precision, what your equipment needs are nor will you be assured of getting the quality of the item required. Further, without a well written specification, there will be no basis for determining whether the supplier has fulfilled your request adequately.

The descriptions of equipment items in specifications will, of course, vary tremendously but should include information about the quantity, size, capabilities, power requirements, accessories, delivery, installation, warranties and service contracts as appropriate. As a general rule it is always better to include more information than is necessary rather than to leave out an important specification that could adversely affect or delay your order. You should also state where the shipment is to be delivered, and how the order will be paid.

The mere stating of the generic name of a piece of equipment is not adequate; it does not communicate any detailed information. Consider the difference between listing the generic name of an item and the more detailed specifications in the following example.

1. MULTIMETER

2. MULTIMETER, Analog, Hand held
   Shock-resistant rubberized cover.
   DC voltage: 7 ranges, 0.1-100 V;
   AC voltage: 5 ranges, 10-750 V;
   DC current: 7 ranges, 50 µA-10A;
   AC current: 5 ranges, 1mA-10A;
   Resistance: 3 ranges, 1Ω-1MΩ;
   Accuracy: ±2.5% full scale.
   Accessories to include: two set of test leads; one set with pin ends and one set with clip ends and one 9v alkaline battery.

3. MULTIMETER, Digital, Hand held.
   Shock-resistant rubberized cover.
   3 1/2 digit LCD display.
   Measure capacitance and transistor HFE.
   Range: voltage (to) 1000 VDC, 750 VAC;
   Range: current (to) 10 A (AC and DC);
   Resistance, 200Ω to 20ΩM.
   Audible continuity check, diode test, high energy fuse.
   Accessories to include: one extra fuse, two sets of test leads; one set with pin ends and one set with clip ends and one 9v alkaline battery.

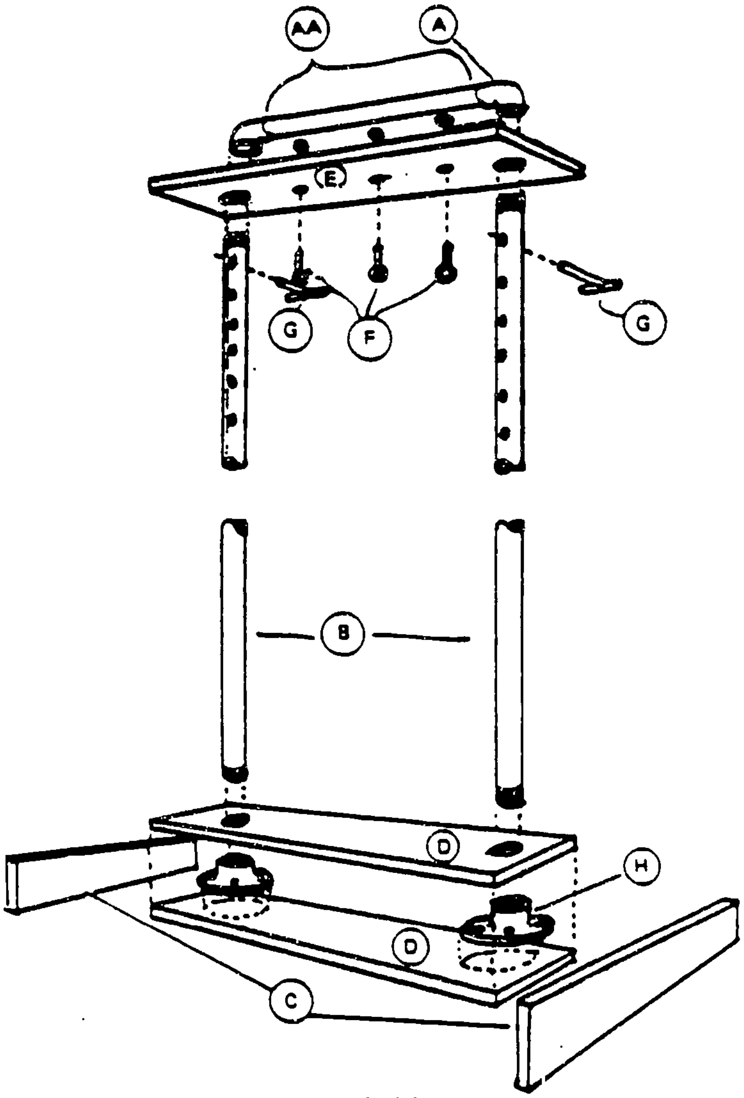
File B:Spec-Rit

Principles of Technology
DESIGN NOTES ON SPECIAL EQUIPMENT

Item Name: Heavy-Duty Support Stand Item No. 1

MATERIALS

1 - 5/8 dia pipe 29" in length with npt threads both ends (AA)
2 - 90 degree elbows for 5/8" diameter pipe (A)
2 - 6 ft long pipes (5/8" diameter) (B)
2 - 1/2" t x 3" w x 24" long boards (C)
2 - 5/8" t x 4" w x 36" long boards (D)
1 - 1" t x 4" w x 36" long board (item No. 1.1) (E)
3 - Eye bolts F
2 - Adjustment pins (G)
2 - mounting flange for 5/8 dia pipe (H)

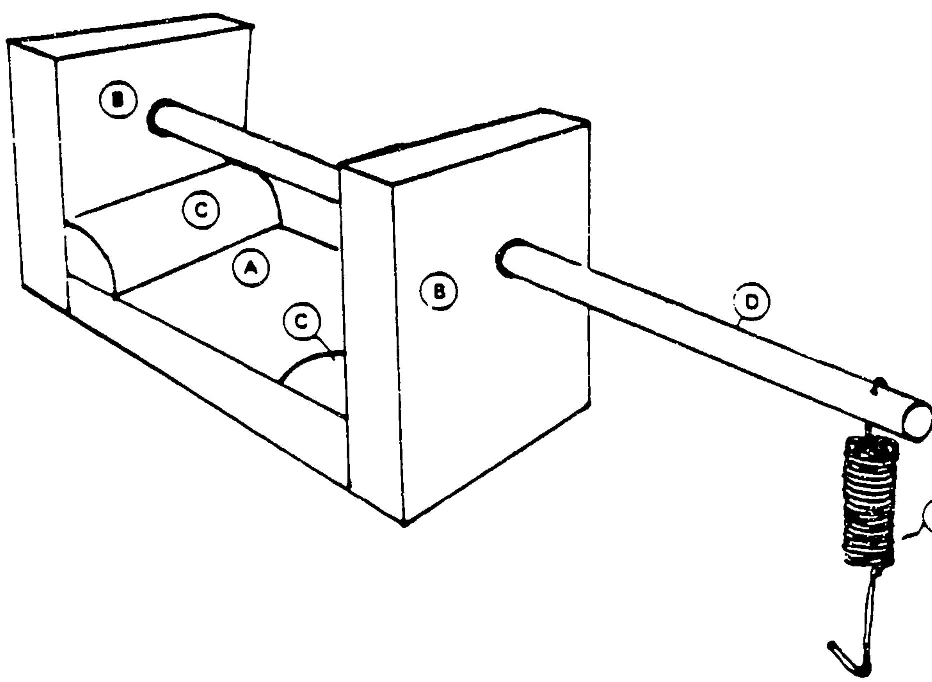


Principles of Technology
DESIGN NOTES ON SPECIAL EQUIPMENT

Item Name: Spring Holder Jig | Item No. 9

MATERIALS

1 - 3 3/4" w x 5/8" t x 5" long plywood board A
2 - 3 3/4" w x 5/8" t x 5 1/4" long plywood boards B
2 - 3 3/4" long x 5/8" radius quarter-round boards C
1 - Aluminum rod 1/2" diam x 12-14" long D
1 - Coiled spring (- automobile or truck clutch pedal return spring) E



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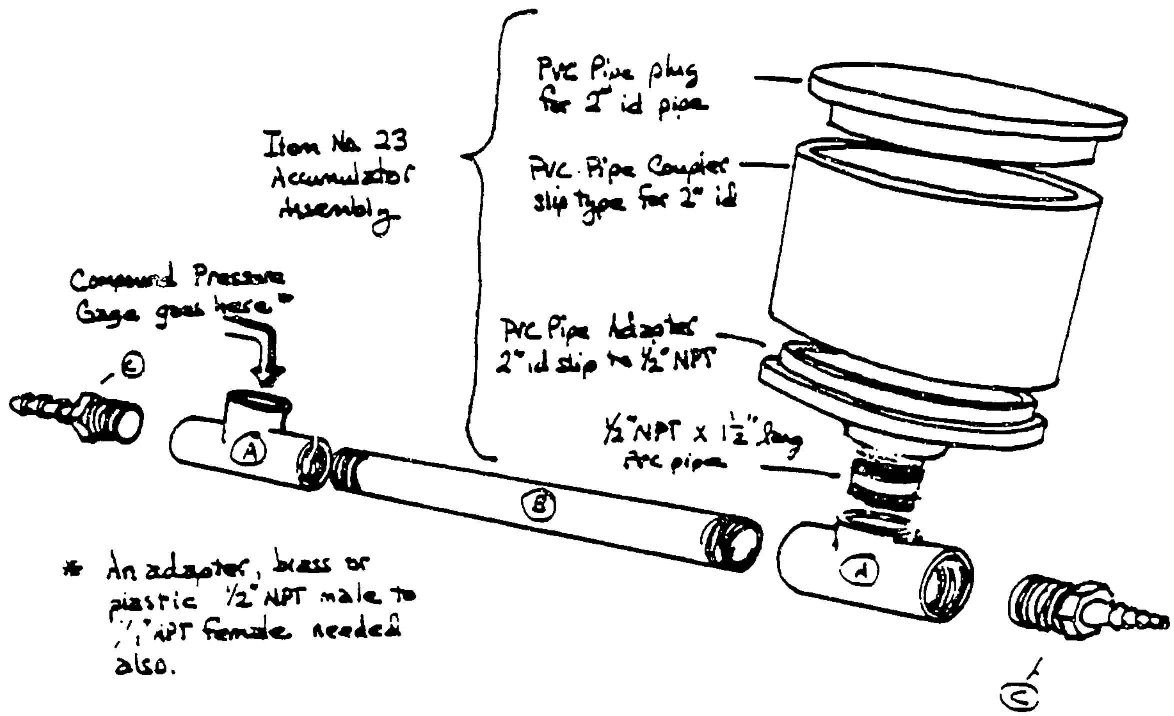
Principles of Technology
DESIGN NOTES ON SPECIAL EQUIPMENT

Item Name: Air Chamber Assembly   Item No. 20

MATERIALS

2 - PVC, 1/2" diam pipe tees with threaded ports (A)
1 - PVC, 1/2" diam pipe 3" long (B)
2 - Tubing barbs, 1/2" NPT to 1/4" tubing (C)
2 - Tubing/hose clamps (D)



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Principles of Technology
DESIGN NOTES ON SPECIAL EQUIPMENT

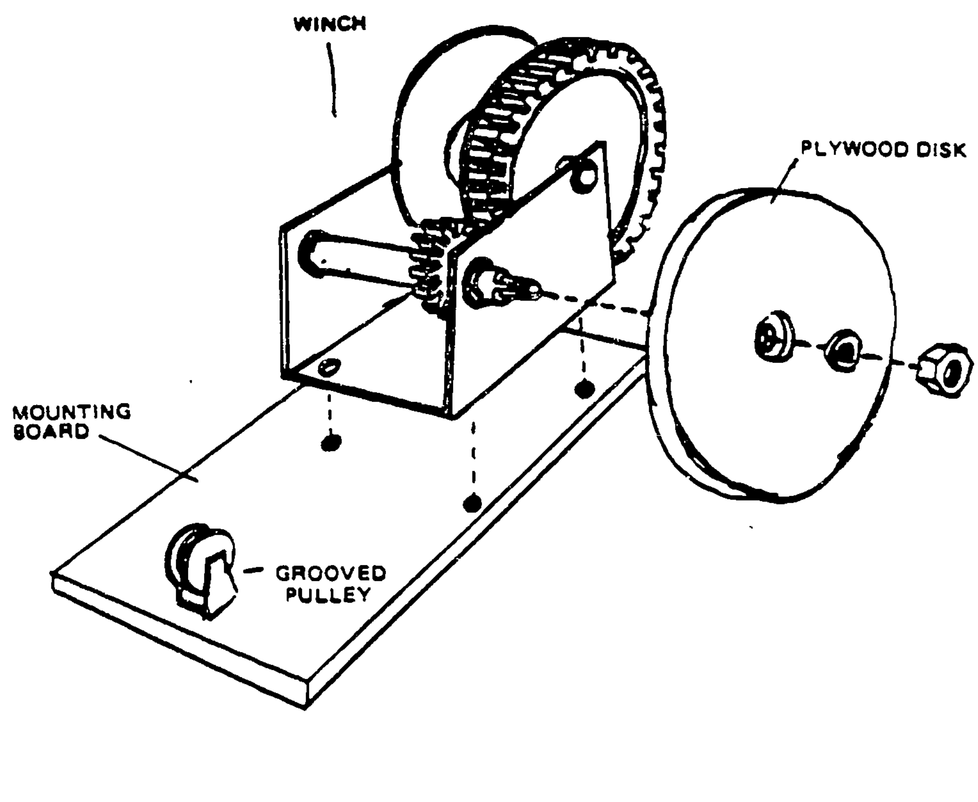
Item Name: Winch Assembly Item No. 43

MATERIALS

1 - Wood board, 10" w x (1/2" - 5/8") t x 14" long
1 - Winch, similar to W.W. Grainger, type 2Z601
3 - Wooden disk, 10" daimeter x 1/2" thick
1 - 1" diam grooved pulley

NOTE: It is important that the winch be able to free-wheel both in and out and that input handle can be removed easily. The handle will be removed to allow the attachment of the disk.

The plywood disk should be grooved to receive the mono-filament line.



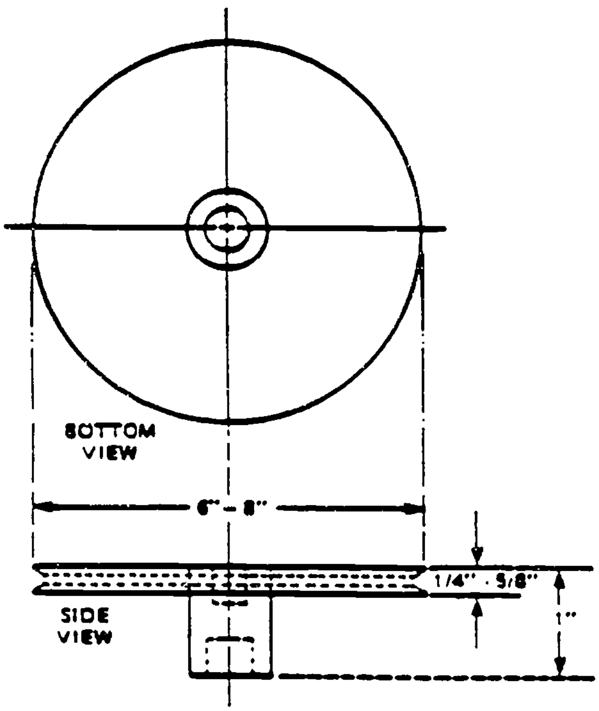
162

Principles of Technology
DESIGN NOTES ON SPECIAL EQUIPMENT

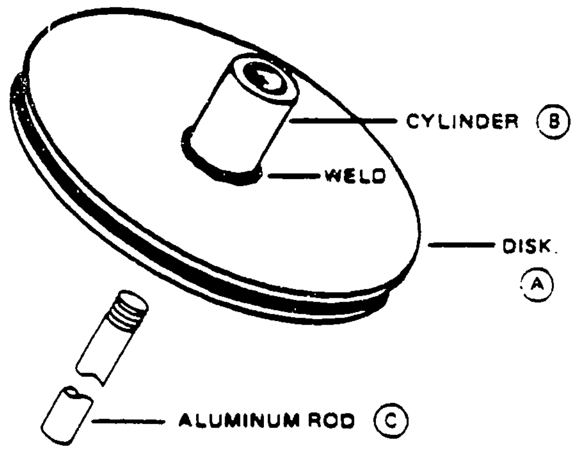
Item Name: Weight Stage Item No. 45

MATERIALS

1 - 6" to 8" diam aluminum disk, 1/4" to 5/8" thick (A)
1 - Aluminum cylinder, 1" diam x 1" long (B)
1 - Aluminum rod, 8" to 10" long x 3/16" diam, threaded at one end (C)



DRAWING NOT TO SCALE



Note: The aluminum rod is to help the slotted weights stay centered on the stage.

163

12/01/8

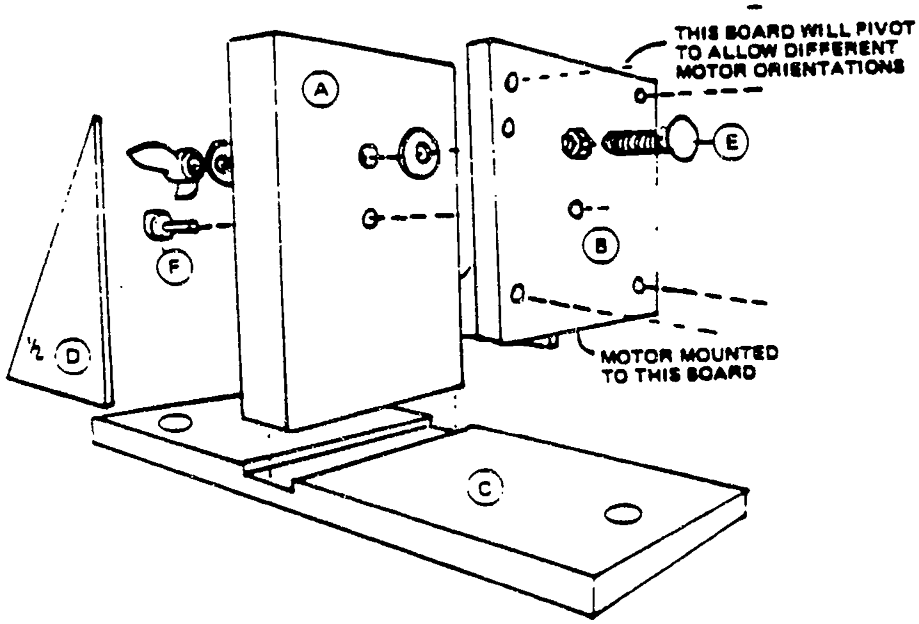
Principles of Technology
DESIGN NOTES ON SPECIAL EQUIPMENT

Item Name: Electric Motor Assembly Item No. 52

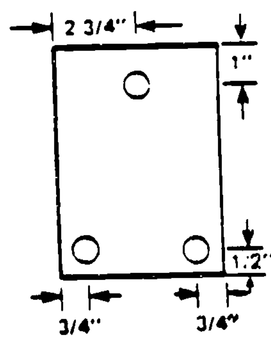
MATERIALS

1 - 5 1/2" w x 3/4" t x 6 3/4" long solid wood board (A)
1 - 4 1/4" w x 5/8" t x 4 1/2" long plywood board (B)
1 - 5 1/2" w x 3/4" t x 8" long solid wood board (C)
1 - 3 1/2" w x 3/16" t x 5" long wood board
(cut diagonally in half) (D)
1 - Permanent magnet DC - 1/16 hp (or less) electric motor
Motor should not exceed 8 amps at 12 V DC max
4 - Screw, washer, nut assemblies to fasted motor to board.
1 - 1/2" diam carriage bolt with washers and wing nut (E)
1 - index pin (F)

Additional materials to be available
1 - 2" o.d. drive pulley for motor shaft (to accept 1/8" diam round belts)
1 - 1" to 2" diam x 1" width drum for motor shaft
1 - 3/4" long piece of rubber tubing slightly smaller than shaft diam to act as a shaft coupler.



DRILL 3– 9/32" DIA HOLES THROUGH BASE AS SHOWN



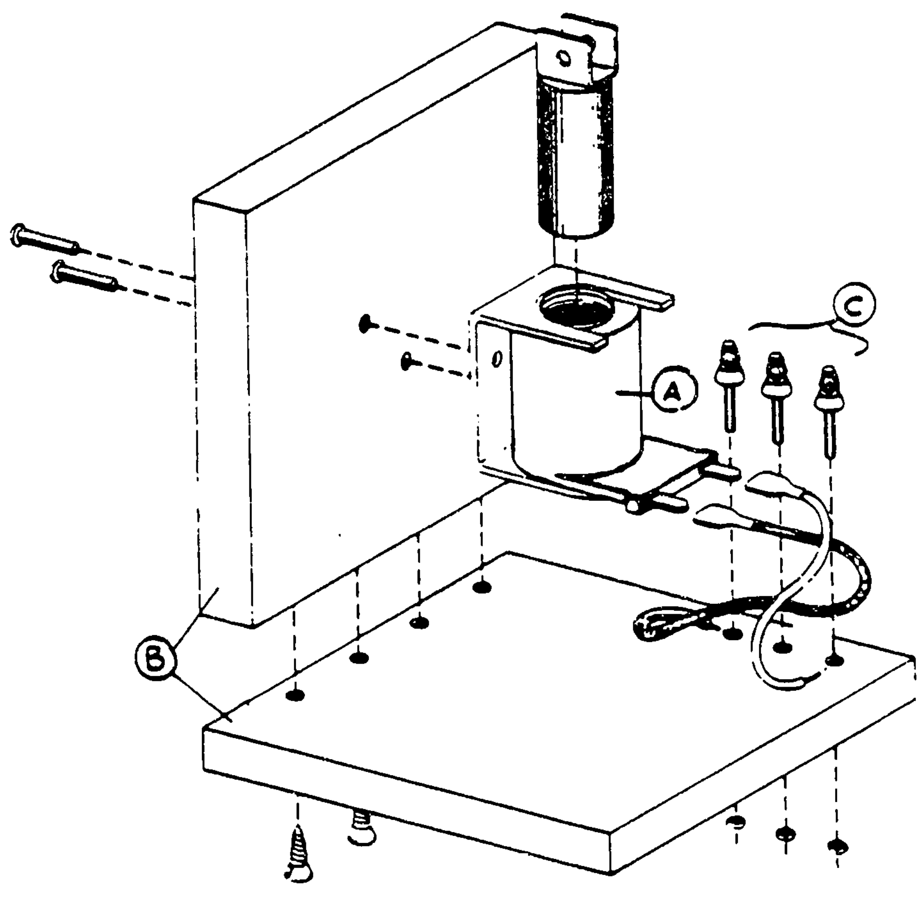
Principles of Technology
DESIGN NOTES ON SPECIAL EQUIPMENT

Item Name: Solenoid Assembly Item No. 54

MATERIALS

1 - 12 V DC solenoid with 3/4" pull (A)
4 - Wood screws
1 - Mounting frame of 2 - 6" x 4" x 5/8" thick plywood (B)
3 - 5-way binding posts (1 red and 2 black) (C)

Construction:
Cut 2 plywood rectangles and mount together with solenoid and binding posts as shown in figure below.

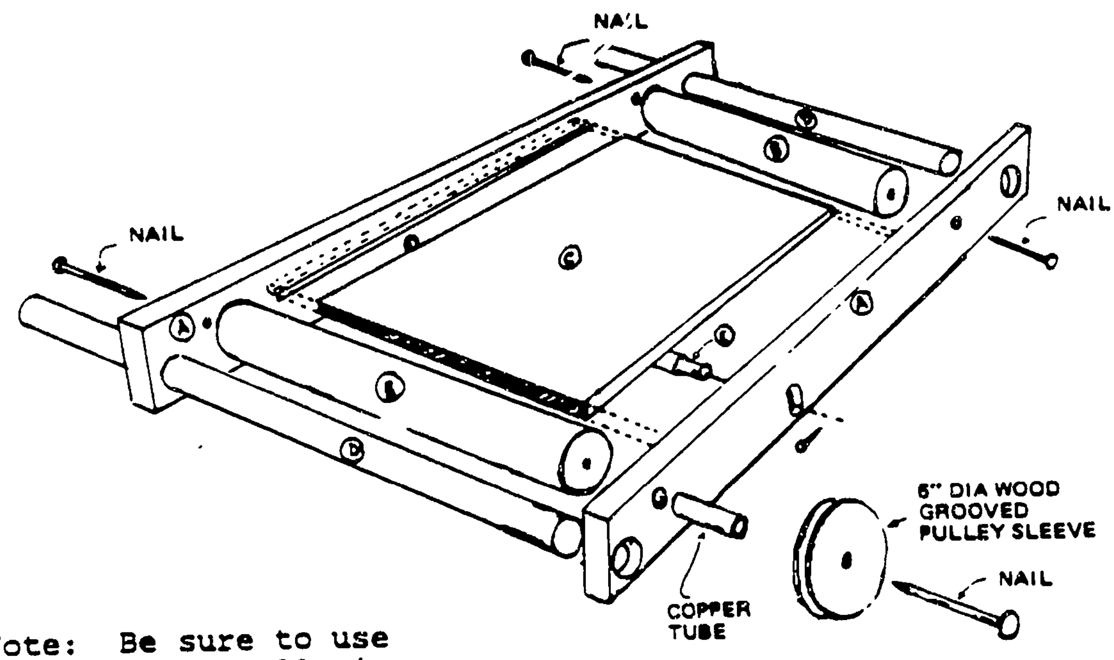


Principles of Technology
DESIGN NOTES ON SPECIAL EQUIPMENT

Item Name: Conveyor Assembly Item No. 55

MATERIALS

2 - Wood boards 2" w x 1/2" - 5/8" t x 18" long Ⓐ
2 - Wood dowels 1" diam x 2 1/2" long Ⓑ
1 - Wood board - top surface covered with aluminum foil Ⓒ
  1/4" t x 2 5/8" w x 10" long
2 - Wood dowels 3/4" diam x 6" long Ⓓ
1 - Wood dowel with plastic straw (2 1/2" long)
  1/8" diam x 4" long (Optional) Ⓔ
1 - 2" to 2 1/4" wide belt
  NOTE: This belt can be a sanding belt or a section cut out of an automobile tire innertube.
1 - Continuous round drive belt with 1/8" diam



Note: Be sure to use graphite liberally in each nail hole in boards marked "A".

Also, the copper pipe 3/4" long x 3/16" id. acts as spacer and bearing. It keeps the grooved pulley from dragging on the wood board.

166

Principles of Technology
DESIGN NOTES ON SPECIAL EQUIPMENT

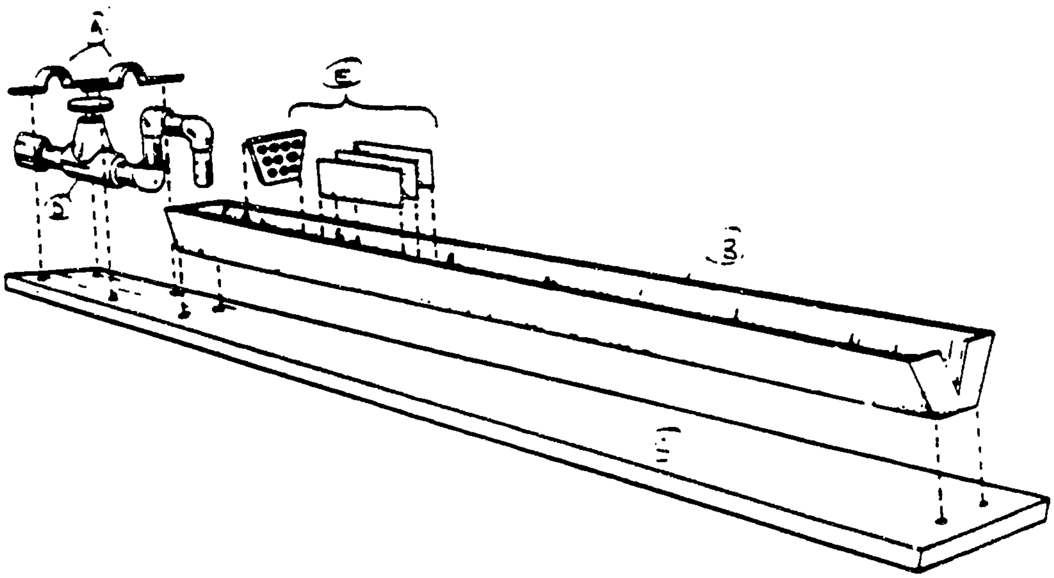
Item Name: Water Channel Assembly Item No. 58

MATERIALS

2 - Pipe clamps Ⓐ
1 - Vinyl plastic or rain gutter, 37" to 42" long x 4 1/2" wide x 2 3/4" high. Ⓑ
1 - Wood board, 46" long x 5" wide x 5/8" thick Ⓒ
3 - PVC 90 elbows
3 - PVC pipe sections
1 - PVC control valve Ⓓ
1 - Baffle and flow straighteners Ⓔ
1 - PVC pipe to hose coupling/connector (female hose connector --male pipe connector)

Assembly:

The flow straighteners should be no less than 4" long x 2" tall x 1/16" thick to no more than 10" long x 2" tall x 1/16" thick. These should be glued across the bottom of the gutter and attached to run exactly parallel to the length.

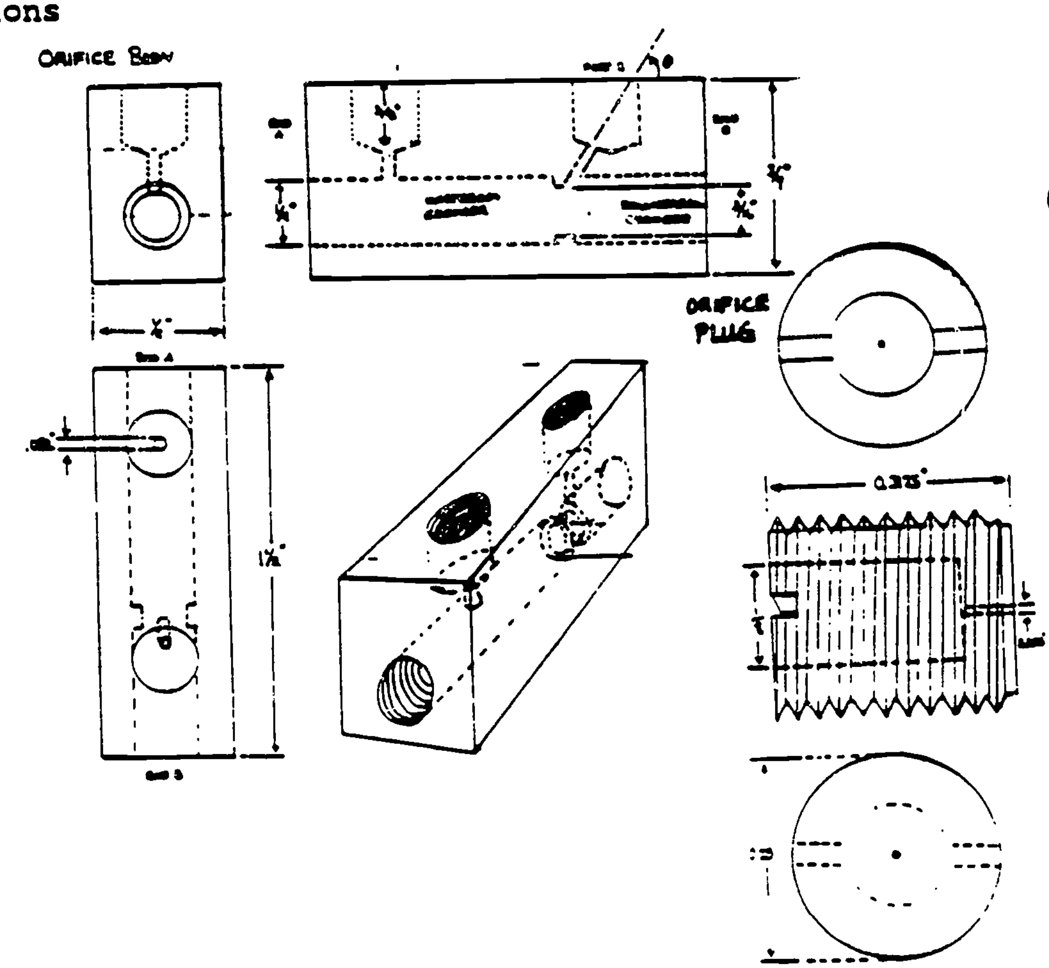


Principles of Technology
DESIGN NOTES ON SPECIAL EQUIPMENT

Item Name: Gas Orifice Assembly   Item No. 62

MATERIALS

1 - Orifice plug, preferably brass
4 - 1/4" NPT brass adaptors
1 - Orifice body, plexiglass or acrylic plastic
1 - Plexiglass tube 2" ID x 24" - 1/8" wall thickness recommended. Tube should be drilled and tapped within 2" of the bottom to receive a 1/4" NPT tubing barb.
1 - 3" square glued to top of tube--drilled and taped for 1/4" NPT
2 - 1/4" NPT tubing barb
1 - Plastic tray or pan 4" - 5" deep with 6" wide x 9" long dimensions



ADDITIONAL DATA AND INSTRUCTIONS ON BACK OF PAGE.

165

PREPARATION OF ORIFICE BODY

Need 1 rectangular plexiglass rod 1/2" w x 3/4" h x 1 1/2"

1. Drill a pilot hole 1/8" diam through the length (1.5")of the block. The hole is not to be centered. This hole should be located 1/4" from 3 sides of the face and 1/2" from the remaining side.
2. Counterbore with 3/16" diam completely through length.
3. Drill and tap for 1/4" - 28 SAE from one end (End A) to a depth of 9/10".
4. Drill and tap for 1/4" - NPT from other end (End B) to a depth of 2/5".
5. Drill 2 pilot holes on the top 1/2" x 1 1/2" face with a 1/8" diam bit to a depth of 3/8". Port 1 should be 0.375" from End A and centered on the 1/2" width. Port 2 should be 0.300" from End B and centered on the 1/2" width.
6. Drill and tap for 1/4" - NPT to a depth of 1/4" for each port.
7. Use a #45 drill (0.082" diam) to drill a hole on center of Port 1 to intersect upstream chamber.
8. Use a #45 drill to drill a 63 degree angle to intersect downstream chamber near orifice plug.

NOTE: Tubing barbs for 1/4" holes come with NPT thread, not with SAE thread. Three of your ports have NPT, one has SAE. Once the orifice plug is installed you may find it necessary to insert an adaptor that would have male 1/4" 28-SAE on one end and female 1/4" NPT on the other.

PREPARATION OF ORIFICE PLUG

Need brass rod 0.25" diam.

1. Run rod through die to thread for 28 turns per inch for a depth of 0.35".
2. Bore from end on center 1/8" diam x 0.25" deep.
3. Counterbore with #97 drill (0.005" diam) to a depth of 3/32".
4. Cut off rod to length of 0.3125".
5. Clean 0.005" diam hole.

12/01/86

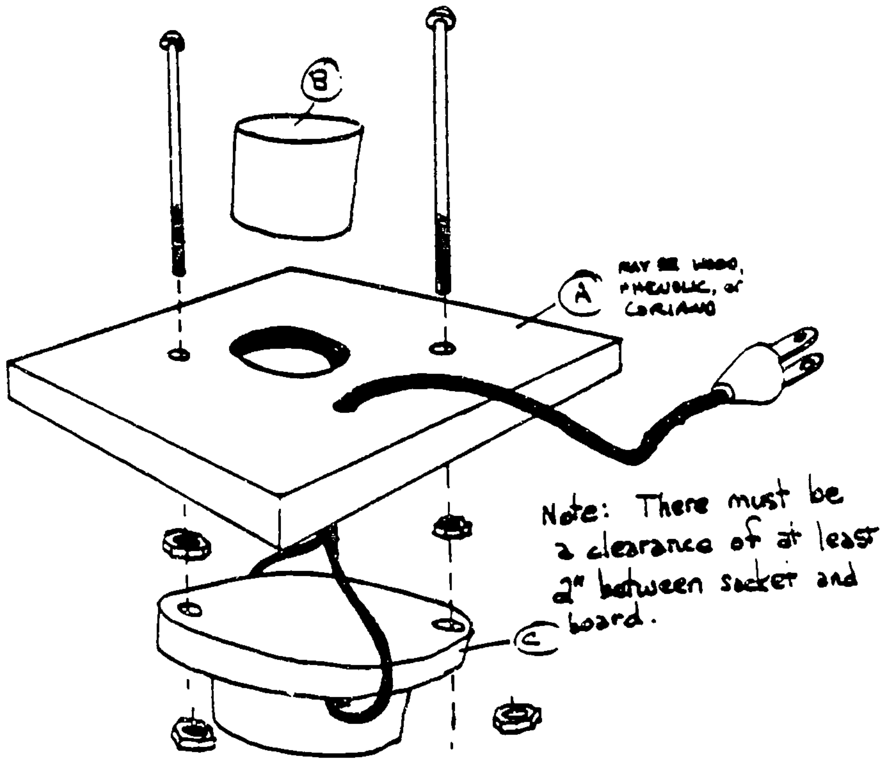
Principles of Technology
DESIGN NOTES ON SPECIAL EQUIPMENT

Item Name: Heat Transfer Assembly Set   Item No. 68

MATERIALS

For 68A (Used in Lab 3T1)

1 - 7 1/2" to 9" square x 1/2" - 5/8" thick plate (A)
1 - 1" to 1 1/2" diam x 1" long aluminum cylinder (B)
2 - 1" x 3/4" strip of metal tape (aluminum)
1 - Lamp socket subassembly (C)
1 - Standard base 100 W light bulb (D)
1 - AC patch cord wired to the lamp socket subassembly



NOTE:

For lab 3T1, you should run the lamp at full voltage, from the power supply, for no more than 4 minutes. After 4 minutes readjust the power supply AC output to approx. 20% of full setting. Note also that we now recommend the use of a 100 watt lamp instead of the 600 watt heater.

MAKE NOTE OF THESE RECOMMENDATIONS IN YOUR TEACHER GUIDE

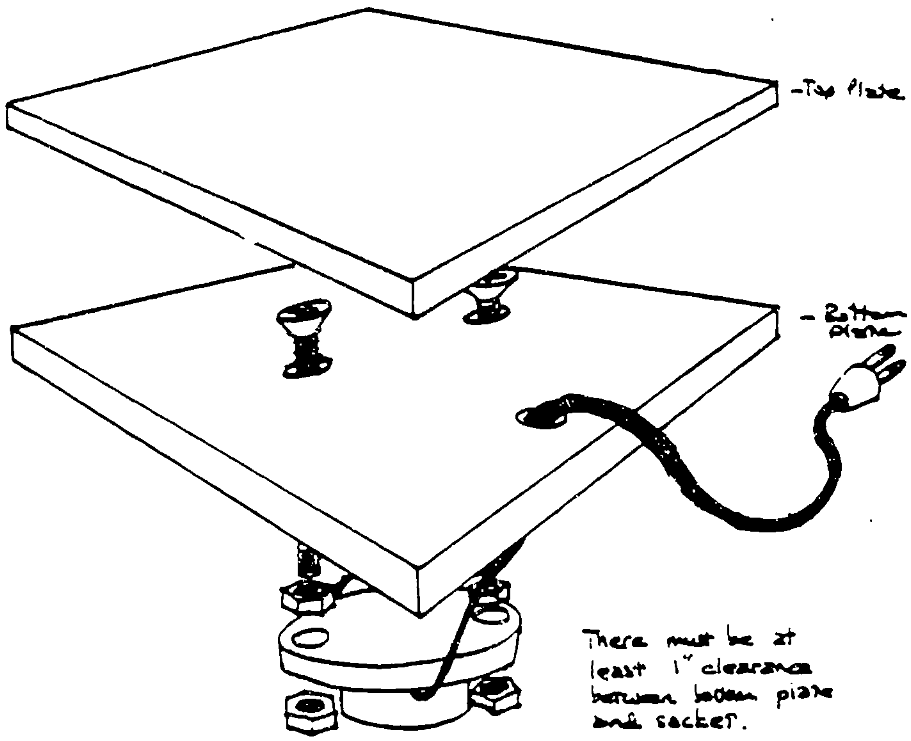
INFORMATION ON 68B ON BACK OF PAGE

MATERIALS

For item 68B (used in Lab 4T1)

2 - Aluminum plates, 3/16" thick x 8" wide x 8" long
  - items from 68A   C , D , and F
2 - bolts, 3 1/2" long x 10-32 thread

NOTE: The upper aluminum plate will be untouched except for the edges being deburred and rounded to remove any sharp edges. The bottom aluminum plate will be prepared as shown below.



NOTE:

Once more, for this lab (4T1) we recommend:

1. Replace the 660 watt resistance heater with a 100 watt light bulb.
2. Allow full voltage (110 V AC) to be applied for no more than 4 minutes.
3. After 4 minutes reduce the input voltage to 40% of full.

MAKE NOTE OF THESE RECOMMENDATIONS IN YOUR TEACHERS GUIDE.

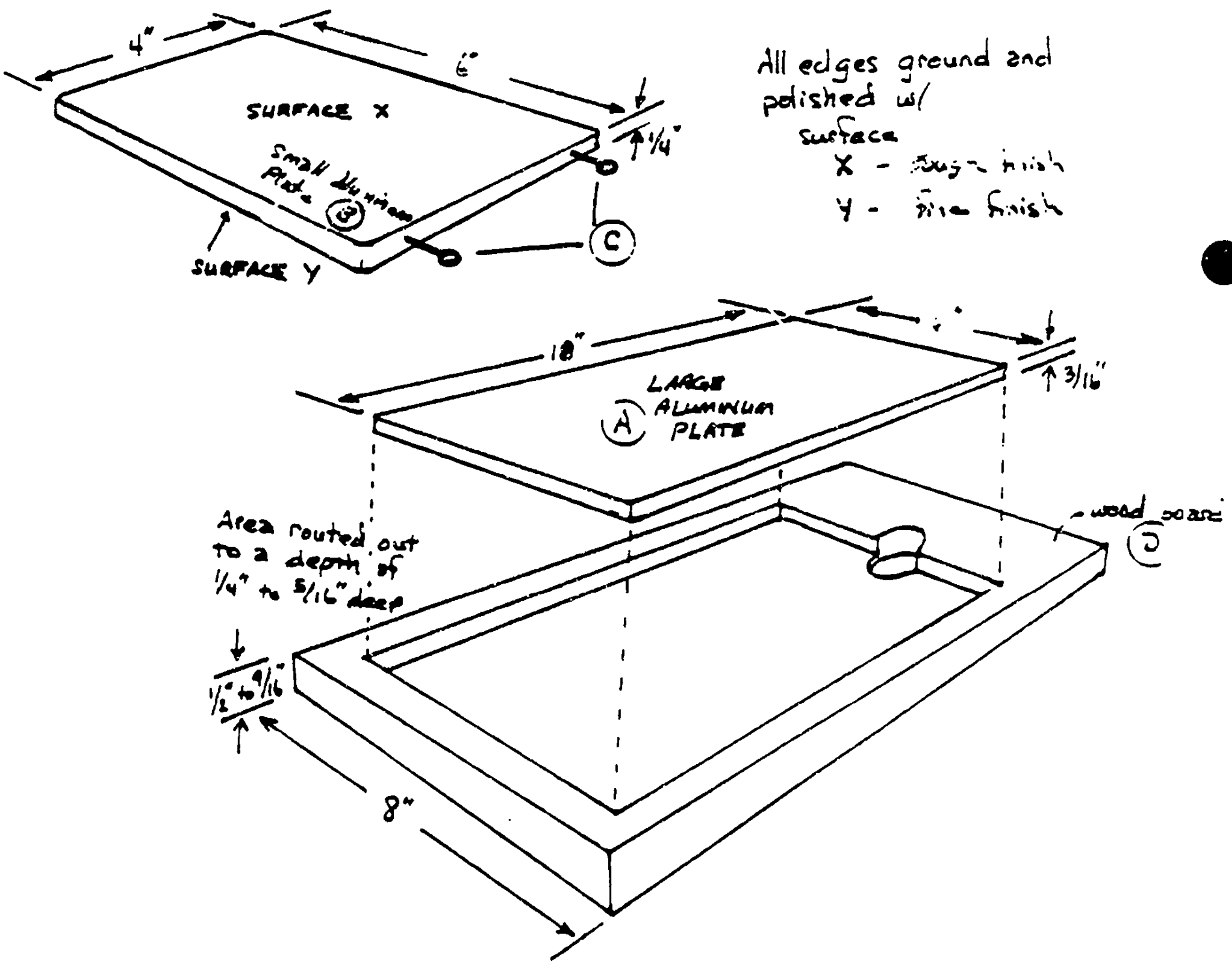
171

Principles of Technology
DESIGN NOTES ON SPECIAL EQUIPMENT

Item Name: Friction Plate Assembly Item No. 71 & 72

MATERIALS

1 - Lg. aluminum plate, 6" x 18" x 3/16", (A)
1 - Sm. aluminum plate, 4" x 6" x 1/4", (B)
2 - Minature eye screws (C)
1 - Wood board, 8" x 24" x 1/2" to 9/16" (D)



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Principles of Technology
DESIGN NOTES ON SPECIAL EQUIPMENT

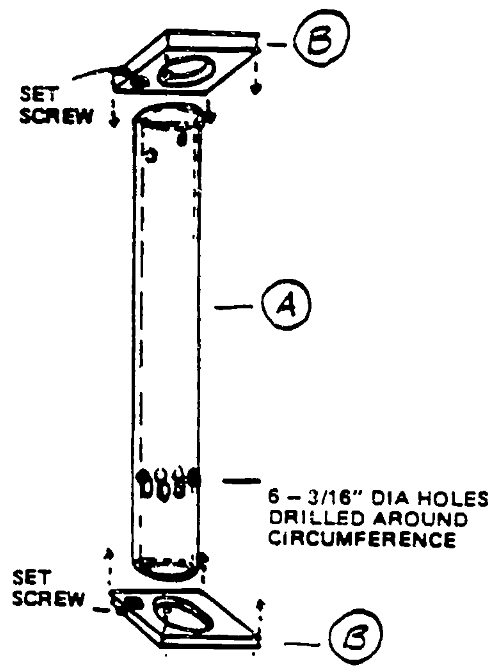
Item Name: Air Flow Assembly Item No. 73

MATERIALS

1 - 36" long x 2" id tube, plexiglas (A)
2 - 4" x 4" squares, plexiglas with 1-2" diam hole drilled on center in each,1/4" thick. (B)
3 - Flow objects (item no. 74)
These objects are to be made of wood or plastic, 3-shapes. Each shape w/ the same cross-sectional diam (d).
NOTE: The value (d) must be between 70% and 80% of the value of the cross-sectional diam of the unrestricted flow tube. Thus d = 1.4" to 1.6"

CONSTRUCTION

Glue squares at each end of the tube so that holes in squares coincide with that of the tube.
Squares should have a 3/8" diam hole drilled in one corner of each square and aligned to the same side. These holes should be drilled and tapped for set screws.



USE NOTE:

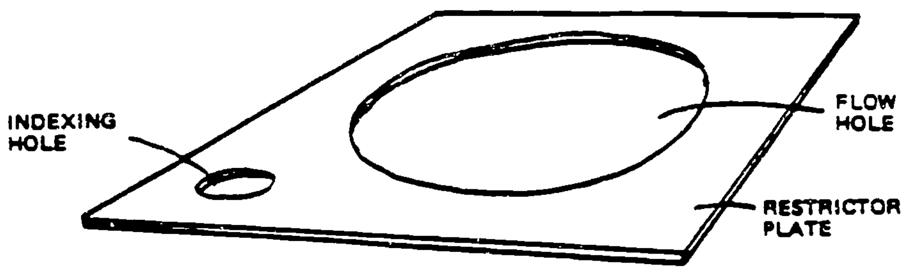
Use a spring balance (0-5 N range). Suspended it above air flow apparatus. The with a length of monofilament line connect the spring balance and drag objects.

Principles of Technology
DESIGN NOTES ON SPECIAL EQUIPMENT

Item Name: Flow Restrictor Set Item No. 79

MATERIALS

8 - 4" x 4" x 1/32" aluminum plates



CONSTRUCTION

Each of the 8 plates is identical except for the size of the flow hole. The diam of the flow hole in each plate is calculated to be a percent of the cross-sectional area of the unrestricted air flow device. The relationship of diam to the percent of cross-sectional area is shown by the following chart.

% of OPEN AREA	DIAMETER MULTIPLIER
100%	D
90	0.95 D
80	0.89 D
70	0.84 D
60	0.77 D
50	0.71 D
40	0.63 D
30	0.55 D
20	0.45 D

NOTE: The diam multiplier has been rounded off to only 2 places, thus the true percent of open area resulting is in error by 0.6% at worst.

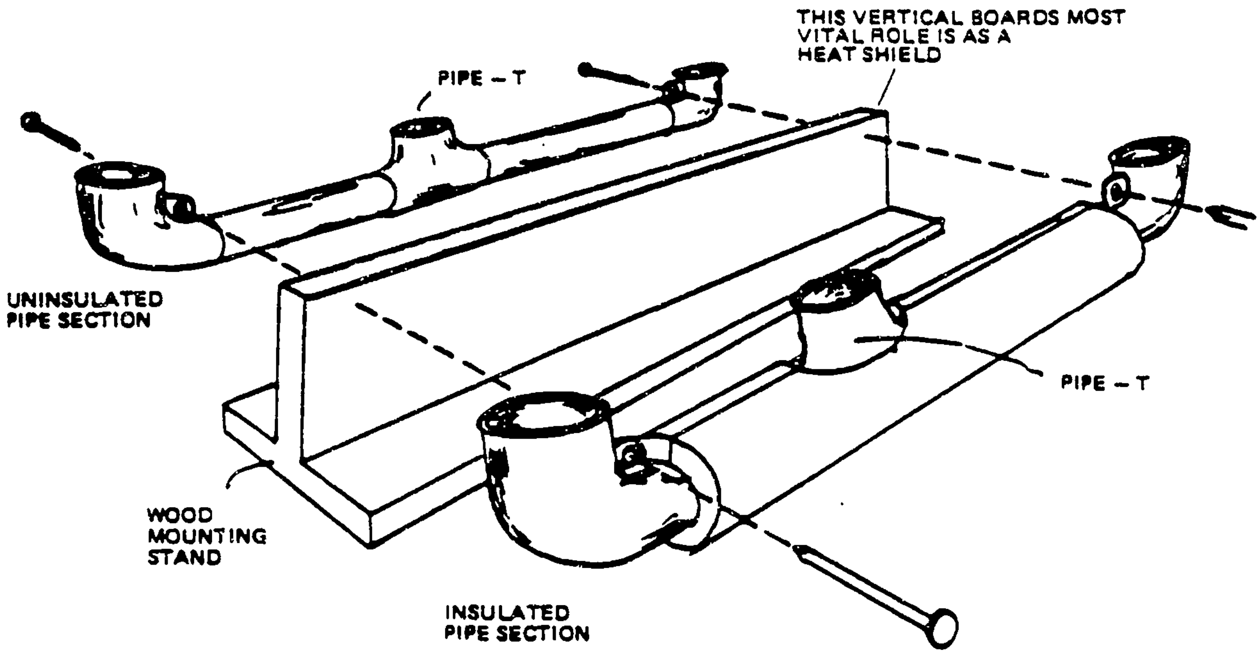
174

Principles of Technology
DESIGN NOTES ON SPECIAL EQUIPMENT

Item Name: Thermal Pipe Assembly Item No. 85

MATERIALS

4 - tubes, copper, 16" long x 1" diam
2 - pipe tees, copper
4 - pipe elbows, copper
1 - thermal insulation 34" long tube for 1" diam pipes
1 - wood mounting stand



175

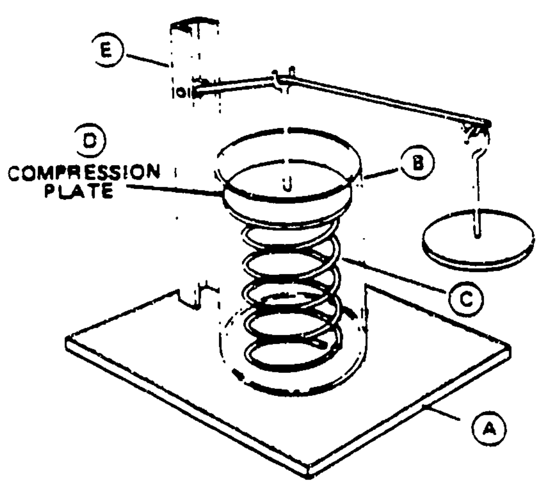
Principles of Technology
DESIGN NOTES ON SPECIAL EQUIPMENT

Item Name: Spring Test Assembly   Item No. 87

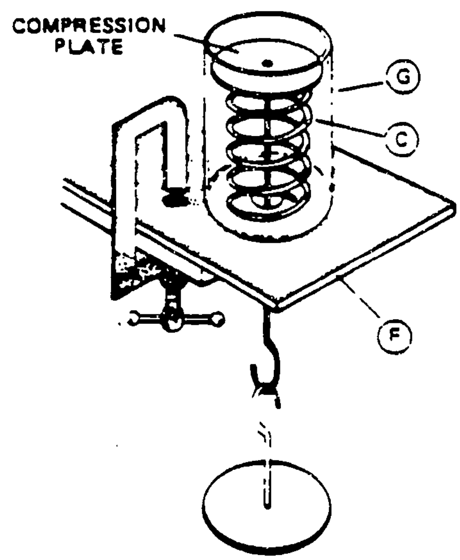
MATERIALS

For Design A
1 - Base, 4" x 4" x 3/4" wood (A)
1 - Tube, 2" diam x 5" tall (B)
1 - Spring, coil type, 1 7/8" diam x 3 1/2" long (C)
1 - Compression plate, circular disk 1 15/16" diam x 1/4" aluminum with vertical 3" long rod mounted on center (rod diam 1/4") (D)
1 - Vertical support rod with lever arm (E)

For Design B
1 - Base, 6" x 4" x 3/4" wood (F)
1 - Tube, 2" diam x 5" tall (G)
1 - Spring, coil type (same as "C" above)
1 - Compression plate (same specs as "D" above except vertical rod must be 5" to 6" long).



DESIGN A



DESIGN B

170

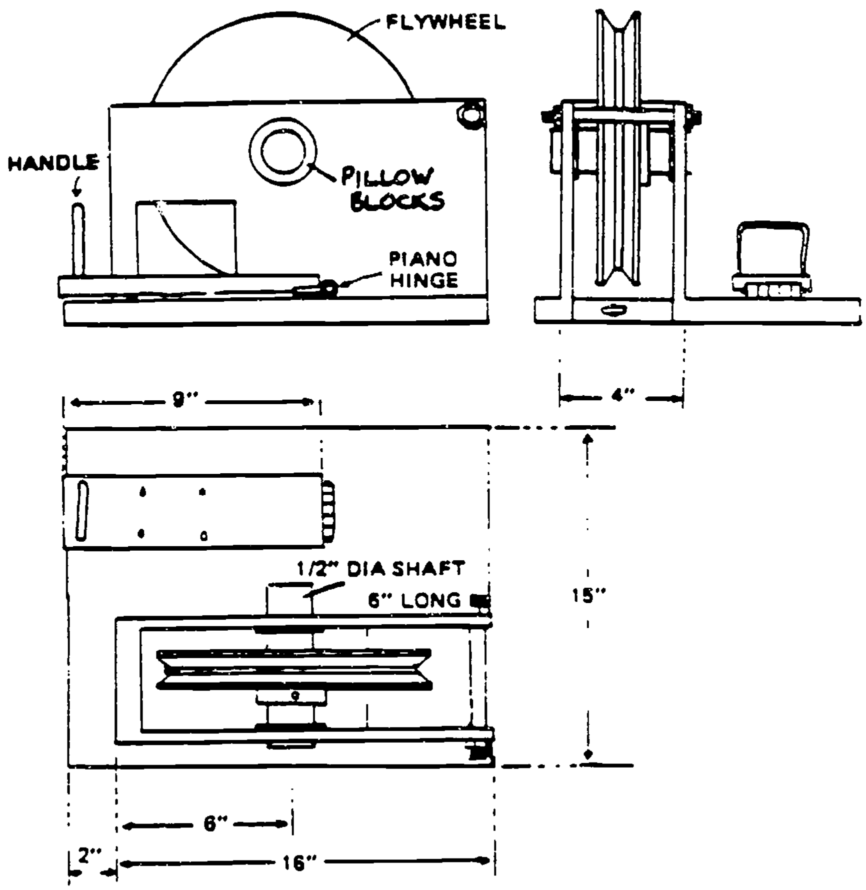
12/01/86

Principles of Technology
DESIGN NOTES ON SPECIAL EQUIPMENT

Item Name: Flywheel Assembly | Item No. 88

MATERIALS

Base 5/8" t x 15" x 18" plywood
Sides - 1/2" t x 16" x 12" plywood
Lever - 1/2" t x 9" x 4" plywood
Piano hinge 3" wide
Flywheel - cast iron pulley sheave 8-10" diam x 3/4" wide with weight of 4 to 5 lb
Shaft - 1/2" diam x 6" long
Threaded bolt 5" long x 1/4" diam
2 - Pillow block with bearings for 1/2" diam shaft
Eye screw 3/4" long - wood screw



ADDITIONAL INFORMATION ON BACK OF THIS PAGE.

All materials listed below are referenced to W.W. Grainger, Inc., cat. #367

Pulley sleeve, 8 1/4" diam	stk # 3X598	$19.73 ea
Bushing set, for 1/2" diam shaft malleable split type	stk # 3X884	6.64 set
Pillow block set Ball bearing for 1/2" diam shaft	stk # 1A396	16.94 set
Shaft collars	stk # 2X568	.59 ea

Principles of Technology
DESIGN NOTES ON SPECIAL EQUIPMENT

Item Name: Hydraulic Flow and Shock Assembly Item No. 91

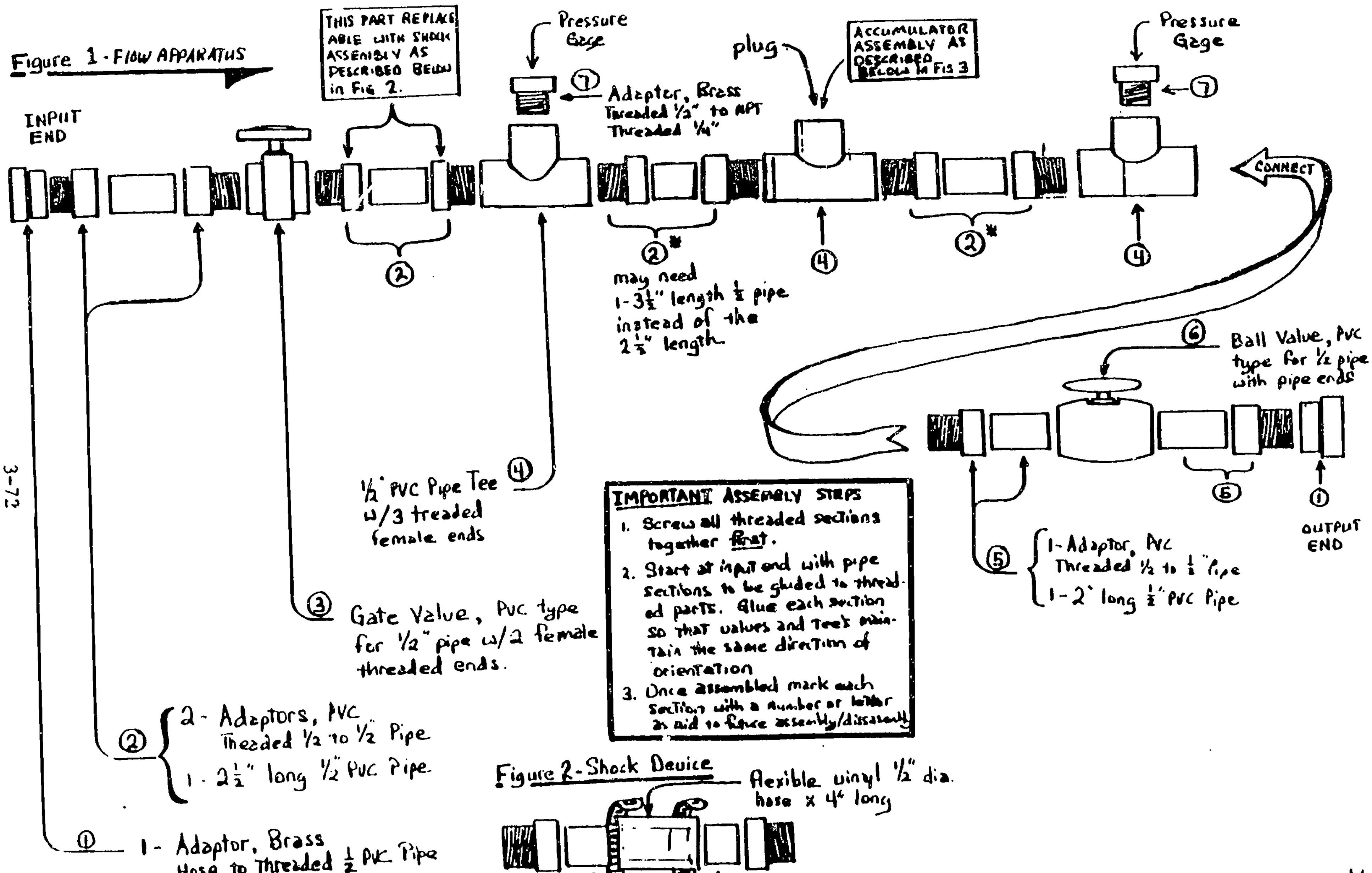
MATERIALS COST OF ACCUMULATOR DEVICE

Item-Description	Cost Each	Number Needed	Total Price
Adaptor, garden hose to 1/2" pipe thread	1.80	2	3.60
Adaptor, 1/2" pipe thread to 1/2" pipe slip	0.33	12	3.96
Adaptor, 1/2" pipe thread male to 1/4" NPT female	0.99	2	1.98
Valve, gate type with 2 female 1/2" pipe thread	7.90	1	7.90
Valve, ball type with 2 slip PVC	2.99	1	2.99
Tee, PVC with 3 female 1/2" pipe thread	0.59	3	1.67
Pipe nipple 1/2" male to male PVC	0.80	1	0.80
1/2" PVC schedule 40 x 24" long	0.80	1	0.80
1/2" vinyl tubing	0.8t/ft	1/3 ft	0.29

TOTAL MATERIALS COST $31.99

The prices lsited are retail prices in Waco, Texas. Prices for Teflon pipe tape and PVC pipe cement are not included--nor the cost of assembly in labor.

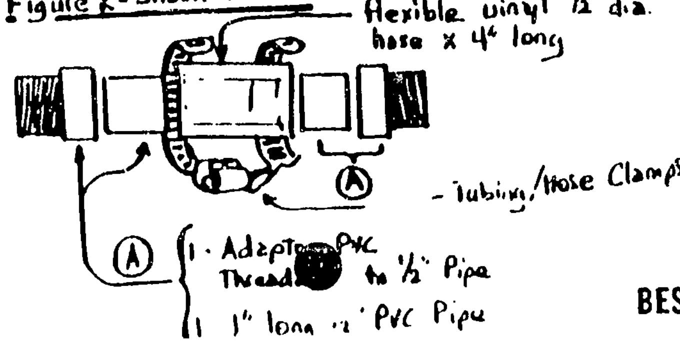
Figure 1 - FLOW APPARATUS



IMPORTANT ASSEMBLY STEPS

1. Screw all threaded sections together first.
2. Start at input end with pipe sections to be glued to threaded parts. Glue each section so that values and Tee's maintain the same direction of orientation
3. Once assembled mark each section with a number or letter as aid to future assembly/dissasembly

Figure 2 - Shock Device



150

181

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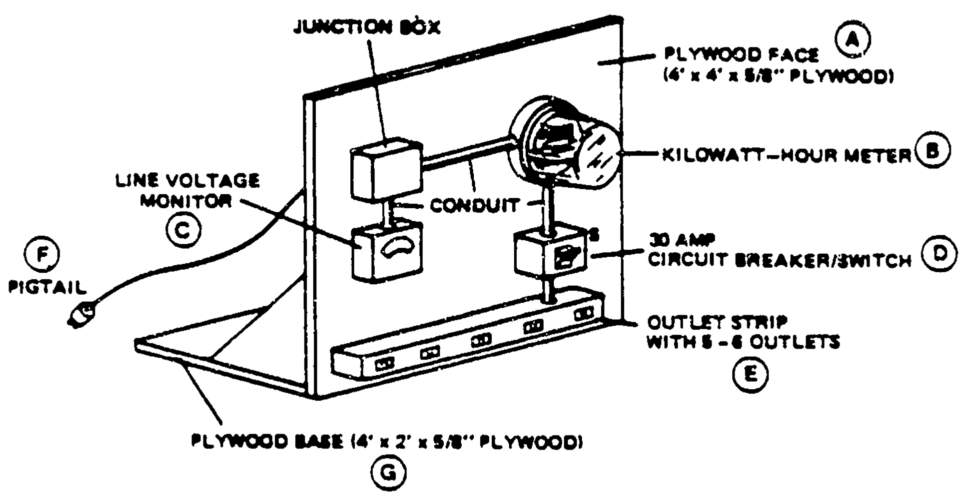
Principles of Technology
DESIGN NOTES ON SPECIAL EQUIPMENT

Item Name: Kilowatt-hour Meter Assembly　　Item No. 98

MATERIALS

2 - 4'w x 5/8" x 4' long plywood Ⓐ & Ⓖ
1 - Kilowatt-hour meter base socket
1 - Kilowatt-hour meter Ⓑ
1 - Line voltage monitor Ⓒ
1 - 30-A circuit breaker/switch Ⓓ
1 - multiple outlet strip (with 5 or 6 outlets) Ⓔ
1 - Pig tail connector (3-wire) Ⓕ
- Conduit and junction boxes



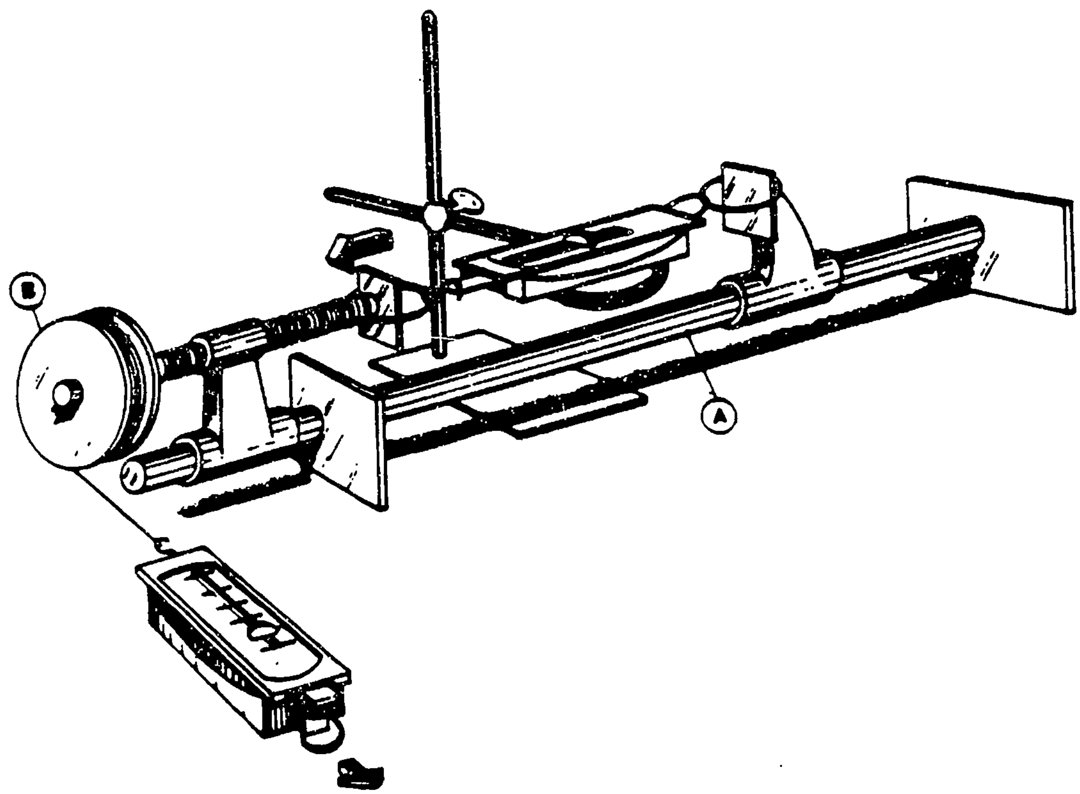
182

Principles of Technology
DESIGN NOTES ON SPECIAL EQUIPMENT

Item Name: Pipe-Clamp Assembly | Item No. 101

MATERIALS

1 - 1" diam x 4' long iron or steel pipe (A)
1 - set of bar clamps, one end with adjustable screw mechanism
1 - 8" diam disk (B)



183

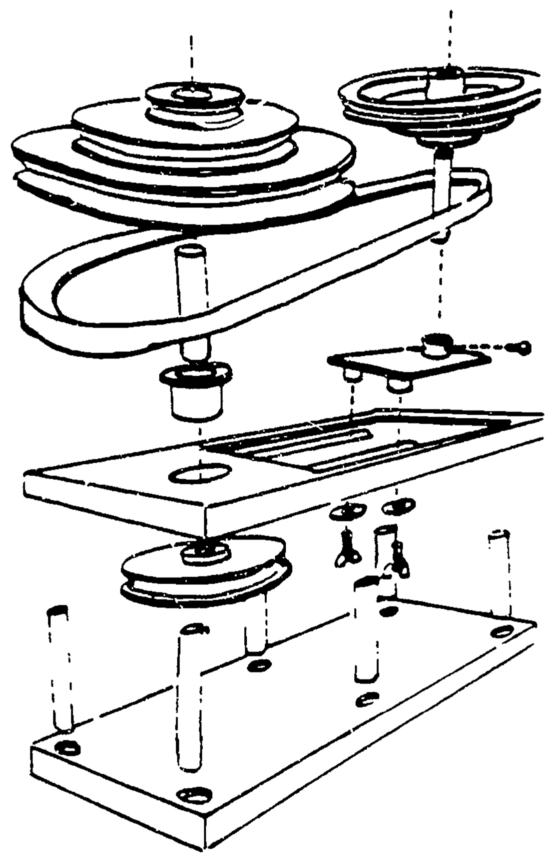
12/01/86

Principles of Technology
DESIGN NOTES ON SPECIAL EQUIPMENT

Item Name: Belt Drive Trainer   Item No. 104

MATERIALS

2 - Multiple step pulleys, V-belt type
2 - Shafts - 12 mm diam
2 - Plywood Boards 6" w x (1/2" - 5/8") t x 22" long
6 - 1" diam x 4" long wood dowels
1 - V-belt to fit
1 - Fixed bearing assembly
1 - Movable bearing assembly
2 - Timing belt pulleys
1 - Timing belt



The two multiple-level pulleys can be removed along with the V-belt and the cogged wheels with cogged belt replace these on the same shaft.

Specifications for the timming belt and the timming belt pulley are from Stock Drive Products. SEE ITEM NO. 201 for information on these.

3 mm pitch	3 mm pitch
300 mm length	Double flange
100 grooves	8.3 cm diameter flange
9 mm width	12 mm bore
	80 grooves
	22 mm width

12/01/86

Principles of Technology
DESIGN NOTES ON SPECIAL EQUIPMENT

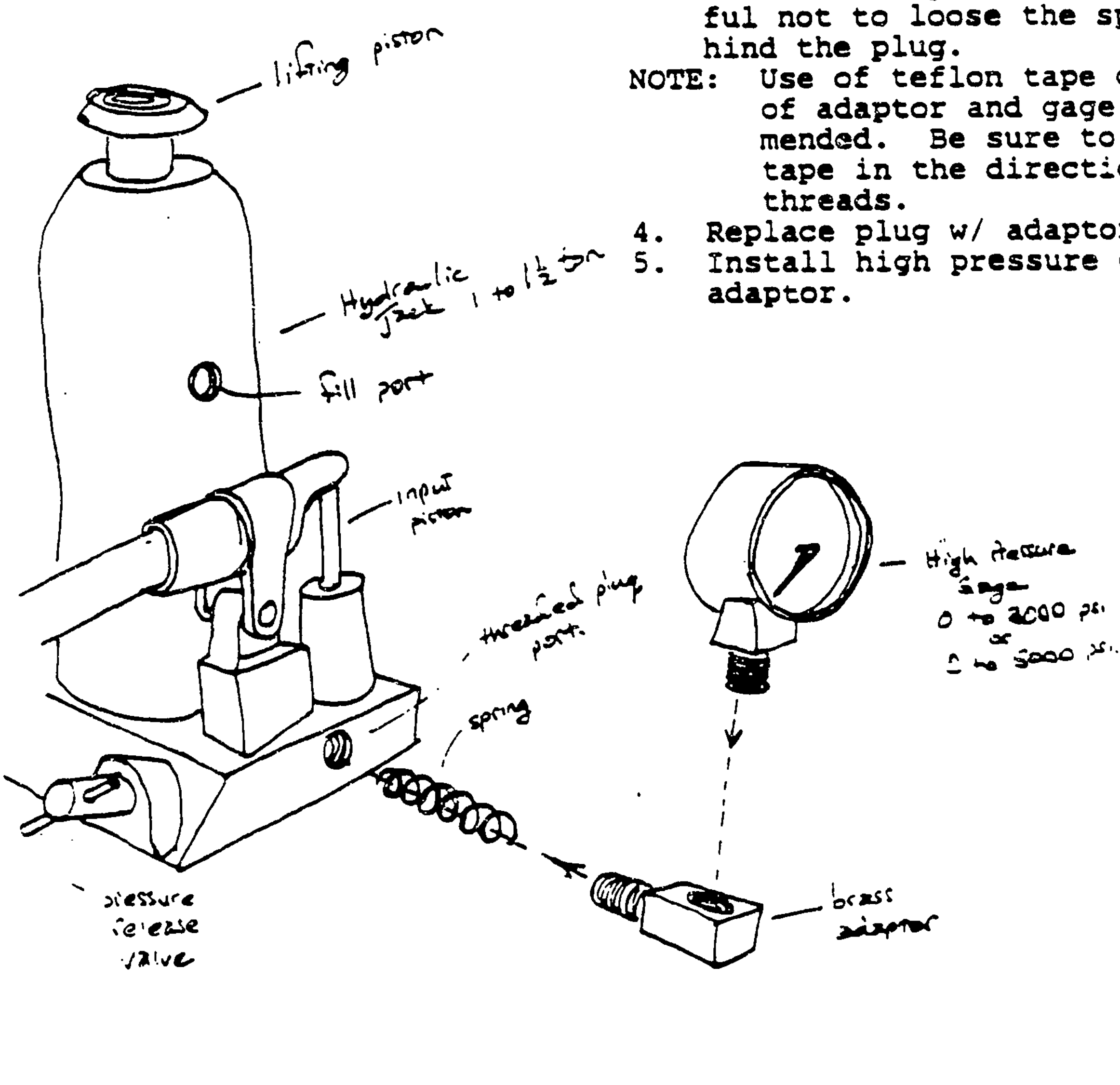
Item Name: Hydraulic Jack Item No. 105

INSTRUCTIONS FOR MODIFICATION

1. Open pressure release valve.
2. Lay jack on side w/ plug port up.
3. Remove threaded plug in the base of the jack. Be very careful not to loose the spring behind the plug.

NOTE: Use of teflon tape on threads of adaptor and gage is recommended. Be sure to wrap tape in the direction of the threads.

4. Replace plug w/ adaptor.
5. Install high pressure gage on adaptor.



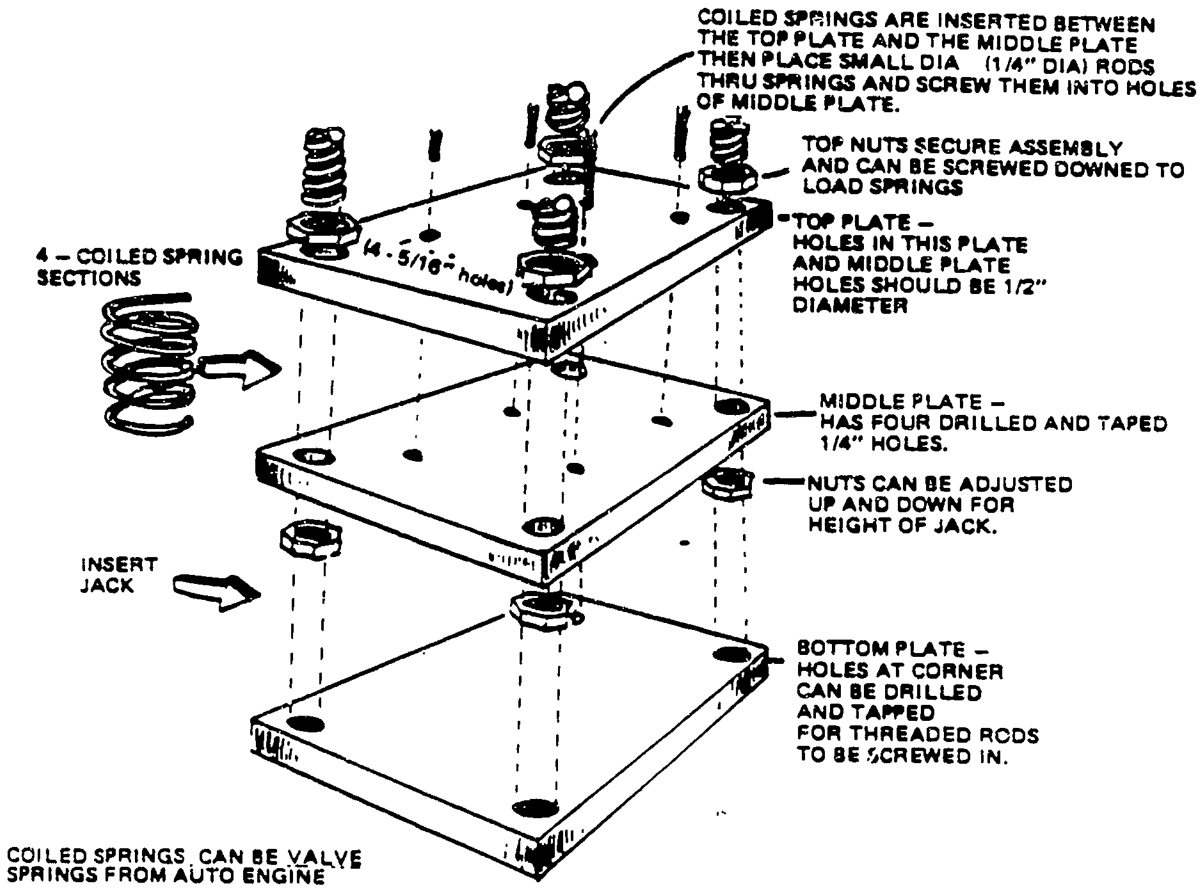
NOTE: On some hydraulic jacks there is a rubber or plastic seal behind the threaded base plug. This must also be removed, but do so with care.

Principles of Technology
DESIGN NOTES ON SPECIAL EQUIPMENT

Item Name: Pressure Stage Item No. 106

MATERIALS

3 - 1/2" t x 3" d x 4" long (minimum)
4 - 3/8: diam x 16" long threaded rods
16 - Heavy-duty nuts
2 - Strong coiled springs
4 - 1/4" diam x 8" long threaded bolts



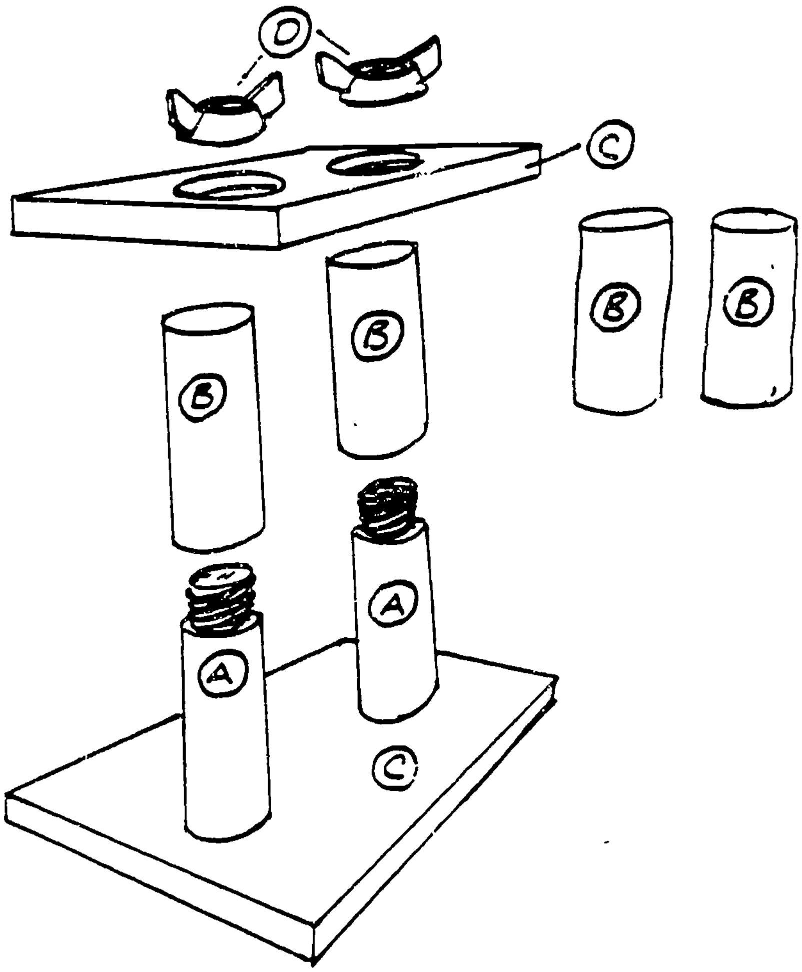
180

Principles of Technology
DESIGN NOTES ON SPECIAL EQUIPMENT

Item Name: Transformer Assembly | Item No. 108

MATERIALS

2 - 4" long x 1/2" diam steel bolts (A)
4 - 3" long x 1/2" diam plastic tubes (B)
2 - 3/16" t x 4" long x 3" w soft iron plates (C)
2 - Wing nuts (D)



NOTE: Weld bolts to bottom plate
with centers 2 1/2" apart.

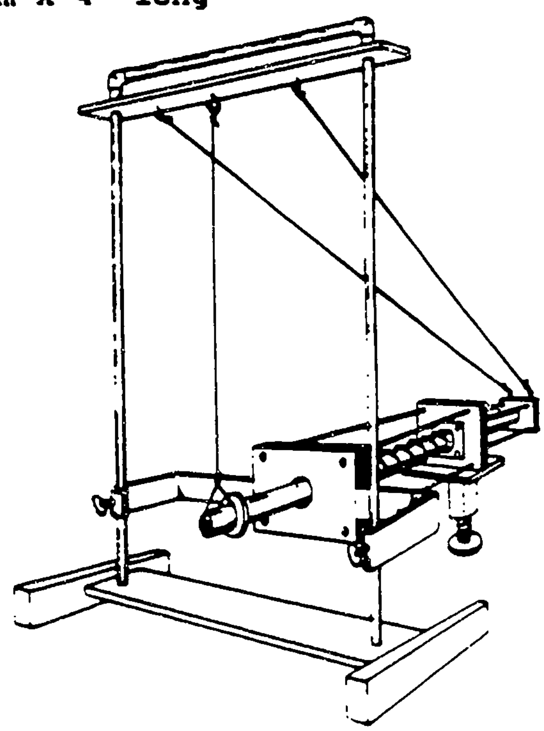
12/01/86

Principles of Technology
DESIGN NOTES ON SPECIAL EQUIPMENT

Item Name: Impulse Measurement Assembly   Item No. 200

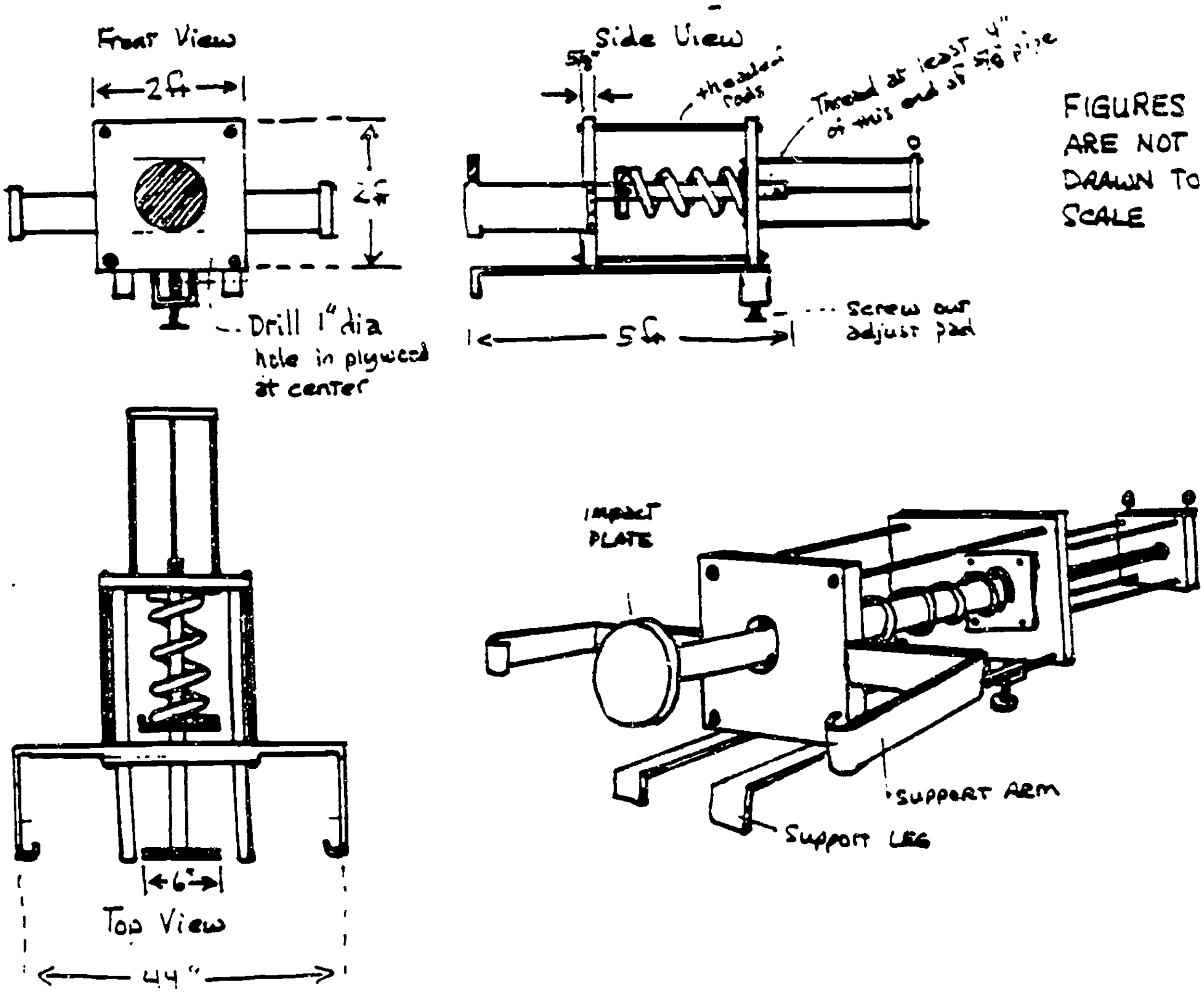
MATERIALS

2 - 2' x 2' x 5/8" t plywood board
1 - 7/8" id steel pipe x 5' long
1 - Impact plate, 6" diameter steel x 3/8" t
1 - 1' x 1' x 5/8" t plywood board
Coil Spring - 3" to 5" diam x 12" x 18" long must be able to withstand 185 to 220 ft-lb energy
8 - 7/16" diam threaded rods 3 ft long
32 - steel washers 1" diam with 7/16" hole
48 - nuts 7/16" diam hole
1 - steel plate 3/16" x 1' square
2 - eyebolts 3/16" diam
2 - threaded collars for od of 5/8" diam pipe
1 - smooth steel pipe 1/2" diam x 4' long
2 - steel support arms
2 - steel support legs
1 - adjustable height leg
6 - 1/4" balls, steel



NOTE: This assembly is intended as an accessory to the heavy-duty support stand (item no. 1). Dimensions and configuration may need to be different due to support and coil spring actually on hand.

FIGURES AND ADDITIONAL DATA ON THE BACK OF THIS PAGE.


Front View
2 ft
2 ft
Drill 1" dia hole in plywood at center
Side View
5/8
threaded rods
Thread at least 4" of this end of 5/8 pipe
Screw out adjust pad
5 ft
FIGURES ARE NOT DRAWN TO SCALE
Top View
6"
44"
IMPACT PLATE
SUPPORT ARM
Support LEG

183

Information on materials for preparing your own spring.

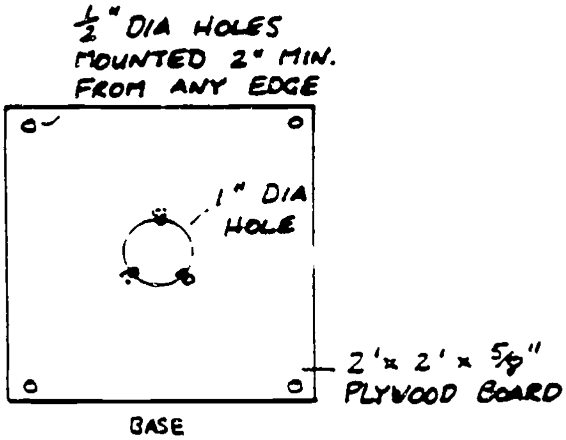
Use #312 wire
OD of spring 3.2"
ID of spring 2.7"
Length of spring 15" to 18"
Number of coils = 20 to 25
Ground and squar ends.
k = 33 lb/in

Impact Head Assembly
Weld impact head to one end of 7/8" pipe and thread the last 6"-8" of other end.

For each board: mounting the impact head assembly

* Drill 3 holes 120 apart with a diam of 5/16" and a depth of 3/16".
* Place a number of layers of felt in each hole to reach a thickness of 5/32".
* Liberally coat top layer of felt with graphite.
* Place 1/4" steel balls in holes and hold in place with 6" long strip of tape.
* Insert 7/8" diameter pipe, then remove strips of tape.

The result is that the pipe is suspended and guided by only three points of contact at each board. And these points of suspension are lubricated.



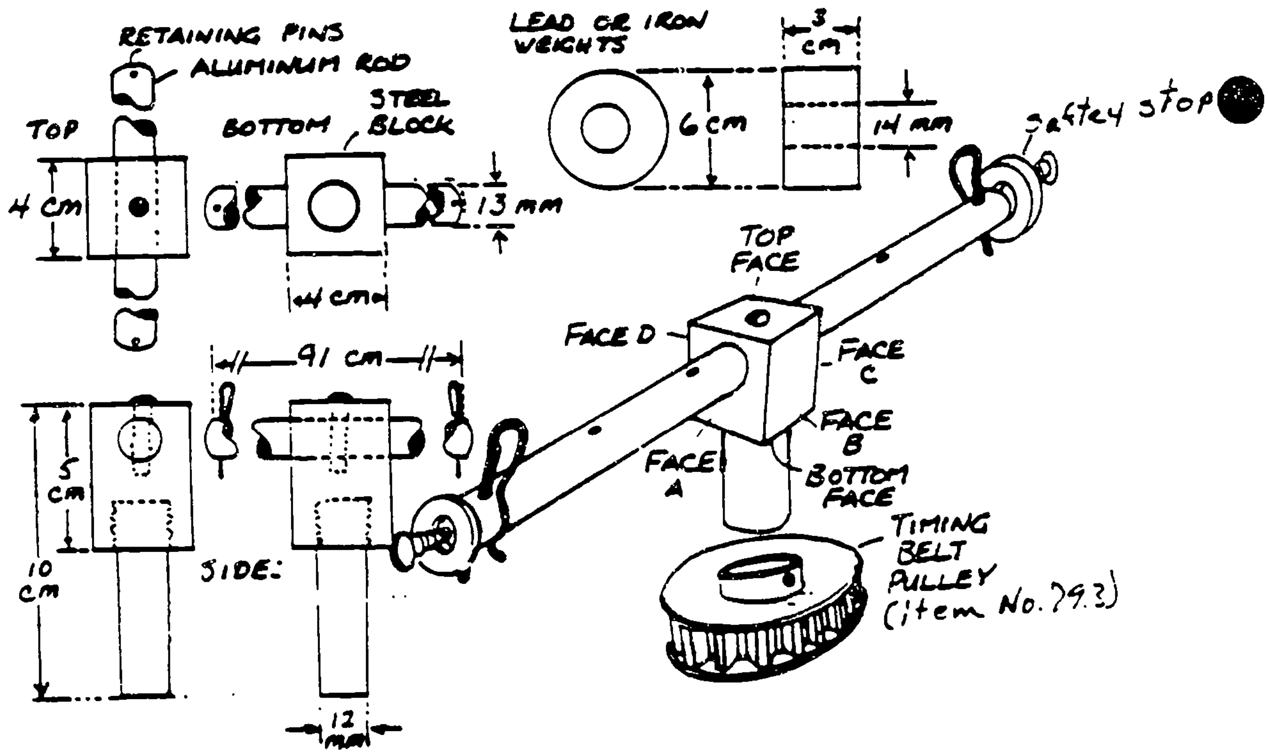
Principles of Technology
DESIGN NOTES ON SPECIAL EQUIPMENT

Item Name: Moment of Inertia Assembly Item No. 201

MATERIALS

Steel block, 4 cm x 4 cm x 5 cm
Aluminum rod, 13 mm diam x 91 cm
Steel rod 7 1/2 cm x 12 mm diam
2 - iron (or lead) disk-shpaed weights
4 - retaining pins
2 - Saftey stops

NOTE: DRAWINGS ARE NOT DONE TO SCALE



FABRICATION STEPS AND ADDITIONAL DATA ON BACK OF PAGE.

12/01/86

This assembly is intended as an accessory to the Belt Drive trainer (item 104)

VENDOR REFERENCE SOURCE

Timing Belt Pulleys - double flange

sdp* cat. no. 6Z23M080DF091

flange diam = 8.3 cm	Bore = 12 mm	Width = 22 mm
OD = 7.56 cm	Hub diam = 22 mm	
# of grooves = 80	3 mm pitch	

Lexan reinforced fiberglass with Al insert (knurled)

Timing Belt

sdp cat. no. 6R23M100090
3 mm pitch
300 mm long
Nylon covered, fiberglass reinforced neoprene

Aluminum Rod

Standard support rod from Sargent-Welch
91 cm long x 13 mm diam
cat. no. S-78454-D

*sdp - Stock Drive Products
55 South Denton Ave
New Hyde Park, New York 10040
(516) 328/0200

FABRICATION STEPS

Steel Block

1. Drill a 13-mm diam hole from FACE A to FACE C. Center of hole should be 2 cm from TOP FACE and FACES B and D.
2. Drill and tap a 5-mm diam hole 25 mm deep at center of top face.
3. Drill and tap a 10-mm diam hole 20 mm deep in bottom face at center.

Aluminum Rod

1. Measure to exact center of length of rod and drill an oversized 5 mm hole completely through rod.
2. From edge of hole measure 44 cm down length (in both directions) and drill a 3-mm hole completely through rod.
3. From edge of center hole measure 21.5 cm down length (in both directions) and drill a 3 mm hole completely through rod.

Steel Rod - 10 mm diam

1. Mark one end of rod 2 1/2 cm from the end.
2. Thread rod to this depth.

Principles of Technology
DESIGN NOTES ON SPECIAL EQUIPMENT

Item No.: 202

Item Name: Fluid Momentum Assembly

MATERIALS:

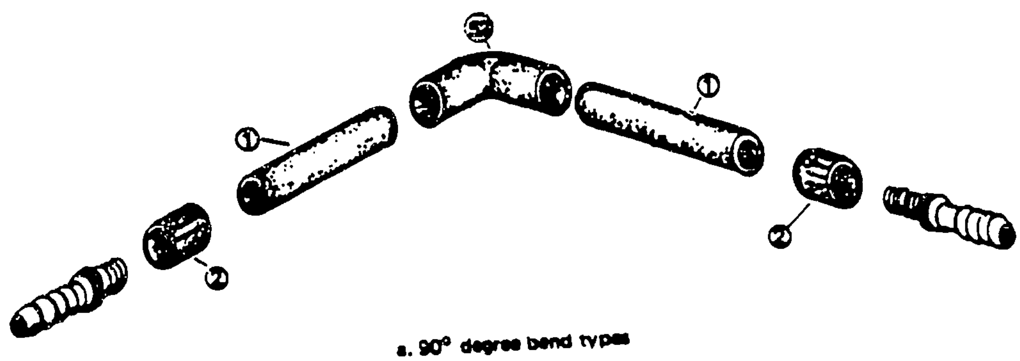
PVC Components; all 1/2" diameter size, all schedule 20
4 - Straight pipe sections, 6" long
8 - Pipe adaptors, slip to NPT female
9 - Tubing barbs, NPT male to barb
1 - Air chamber assembly (Item no.20)
2 - Elbows: 2-90 , 1-slip type, 1-slip type to NPT male

2 - Flexible plastic tubing-accordian pleated 10" long and 1/2" diam
8 - Hose clamps; adjustable 7/16" diameter to 1 1/16" diameter
4 - Pipe hold-down bracket
1 - Compound pressure gage (Item no. 21)
1 - Accumulator assembly (Item no. 22)
- Assorted wood screws and 1 eye-bolt screw

Wood Components:
1 - Mounting base; plywood, 3/8" - 1/2" t x 4' x 2' w
2 - Wood dowels; 1/4" diameter x 12-14" long
2 - Wood blocks; both 1" tall x 3/4" thick, 1 - 3" , 1 - 6"

CONSTRUCTION DETAILS:

I. Reaction Components



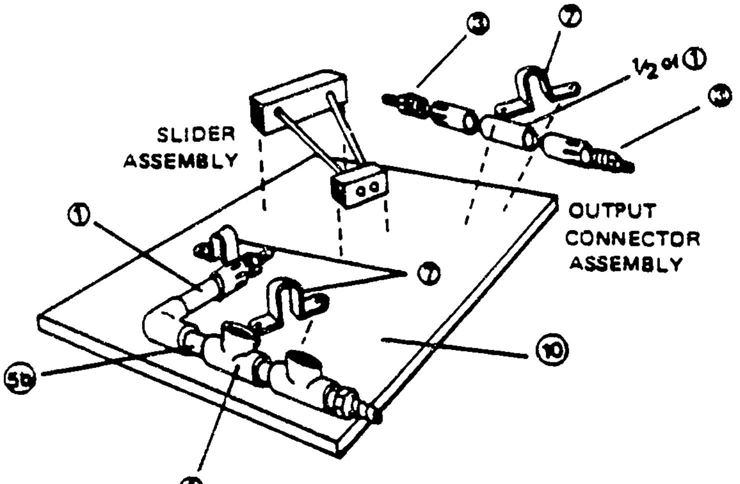
a. 90° degree bend types

ADDITIONAL FIGURES ON BACK OF PAGE.

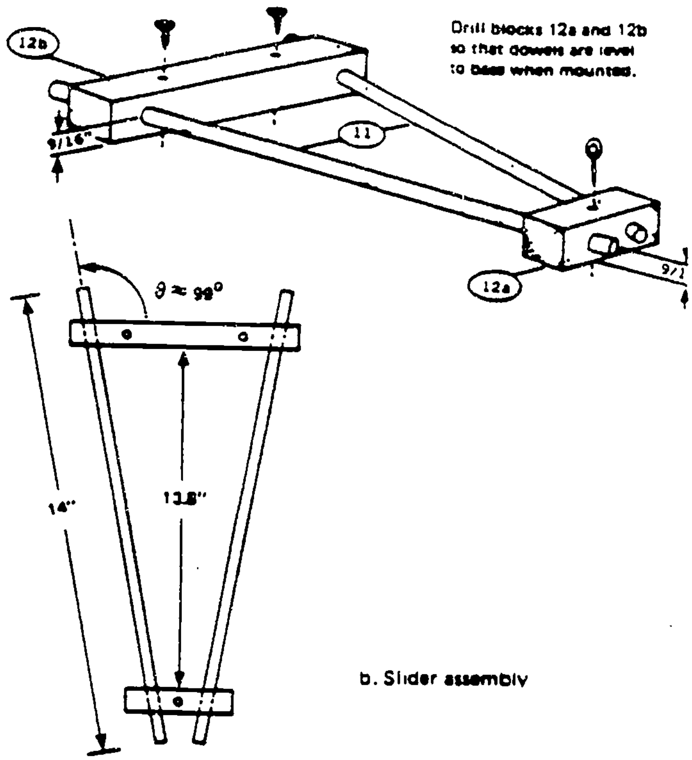
193

II. Work Base

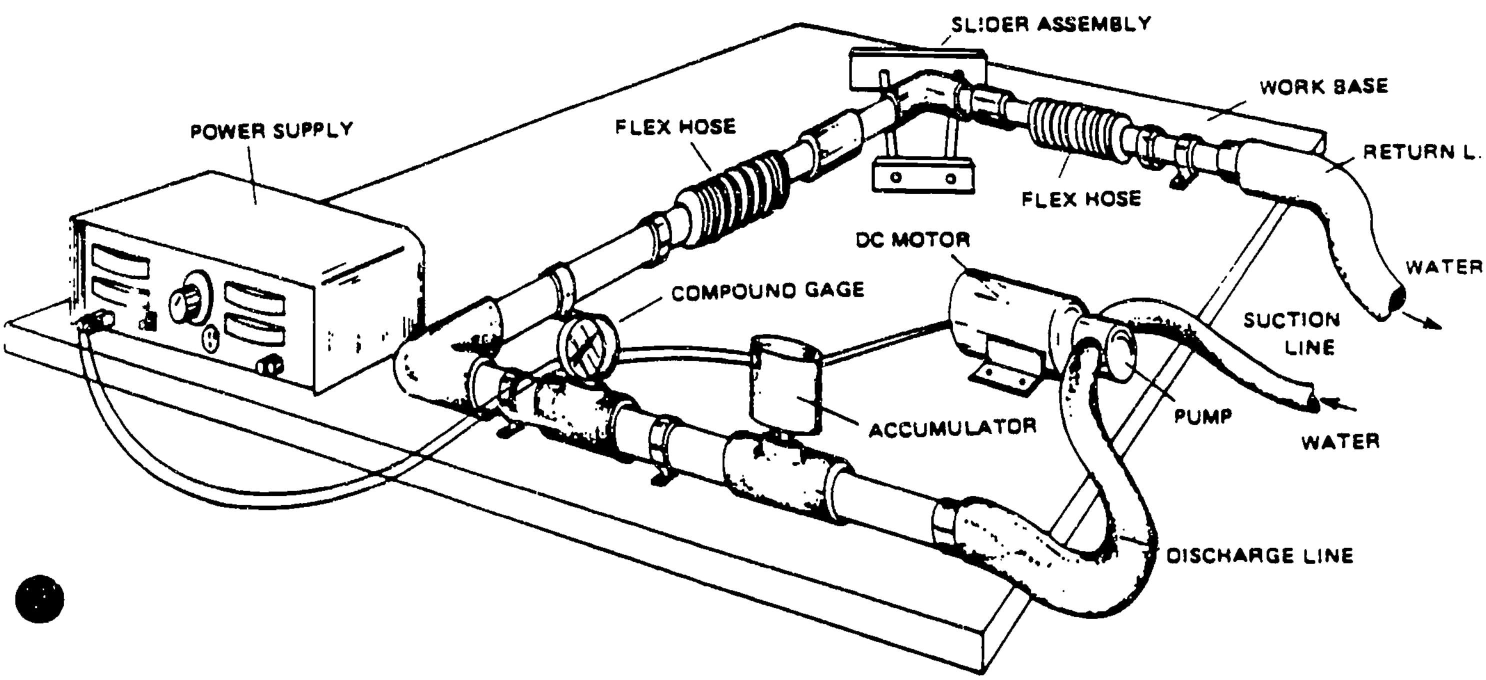
The flex hose is available from:
Nautical Rubber Corp.
Okland Center
8980 Route 108
Columbia, MD 21045
at a cost of $0.89 per foot of 3/4" o.d. "bilge hose".



a. Composite



b. Slider assembly



19-

ITEM 205 DELETED

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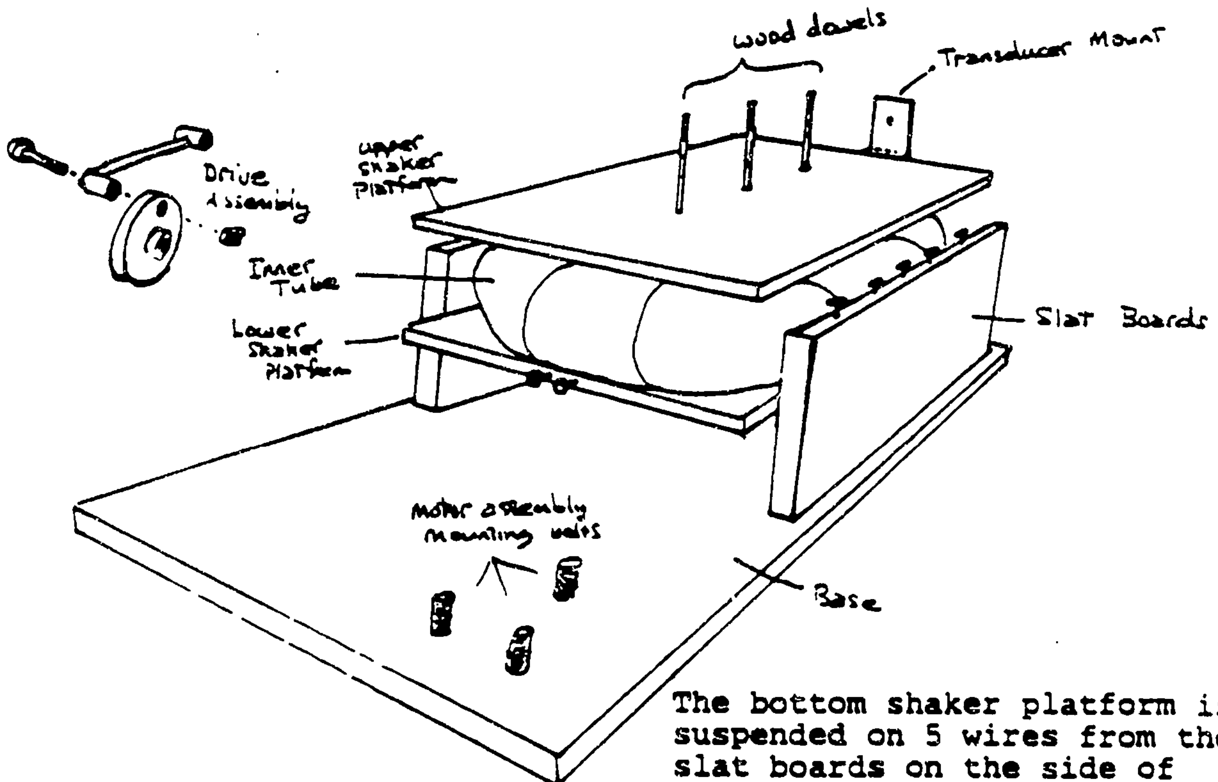
12/01/86

Principles of Technology
DESIGN NOTES ON SPECIAL EQUIPMENT

Item Name: Mechanical Shock Assembly   Item No. 206

MATERIALS

Wood base, 24" x 18" x 5/8" plywood
2 - shaker platforms 12" x 12" x 1" plywood
Air inner tube (12" od max)
Steel wire, high tensile - 1 mm diam
2 - transducer mounts
Motor connector assembly
Mounting hardware
Wood dowel 5/16" diam x 14"
2 - wood slat boards 8" x 10" x 1"
Aluminum disk 2" diam x 3/16" thick with 3/4" x 9/16" diam hub
Brass tubes 3/16" id x 1/2" long
Brass rod 1/8" diam x 4 5/8" long



The bottom shaker platform is suspended on 5 wires from the slat boards on the side of the base. Each wire will need to be 25" long.

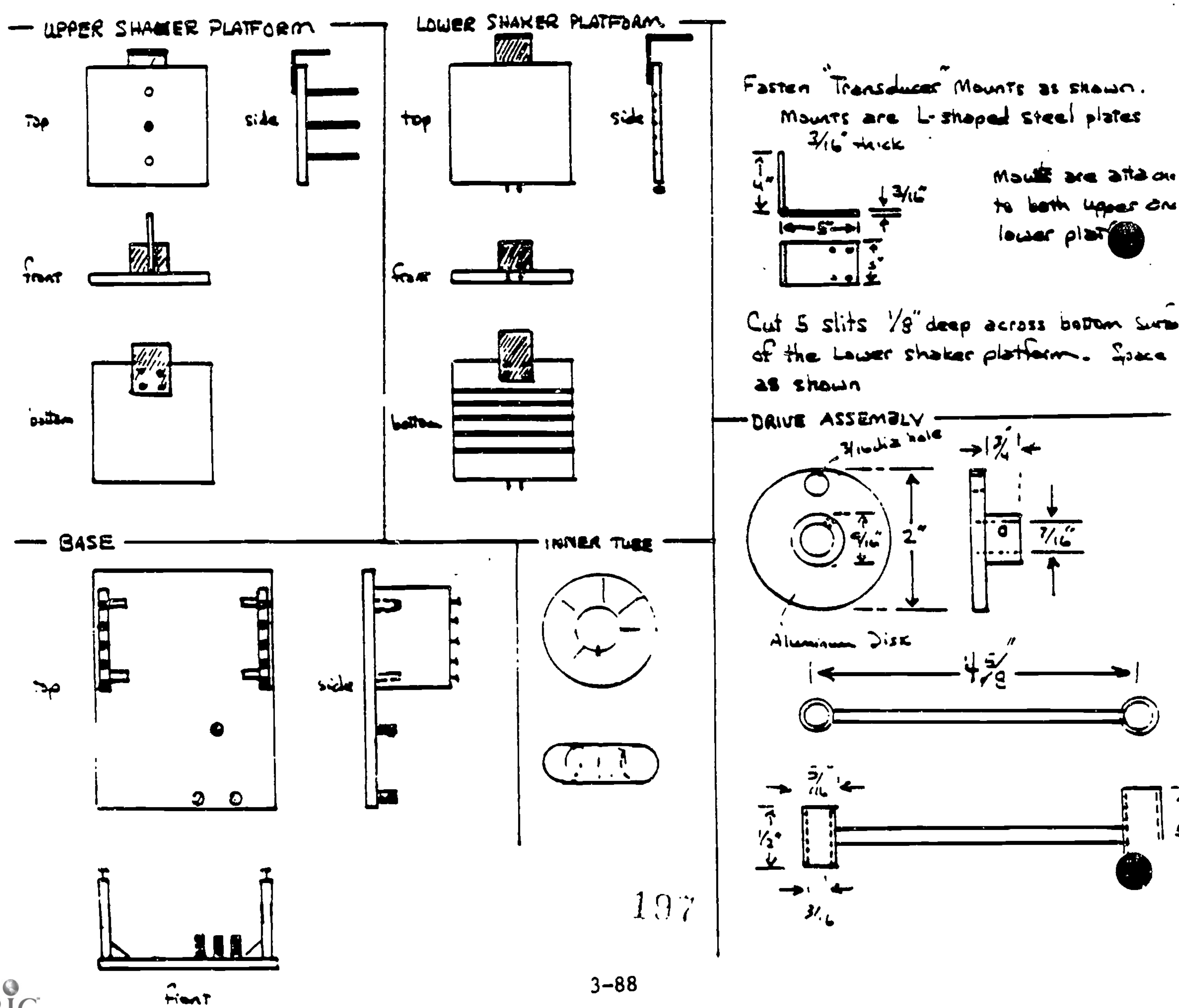
ADDITIONAL FABRICATION AND ASSEMBLY INFORMATION ON BACK OF PAGE

12/01/86

NOTE: An alternative way to induce vibrations is to use a cam drive.

The 2" diam x 3/16" thick disk can act as the cam. The 3/4" x 9/16" diam hub can be mounted off-center. This hub should be mounted no more than 1/4" off-center. When the slug is mounted to the motor shaft and placed so that only the circumference of the disk is in contact with the bottom shaker platform a cam action occurs.

Be sure that the cam (off-center disk) contacts the bottom shaker platform where the axis of rotation (the motor shaft) and the circumference (the edge of the disk) are in closest approch.



12/01/86

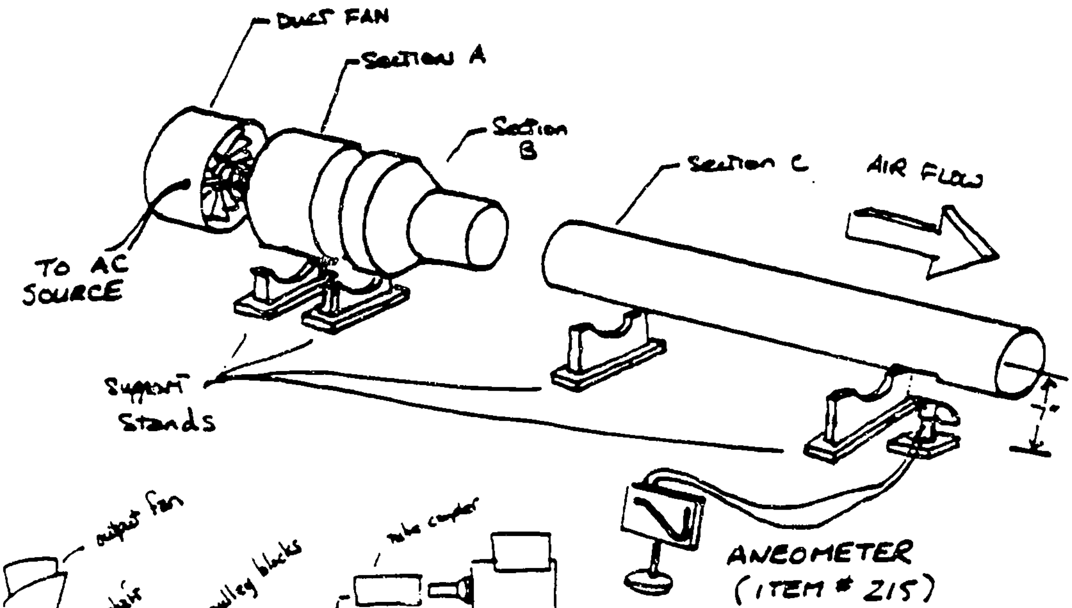
Principles of Technology
DESIGN NOTES ON SPECIAL EQUIPMENT

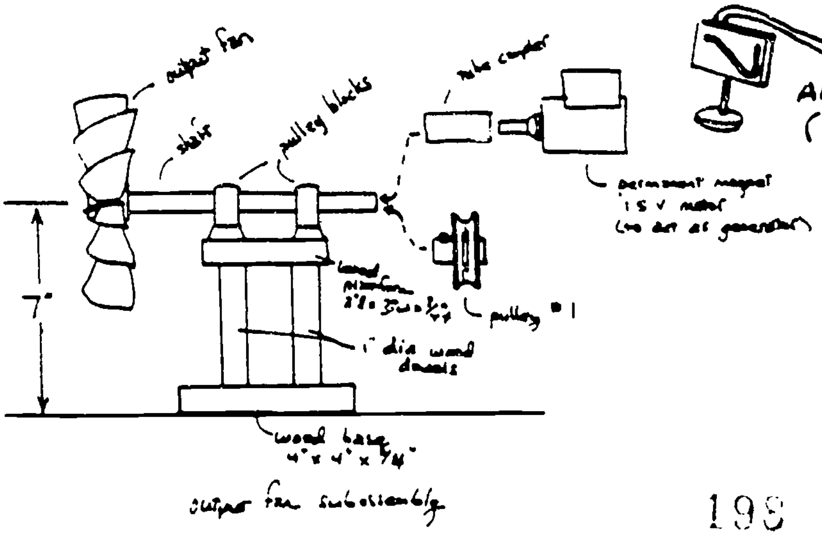
Item Name: Wind Generator Assembly   Item No. 214

MATERIALS

Duct fan - 10" diam
Duct section A - 10" diam x 2' long
Duct section C - 8" diam x 5' long
Duct reducer (section B) - 10" to 8" diam
Duct tape
Support stands - made of wood
Bands
Output fan subassembly

Optional
38' x 1" id PVC pipe
PVC pipe cement





Apparatus must be built so center of flow is 7" above table top.

Output fan subassembly is constructed so axis of fan rotation is also 7" above table top.

Duct Fan and Output Fan Referenced
from W.W. Graingers, Inc.

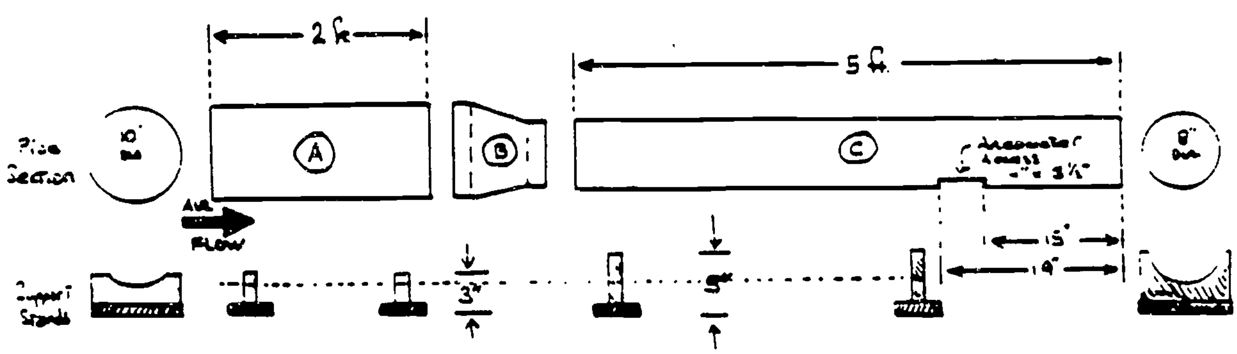
Duct fan - 10" diam with 1/100 hp motor 300 CFM at 0.73 A draw
Stock no. 2C222
Output fan - 7" diam with 5 wings of Al Stock no. 4C473

Output fan connecting shaft and pillow block referenced
from Stock Drive Products

1/4" diam shaft (0.2497" diam) 12" length, cat. no. 7X1-08120
Pulleys for round belts
#1 - 1/4" bore, 1" od with 5/8" hub diam,
cat. no. 6T10-1241008
#2 - 3/16" bore, 1" od with 5/8" hub diam,
cat. no. 6T10-1241006
Round belt
1/8" diam x 8" loop diam, cat. no. 6R11-04080
Two pulley blocks
1/4" bore with mounting holes 1 1/2" apart,
cat. no. 7Z6-F2208
Shaft collar
1/4" bore, 1/2" od, 9/32" wide with #10-24 x 1/8" set screw,
cat. n. 7C2-11608

Output generator
Small 1.5 VDC permanent magnet motor or a bicycle generator
coupled to output fan shaft.

NOTE: The 10" & 8" diam ducting is the most difficult thing to find and presents a hazard because of the sharpness of the edges. It would be possible to use PVC sewer pipe.



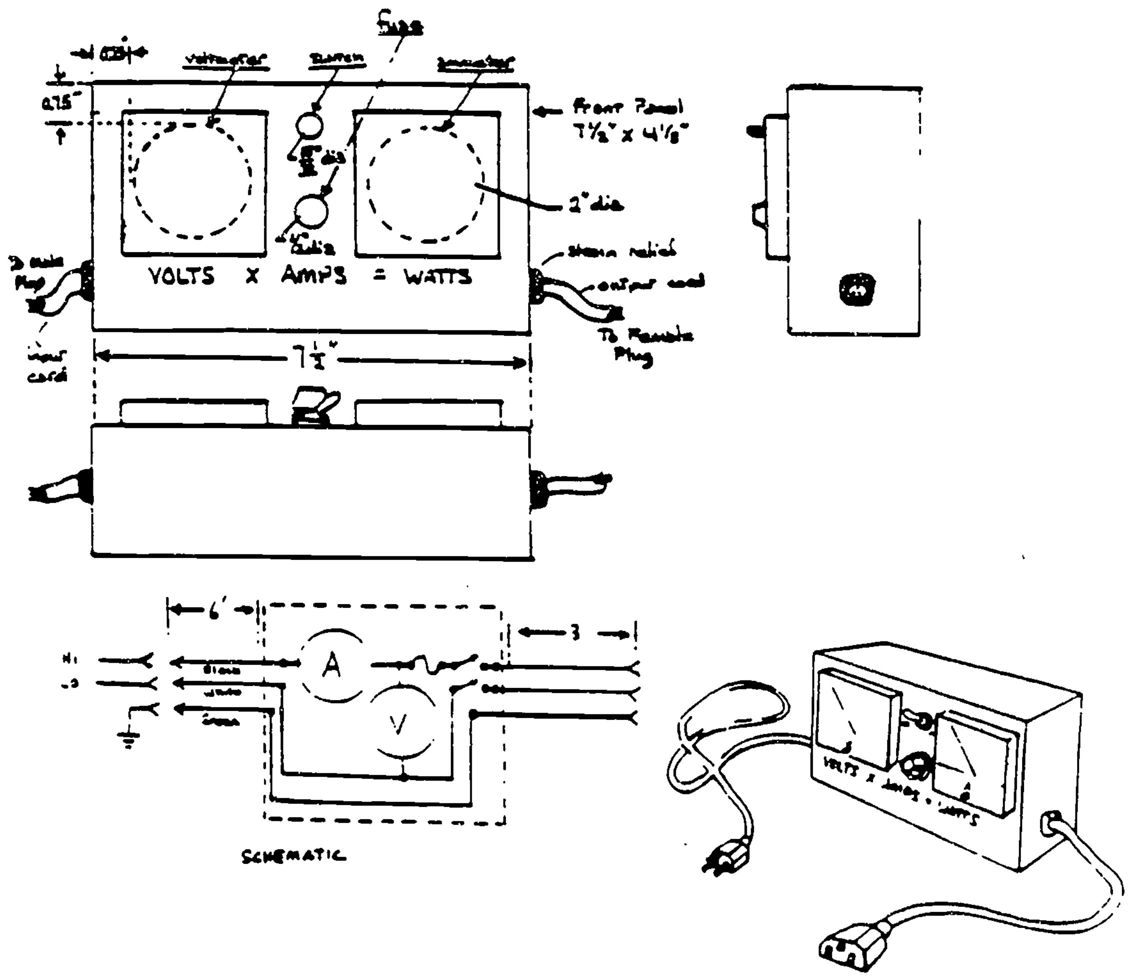
12/01/86

Principles of Technology
DESIGN NOTES ON SPECIAL EQUIPMENT

Item Name: AC Power Measurement Module   Item No. 227-ALT

MATERIALS

- Panel meters
  - AC Ammeter 0-15 V AC
  - AC Voltmeter
- Fuse holder with fuse
- DPDT switch
- Cabinet
- Wire
- Power cord



PARTS AND ESTIMATED COSTS OF MATERIALS ON BACK

12/01/8

All parts referenced to Allied Electronics Catalog #834

	Stock No.	Single Item Cost
* Ammeter, AC 0-15 A ±5%	701-8508	$10.92
* Voltmeter, AC 0-150 V ±5%	701-8406	13.95
Switch, DPDT ON-OFF 15 A @ 125 V AC rating	757-4500 (mfr's type 7560KS)	4.60
Fuseholder	740R2006 (mfr's type HTA)	2.20
Fuse (311015/AGC)	603R0202	1.40/5
Cabient (7 1/2" x 4 1/3" x 2 1/4")	806-1599 (mfr's type 11591EOR)	7.90
Power cord 9" x 14 AWG, Type SJ	663-7086 (Belden #17629)	10.40
Strain reliefs - 2		

Total Materials Cost Estimate= $52.00

*model 850Z, 2 1/2" rectangular

12/01/86

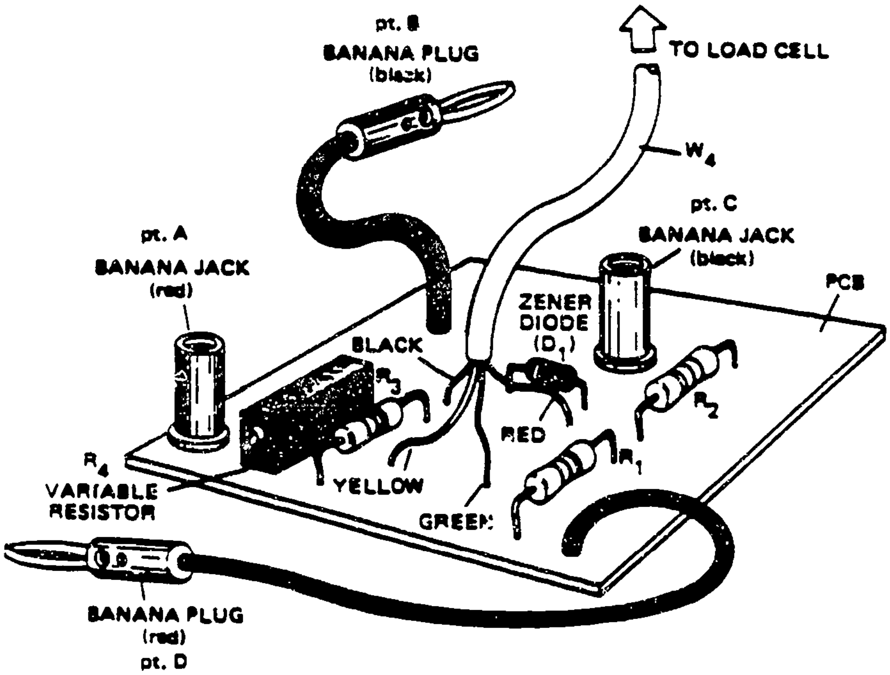
Principles of Technology
DESIGN NOTES ON SPECIAL EQUIPMENT

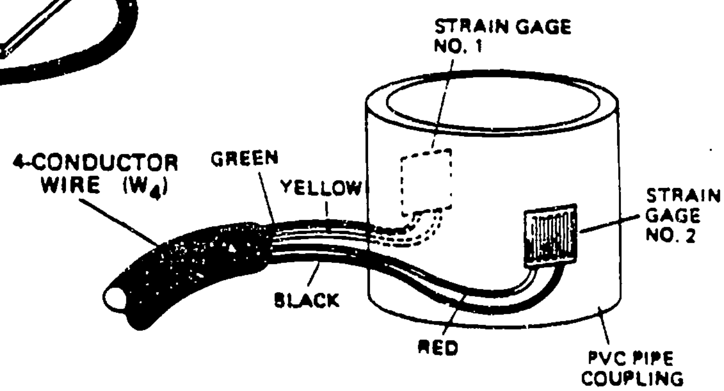
Item Name: Load Cell Assembly

Item No. 228

MATERIALS

PVC slip-type pipe coupler, 2 3/8" long x 2" i.d.
Unbonded strain gages
Strain gage adhesive (cold cure)
Strain gage protective coating
Hook-up wire
Bridge output board
9-V battery connector





BRIDGE OUTPUT BOARD

R_1 = 330 ohms, 1/4 watt
R_2 = 15 ohms, 1/2 watt
R_3 = 1500 ohms, 1/2 watt
R_4 = 0 to 500 ohms, 3/4 watt
D_1 = Zener Diode 1n4739 (9.1 V)

ADDITIONAL INFORMATION AND DATA ON BACK OF PAGE

All strain gage materials are referenced to Omega Engineering, Inc. "Pressure and Strain Measurement Handbook and Encyclopedia" for 1985

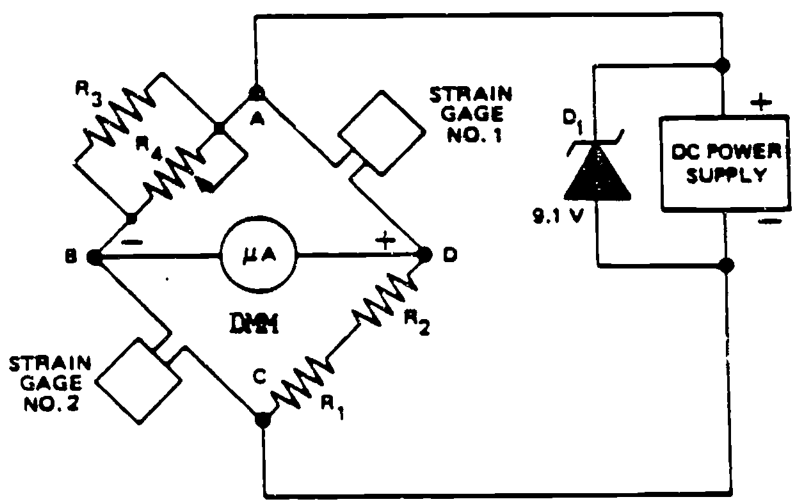
Strain gages, HBM 6/360 LY 11 10 for $46.00
Nominal Resistance = 350 ohms
Energizing Voltage = 15 VDC
GF = 2

Cold cure rapid adhesive, Z70 10 cc for $9.50
(enough for 250 gages)
Protective coat foil, ABM 75 11-205 x 100 mm pieces for $17.00
(enough for 200 gages)
Hook-up wire, TFCP-0 5-50 $11.00
(50 ft of 0.015" diam wire teflon coated)

NOTE:
Extensive educational materials on stress measurement technology is available from:

Measurements Group, Inc.
P.O. Box 27777
Raleigh, NC 27611

Student strain gages are also available--comparable to those listed above,
Model # EA-06-240LZ-120 for $10.00 per package of 10.
Nominal Resistance = 120 ohms, intended for mount to steel.



12/01/86

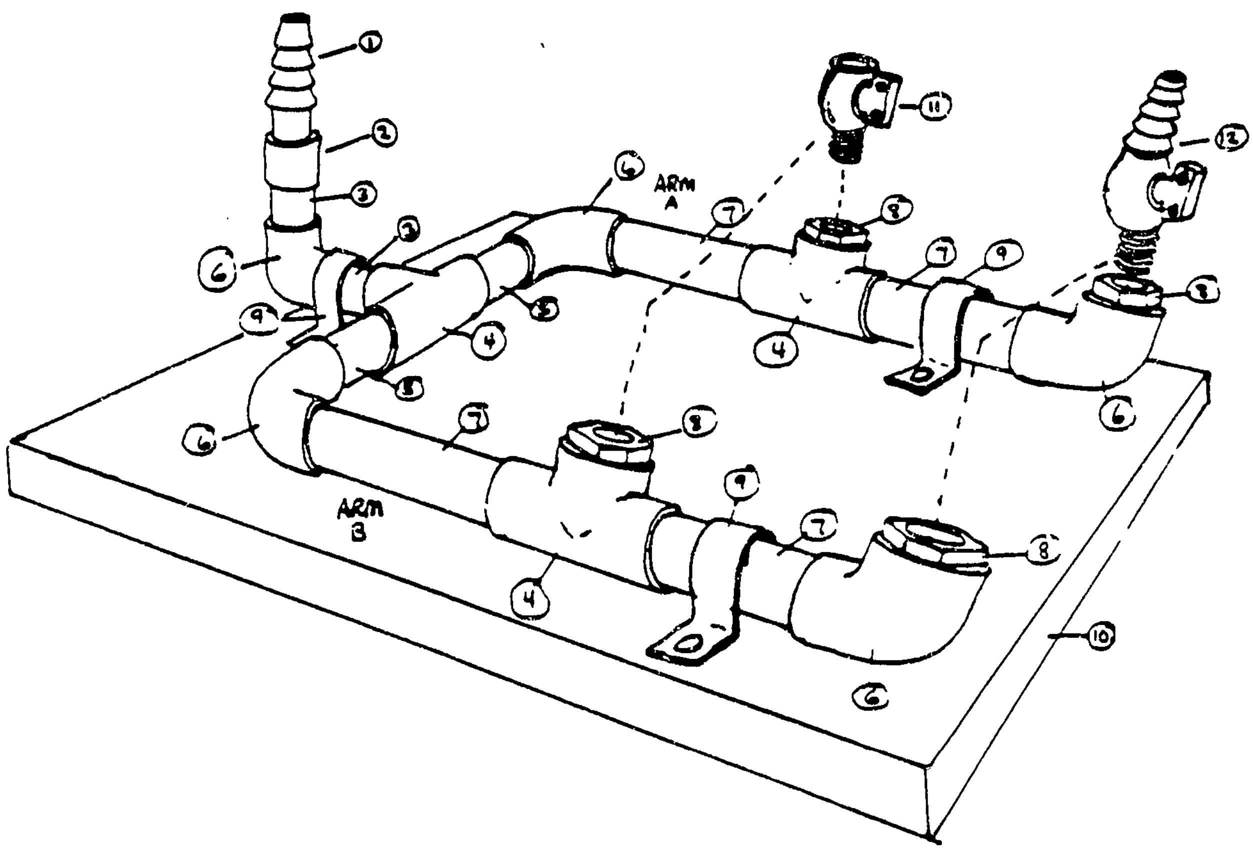
Principles of Technology
DESIGN NOTES ON SPECIAL EQUIPMENT

Item Name: Pressure Manifold Assembly Item No. 231

MATERIALS:

1 - Plywood board 10 18" x 8" x 5/8"
1 - PVC adaptor 1 Tubing to 1/4" id pipe to NPT
1 - PVC adaptor 2 1/4" female NPT to slip
3 - PVC pipe tees, 1/4" id, slip type 4
3 - PVC elbows, 90 , 1/4" id, slip type 6
4 - PVC adaptors, 1/4" id slip to female NPT 8
3 - Pipe hold-down clamps 9
2 - Brass cutoff valves 11
2 - Brass cutoff valves with nipple 12

PVC pipe sections - 1/4" id
2 - 3 2"
2 - 5 3"
4 - 7 4"



204

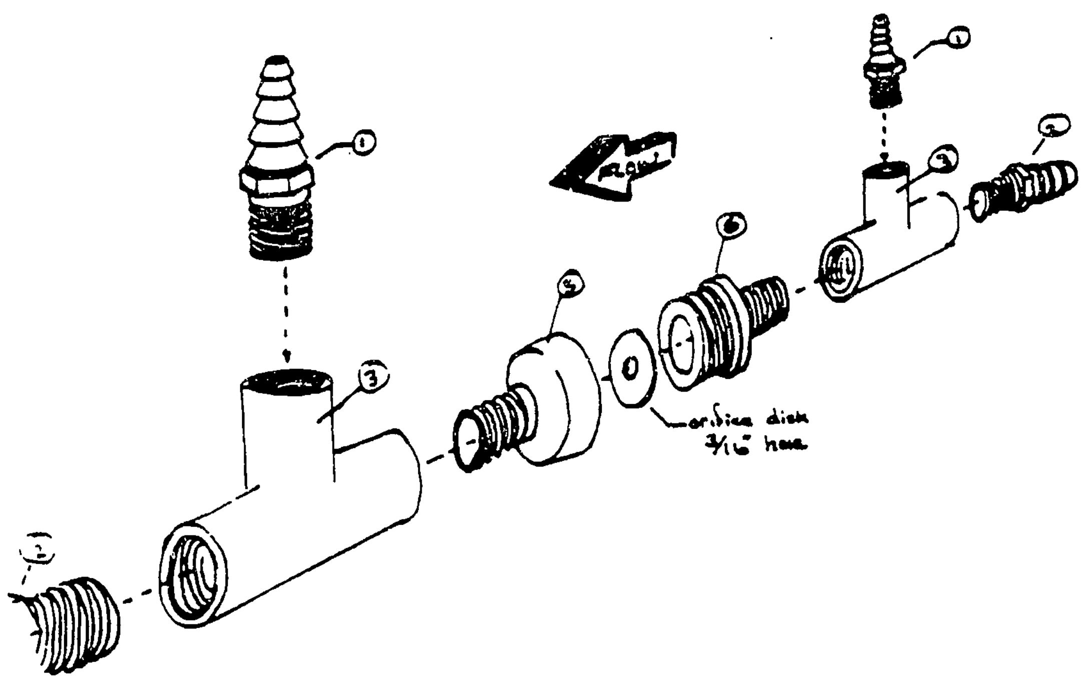
12/01/8

Principles of Technology
DESIGN NOTES ON SPECIAL EQUIPMENT

Item Name: Liquid Flow Orifice Item No. 233

MATERIALS

Adaptors NPT to nipple for tubing 1
Adaptors NPt to nipple for hoses 2
PVC tees NPT type 3/8" - 1/2" id 3
Orifice disk, copper 1 1/4" od x 1/16" t with 3/16" id hole
Male-female threaded coupler 5
Male-male threaded coupler 6



205

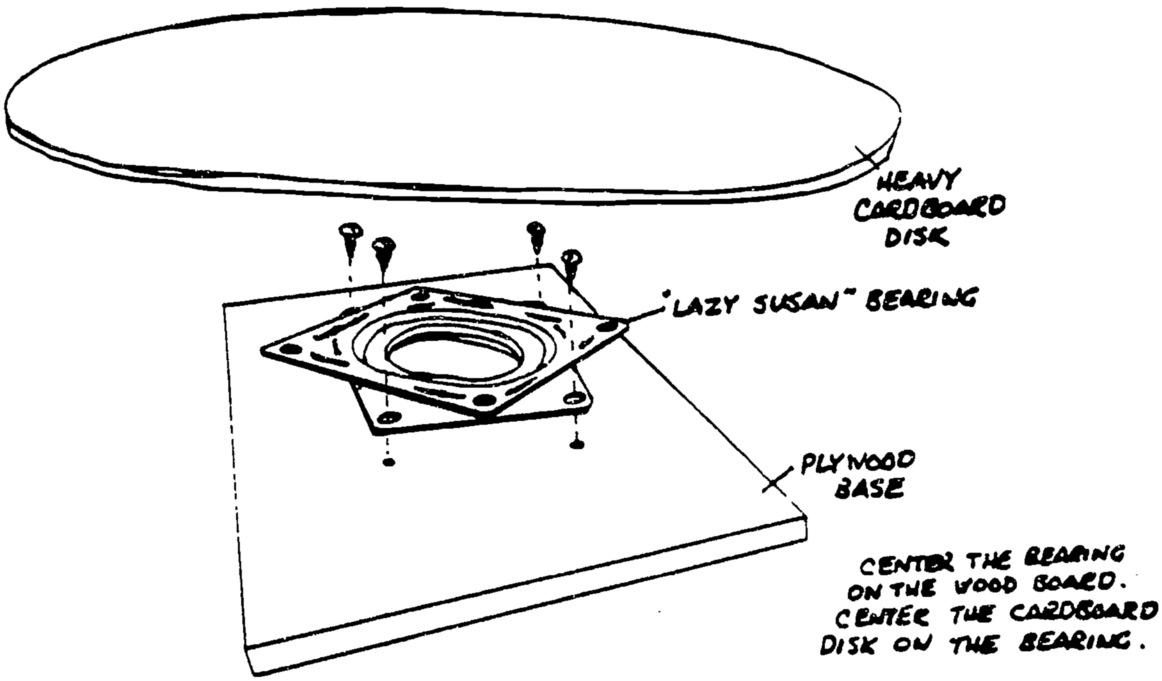
12/01/86

Principles of Technology
DESIGN NOTES ON SPECIAL EQUIPMENT

Item Name: Lazy Susan Optics Table | Item No. 240

MATERIALS

"Lazy Susan" 3" diam bearing
Wood base - plywood 1" x 1" x 5/8"
Heavy cardboard disk 17 1/2" diam with white matte finish
4 - wood screws
Adhesive



Center the bearing on the wood board. Center the cardboard disk on the bearing.

"Lazy Susan" is available in 3", 4", 6 1/8", and 12" sizes from Edmund Scientific Co with part no. H40,600 (3" size)

PRINCIPLES OF TECHNOLOGY: COST COMPARISON WORKSHEET

ITEM NO.	QUANTITY	VENDOR ______			VENDOR ______			NOTES OR COMMENTS
		CAT. NO.	UNIT PRICE	TOTAL PRICE	CAT. NO.	UNIT PRICE	TOTAL PRICE	

Useful Physics Software

Here is a list of some computer software that may be used to supplement instruction and in-depth discussions about various *Principles of Technology* topics. George Taliadouros of Minuteman Regional Vocational Technical School District in Lexington, Massachusetts, is currently using these materials in his *PT* and physics classes.

The author has volunteered to try to update this list as often as possible. In addition, R. G. Dunn and Jim Everett of Platte County Area VoTech School in Missouri would like to know of any mathematics or other software that *PT* instructors are successfully using. Send any information to the *PT Newsletter*.

Methods and Measurements

Title	Type*	Computer	Status*	Publisher
1. Mass Spring	S	Apple	P	CDL
2. Math for Science Series	T	Apple; PET	P	Merlan
3. Measurements: Length, Mass & Volume	T	Apple; Commodore 64	P	Focus Media
4. Discovering the Scientific Method	S	Apple; TRS 80	P	Focus Media
5. The Metric System	T	Apple	P	COMpress
6. Isaac Newton & F.O. Newton	S	Apple; TRS 80; Atari; PET	P	Krell

Force, Motion and Energy

Title	Type*	Computer	Status*	Publisher
7. Vectors & Graphing	T	Apple	U	Cross
8. Flight Vector	S	Apple	P	EduSoft
9. Vector	S	Apple	P	EduTech
10. Vector Addition	D	Apple	U	Vernier
11. Kinematics	D	Apple	U	Vernier
12. Motion	T	Apple; IBM	U	Cross
13. Projectile Motion Workshop	D	Apple	P	High Technology
14. Target	S	Apple	P	EduTech
15. Mechanics	D	Apple	P	EduTech
16. Projectiles	D	Apple	U	Vernier
17. Gravity Simulation	S	IBM	U	Cross
18. Circular Motion	T	Apple; IBM	U	Cross

Force, Motion and Energy (continued)

Title	Type*	Computer	Status*	Publisher
19. Statics	T	Apple; IBM	U	Cross
20. Rendezvous	S	Apple	P	Peachtree
21. Space Station	S	Apple	P	EduTech
22. Orbits	D	Apple	U	Vernier
23. Harmonic Motion Workshop	D	Apple	P	High Technology
24. Air Track Simulator	S	Apple	P	CDL
25. Conservation Laws	T	Apple; IBM	U	Cross
26. Yellow Light Problem	S	Apple	P	CDL
27. Saturn Navigator	S	Apple	P	SubLogic
28. Law of Motion	D	Apple; IBM; TRS 80	P	BME

Heat and the Structure of Matter

Title	Type*	Computer	Status*	Publisher
29. Energy House	S	Apple	P	MECC
30. Ideal Gas Law	S	Apple	P	High Technology
31. Gas Law Simulator	S	Apple	P	CDL
32. Three Mile Island	S	Apple	P	Muse

*Type: S (simulation); T (tutorial); or D (demonstration)

*Status: P (copy protected) or U (unprotected)

BEST COPY AVAILABLE

Wave Motion: Sound and Light

Title	Type*	Computer	Status*	Publisher
33. Waves & Vibrations Series	T	Apple; PET	P	Merlan
34 Wave Addition	D	Apple	U	Vernier
35. Harmonic Motion Workshop	D	Apple	P	High Technology
36 Standing Wave Workshop	D	Apple	P	High Technology
37. Optics: Mirrors & Beams	D	Apple	P	HRM Software
38. Ray Tracer	D	Apple	U	Vernier
39 Optics/Light Waves	S	Apple; IBM; TRS 80	P	EME
40 ChemDemos	D	Apple	P	CDL
41. Optics	T	Apple	U	Cross

Electricity

Title	Type*	Computer	Status*	Publisher
42. Electric Field	D	Apple	P	EduTech
43. Basic Concepts of Electricity	T	Apple; PET	P	Merlan
44. Oil Drop	S	Apple	P	EduTech
45. Charged Particles	D	Apple	U	Vernier
46 Atomic Physics - 2	S	Apple	U	Programs for Learning

Electromagnetism

Title	Type*	Computer	Status*	Publisher
47. Charged Particle Workshop	D	Apple	P	High Technology
48 Electricity & Magnetism	T	Apple	U	Cross

Modern Physics

Title	Type*	Computer	Status*	Publisher
49. Atomic Physics	T	Apple	U	Cross
50 Atomic Physics - 2	S	Apple	U	Programs for Learning

Publishers' Addresses

Cambridge Development Laboratory (CDL)
100 Fifth Avenue
Waltham, MA 02154

COMpress
P.O. Box 102
Wentworth, NH 03282

Cross Educational Software
1802 N. Trenton Street
P.O. Box 1536
Ruston, LA 71270

Educational Materials and Equipment (EME)
P.O. Box 17
Pelham, NY 10803

EduSoft
P.O. Box 2560
Berkeley, CA 94702

EduTech
303 Lamartine Street
Jamaica Plain, MA 02130

Focus Media
839 Stewart Avenue
P.O. Box 865
Garden City, NY 11530

High Technology Software
1611 NW 23rd Street
Oklahoma City, OK 73106

HRM Software
175 Tompkins Avenue
Pleasantville, NY 10570

Krell Software
1320 Stony Brook Road
Stony Brook, NY 11790

Merlan Scientific
247 Armstrong Avenue
Georgetown, Ontario
CANADA L7G 4X6

Minnesota Educational Computing Consortium (MECC)
2520 Broadway Drive
Lauderdale, MN 55113

Muse Software
347 N. Charles Street
Baltimore, MD 21201

Peachtree Software
3445 Peachtree Road
Atlanta, GA 30326

Programs for Learning
P.O. Box 954
New Milford, CT 06776

SubLogic Corporation
210 W. Springfield
Champaign, IL 61820

Vernier Software
2920 SW 90th Street
Portland, OR 97225

*Type: S (simulation); T (tutorial); or D (demonstration)

*Status: P (copy protected) or U (unprotected)

Outcomes Activity Guide 6

1. Outcome:

   Describe the mechanics and logistics for laboratory management, safety, inventory control, grading and other problems which arise during the planning, preparation and delivery for a Principle of Technology program.

2. Methods:

   Oral presentation and discussion

3. Resources and Materials Needed:

   A. Information Sheets:

      IS-9, Lab Design and Facilities Considerations
      IS-10, Lab Management
      IS-11, Grading

   B. Principles of Technology Safety Supplement

4. Suggested Activities:

   A. Using information sheet IS-9, make a presentation on lab design and facilities considerations.

   B. Using the safety section of information sheet IS-9 and the Principles of Technology Safety Supplement make a presentation on each of the topics covered in the supplement.

   C. Using information sheet IS-10, make a presentation on lab management.

   D. Have workshop participants form into small groups and develop a set of general safety, management operating procedures for a Principle of Technology lab. Share and discuss results among groups.

   E. Using information sheet IS-11, make a presentation on grading.

LAB DESIGN AND FACILITIES CONSIDERATIONS

The design and supporting systems of a Principles of Technology lab are critical to its safe and successful operation. Consideration in respect to size, utility services, storage, furniture arrangement and safety, must be carefully reviewed in the construction of a new facility or in the renovation of an existing one. Each one of these categories are developed for your reference:

SIZE

The major factors that will influence the size of the lab facility include: (1) student load, (2) apparatus requirements, (3) location of utilities, (4) budget, and (5) whether it would be for dedicated subject use or multiple-subject use. Except for apparatus requirements, all of the factors listed may vary from school to school.

The optimal student load is between 12 and 18 students. In practice, the number of students is often 24. Generally, the dedicated lab should have a minimum space allotment of 40 square feet per student. This allotment includes work space, storage space and access space. The classroom/laboratory multiple-purpose room has different space requirements. Multiple-purpose classroom/laboratory sizes can be determined by applying the following formula:

$$\begin{array}{c}\text{Section capacity}\\ \text{in number}\\ \text{of students}\end{array} \times \left[\begin{array}{c}\text{Laboratory space}\\ \text{@ 40 ft 2/student}\end{array} + \begin{array}{c}\text{Classroom space}\\ \text{@ 15 ft 2/student}\end{array}\right] = \begin{array}{c}\text{Minimum}\\ \text{space}\end{array}$$

For rooms to be used as labs for more than one subject, additional storage space must be provided for specialized apparatus and supplies.

UTILITY SERVICES

When the maximum number of lab work stations has been identified and the size of the room determined, the requirements for utility services should be considered. Utility services include: electricity for outlets and lighting and the piped services of gas (optional), compressed air, water and drain. Related considerations are the number of connections to each service, the arrangement of service connections, and the safety devices and precautions built into the utility service systems.

FURNITURE

Lab furniture is generally found in two basic designs: low-form and standard. Low-form furniture is 28 to 30 inches from the floor to the top working surface and is intended to be used by students who are seated. Low-form furniture may or may not have drawers or cabinets. Traditional or standard furniture has a floor-to-working-surface distance of 36 to 38 inches and normally has storage space consisting of drawers and/or cabinets. Lab furniture may be placed against the walls--jutting out into the room in peninsula fashion--or it may be isolated from the walls in an island style. The island style provides the greatest efficiency and maximum flexibility. Many companies manufacture lab furniture with various arrangements of storage areas and utility service outlets.

Although lab furniture can provide a great deal of room for storage, it may not provide a total solution. If additional storage space is needed, storage cabinets or a separate storage room may be necessary. In all instances, the issue of security and safety of stored items must be given serious consideration.

SAFETY

The promotion of safety in a Principles of Technology lab is ultimately the responsibility of the teacher. Safety instruction and the practice of safety is necessary throughout all aspects of Principles of Technology activities. You as a Principles of Technology teacher must serve as a role model for safe practices in the classroom and lab. It is recommended that general safety rules and procedures be developed and followed by all in each Principles of Technology lab. Further, it is recommended that specific safety instruction be provided as an element of each lab activity.

Electricity provides power for lighting and for activating many of the devices used in lab experiments. Most electrical service needed is single-phase, 120-volt A.C. The amount of light needed at bench-top surface varies with the type of activity to be performed. A general rule of thumb is that it should never be less than 100 candle power. Fluorescent lighting that's set diagonally to the orientation of work surfaces maximizes the amount of light reaching the work surface, regardless of the student's position. Lighting circuits should be isolated from those circuits that provide power to outlets present in the lab.

Electricity must be delivered at workbench outlets according to a unique scheme. Each workbench should have its own circuit or circuits, with each protected by its own circuit breaker. Ideally, a workbench with 10 lab stations should have two 20-amp circuits, with each circuit providing half the power to each lab station. This arrangement prevents the disruption of power at all lab stations if one circuit becomes interrupted or overloaded. Each outlet should be color-coded by circuit. The circuit breaker may be located remotely from the bench; however, cutoff switches for each circuit should be located at one end of the bench.

During one of the Principles of Technology conferences in Harrisburg, a safety hazard associated with the Principles of Technology labs was discussed at length. The problem dealt with the combined use of electricity in close proximity to water in many of the labs. It was pointed out that the technology to make these labs safe for students under these conditions exists and should therefore be used. Ground-Fault-Interrupt receptacles can be used as sources of electricity for power supplies. Once these are installed in the lab, they should be used for all the labs that require 110 volt A.C. current.

Ground-Fault-Interrupt receptacles and breakers work by sensing the balance of current in a circuit. If an imbalance (an electrical short or grounding) of current is sensed in the circuit, the current is interrupted instantly. The protection offered by these devices makes it possible to do the kinds of labs encountered in Principles of Technology safely. Since the technology exists to do the lab safely, there is no justification to put ourselves and our students at risk. No Principles of Technology laboratory should be without ground-fault-interrupt protection.

Some utility services can be portable or permanently installed. Compressed air and vacuum can be provided by the use of portable manual or electric pumps. Gas can be provided by portable torches or bottled compressed gas, connected by hose to a burner. The decision to use a portable alternative in place of permanent installation of pipes is usually based upon frequency and quantity of use, economics and convenience.

Water service can be a particularly troublesome problem in retrofitting a room for lab use. It's little trouble to bring water in; the difficulty is in getting the water out. Traditionally, the drains need to be installed either below floor level or through a wall. If a drain is installed into the floor, cutting a trench in a cement floor can be very costly. Taking the drain through a wall results in the use of peninsula lab benches rather than the more efficient island lab benches. One innovation in retrofitting that may be used is a drain basin below a lab sink fitted with a sump pump; this may simplify the removal of water from a renovated lab.

Some lab activities may involve the use of or production of substances that can be potentially noxious or toxic. Therefore, ventilation requirements must be considered. Requirements on this topic vary and in some instances may be in a state of evolution. Safe practice dictates that no fumes should be inhaled. For further advice, refer to appropriate manufactures information, Material Safety Data Sheet (MSDS) or OSHA.

All electrical service and other utilities used in a Principles of Technology laboratory should be installed and used in compliance with the National Electrical Code, and any other appropriate federal, state and local code requirements and/or regulations.

The issue of personnel safety, equipment safety, and security is of increasing concern. Society's growing awareness of hazards and the increased willingness of many citizens to pursue damages through legal action also motivate attention to safety. The overriding concern should not be "Must a given device be present by law?" but "Should this device be present and what practices must be followed to safeguard the health and safety of students?" We must recognize that the potential for injury is greater in the lab than in the classroom and be willing to take extra steps to protect the students for whom we are responsible.

The lab is an area of increased hazard. Therefore, you should place great emphasis on safety. This emphasis can be accomplished through the installation of safety devices and the enforcement of safety procedures. We've already cited the use of ground-fault-interruption devices, circuit breakers and separate disconnect switches for each circuit of each bench. There should also be an emergency electrical disconnect switch for all electrical circuits in the lab except for the main room lighting circuit. This emergency switch should be wired to deactivate all gas and water utility services and to activate an alarm. Such an arrangement is called a "scram circuit." The scram switch should be placed near the main room exit, and can be placed behind a breakable glass window in order to discourage pranksters.

The practice of safety precautions should be routine. Cabinets, drawers and separate storage areas should be locked when not in use. Students should be required to memorize and practice all safety procedures. Personal protective equipment such as aprons, safety glasses, gloves, etc., should be provided and required as conditions warrant. Class "C" fire extinguishers should be included in the lab and inspected on a regular basis. In order to avoid contact or entanglement with anything hazardous, jewelry, rings, chains and watches should be removed and loose clothing and long hair should be tucked in or restrained. There should never be fewer than two people in an area when experiments are being performed. The two persons rule is particularly important when high voltages are present.

No lab work should be performed in the absence of qualified supervisory personnel. Instructors and lab assistants who are responsible for conducting lab experiments should be familiar with the various federal, state and local laws and regulations governing safety and health as well as the use and control of toxic or explosive substances and certain hazardous equipment. An excellent source for information in these areas is the Pennsylvania Industrial Arts/Technology Education Safety Guide, third edition and is recommended as a reference for maintaining a safe environment in the Principles of Technology lab. Selected sections of this guide have been reproduced and have been included in the form of a Safety Supplement for your reference. Included in the supplement are sections on: Teacher Responsibility, Pennsylvania Regulations, OSHA, Emergency Action, Safety for Special Needs Students, Hazardous Substances, Material Safety Data Sheet (MSDA), Electrical and Fire Safety, Personal Protection, Eye Safety, PA Act 116 and Teacher Liability.

File B:Labdesig

LAB MANAGEMENT

A well organized and maintained lab facility for Principles of Technology will contribute to student success and achievement. Field tests and feedback from operating Principles of Technology programs indicate that students enjoy the laboratory aspect of the course. Further it has been consistently shown that students spend about 40% of their time in a Principles of Technology course conducting lab activities. Due to its importance to the success of a Principles of Technology program, the following points on lab management have been provided for your reference:

1. Lab activities provide an opportunity for students to conduct experimentation and learn through doing. They also provide an opportunity to develop procedures and practices that should be safe, orderly and neat. Your actions as a teacher should serve as a role model and contribute to the development of these behaviors.

2. To facilitate the maximum use of space and the economy of equipment it is important to organize students into teams of 2 to 4 to complete lab activities. These lab teams can remain the same or change in composition on a scheduled basis.

3. The lab facility should be properly heated, air-conditioned, ventilated and lighted in order to promote safe and efficient student activity.

4. It is important to set up and maintain an inventory system to keep records on equipment and supplies. This will help prepare budgets from year to year and allow you to be aware of the condition or availability of lab items. An inventory system can be set up on index cards or on a computer file.

5. A check out procedure can be set up and used to keep control and maintain accountability of lab items.

6. Students can be assigned rotating responsibilities for the maintenance up-keep of the lab.

7. Specific guidelines, rules and procedures should be developed to aid student activity and behavior while in the lab.

8. Don't assume your students really know how to use a meter or any of the other instruments in the lab. You may want to give specific instruction coupled with practical activities to aid students on their ability to use the equipment in order to successfully complete a lab assignment.

9. In many cases, students will work together on labs. You should keep tabs to see that the distribution of work is rotated in order to eliminate the possibility of one student doing all the work. You may also want to rotate partners--or make sure students take turns doing the same experiment or different experiments.

10. As a cost cutting consideration, a Principles of Technology lab may be set up with 1/2 of the equipment to do selected labs. In operation this will work with two rotating groups of students; with one group doing Lab 1 while the other group is doing Lab 2. After both groups are done; they rotate. Although this approach can not be used for all labs, it is effective in many and should therefore be considered.

11. There are some times when students must rotate between labs. There are other times when students will all be doing the same thing at the same time. Sometimes, they'll use the same equipment, but will do different things. Be sure to point out--and emphasize--these distinctions to your students in order to eliminate confusion.

12. There may also be labs where there will be only one lab setup for the entire class. This is a case where the lab portion is more like a detailed, highly structured demonstration. Students must still participate, however, if the lab is to be used to its best advantage. Students can take data or take turns doing some portion of the lab so that they can see what's happening first-hand.

13. The first time you teach Principles of Technology, you should do the lab yourself before you have the students do it. This way, you can find any surprises or variation. Some surprises may be helpful in structuring a more creative lab than you find in the text.

14. The labs in the text are written to a large general audience. Therefore, there may be times when you can add to the lab in the book by adapting labs according to available equipment at your location. As you know, these labs were written with equipment cost and availability in mind. You may have other equipment that can be used to demonstrate the ideas in the lab in different ways.

15. The purpose of the labs are twofold. You don't just want your students to see the experiment. You also want your students to get practice in setting up the equipment and using it. You're trying to get your students to think with their hands as well as with their minds.

16. It is recommended that labs be scheduled in a double class period. If this is not possible, plan on using two single class periods on consecutive days to complete the majority of the Principles of Technology Labs.

GRADING

Grading students in a Principles of Technology program will differ due to school policies, the delivery format of the program and the preference of the individual teacher. Although the grades will be influenced by several situational factors, the grades should be based on objective criteria, reflect classroom and laboratory activities and provide for accurate measurement of student achievement.

Two examples of grading systems used in different Principles of Technology programs are presented for your reference. The first example is from an AVTS in Pennsylvania:

- Grading System 1 -

Student grades are based on the following components:

25% - Ability to meet objectives (sub-unit and unit tests)
25% - Assignments (math, labs, student exercises and worksheets)
25% - Lab activities
25% - Notebooks

Students are informed of their current grade status on a weekly basis. At the start of each five day cycle a computer printout of student grades, by student number, is posted on the bulletin board in the classroom. This report contains all of the scores for each student for the grading period, as well as an approximate final grade. If a student has been absent, he/she can find out what was missed by looking at this report. Makeup work is due before the next report is posted (10 school days). If the student does not assume the responsibility of making up missed work within 10 school days, a 0 (zero) is recorded for those items. This causes students to be aware of what goes on in the class when they are absent. It also serves to cut down the number of absences.

The second example is from a comprehensive high school in Texas:

- Grading System 2 -

Student grades are based on the following components:

25% - Student lab notebook
25% - Student exercises and Math labs
25% - Sub-unit tests
25% - Unit tests

The grades in the student lab notebooks are determined through a review of: (1) data collection and calculations, (2) answer to lab wrap-up questions, (3) student comments on lab activities and (4) student conclusions on lab activities (student comments and conclusions on lab activities are presented as a brief narrative report). Each of these four student lab notebook grade areas receive equal value. Lab notebook grades are computed on a weekly basis.

Student exercises and Math labs, sub-unit tests, and unit tests are computed as progress dictates. Communication of student progress is continuous throughout the program. Students are aware of their grades on a weekly basis and understand their responsibilities toward the achievement of their grades.

file b:grading

PRINCIPLES OF TECHNOLOGY

SAFETY SUPPLEMENT

This Safety Supplement for Principles of Technology is composed relevant material selected from the third edition of the Pennsylvania Industrial Arts/Technology Education Safety Guide.

- Contents -

Copies of the complete Safety Guide may be available in your school or Intermediate Unit. If not, copies can be requested through the Planning, Development and Evaluation Section of the Division of Vocational and Adult Education, The Pennsylvania Department of Education, 333 Market Street, Harrisburg, PA 17126-0333; (717) 783-6592.

THE TEACHER

The major responsibility for laboratory safety instruction in accident prevention falls on the teacher. The following are considered the responsibilities of the teacher in a comprehensive accident prevention program in school laboratories.

1. Incorporate safety instruction in the course of study and maintain documentation as to who received instruction and when instruction was given.

2. Present instruction on potential hazards and accident prevention specific to the particular school laboratory.

3. Instigate a comprehensive safety program for your particular school laboratory.

4. Develop specific safe practices, rules, and regulations relating to your facilities and provide for their enforcement.

5. Keep informed of new and accepted safe practices for accident prevention.

6. Provide proper instruction in the use of all tools, machines and equipment. Keep a record of each student's attendance, safety training, and safety evaluation.

7. Require that a student be enrolled in the industrial arts/technology education program and receive the required safety instruction prior to working in the laboratory.

8. Set a proper safety example for students to follow.

9. Insist that adequate eye protection be worn in all industrial arts/technology education laboratories at all times in accordance with Act 116 as found in this document.

10. Insist on proper protective equipment in all laboratory areas and require students to wear proper clothing and adequate hair guards while working in the laboratory.

11. Devise and enforce safe housekeeping procedures.

12. Insist that guards meeting accepted standards be provided and used whenever a machine is operated.

13. Establish and maintain the safest possible working environment.

14. Have set, pre-planned procedures in case of an accident or emergency.

15. Provide prompt and thorough reports of accidents including:

    a. Written report by instructor.

    b. Written accounts by witnesses.

    c. Photographs of accident scene and conditions.

16. Always provide for the supervision of students in the classroom or laboratory in accordance with legal requirements.

    NOTE: DO NOT LEAVE THE CLASSROOM UNSUPERVISED AT ANY TIME WHEN STUDENTS ARE PRESENT.

17. Be aware of the emotionally disturbed and accident repeater student.

18. Regularly review laboratory facilities to maintain safe conditions. Give special attention to:

    a. Layout.

    b. Utilities and building services.

    c. Equipment guarding.

    d. Storage and condition of tools.

    e. Storage, labeling and handling of materials.

19. Make recommendations to the administration for improving safety conditions.

20. Carry out recommendations of the administration for improving safety instruction.

224

PENNSYLVANIA REGULATIONS

Legislation in Pennsylvania exists and is applicable to school safety and health. This includes the Worker and Community Right-to-Know Act, Act No. 159 of 1984, and the General Safety Law, Act No. 174, which has been in effect since 1937. The Right-to-Know Act is briefly covered in this guide under the section "Hazardous Substances." The General Safety Law contains provisions aimed at controlling specific hazards. The sections of this law most applicable to industrial arts/technology education are as follows:

Section 2. General Safety and Health Requirements.

1. All establishments shall be so constructed, equipped, arranged, operated, and conducted as to provide reasonable and adequate protection for the life, limb, health, safety, and morals of all persons employed therein.

2. All belts, pulleys, gears, chains, sprockets, shafting, and other mechanical power transmission apparatus, stationary engines, electrical equipment, and apparatus shall be properly guarded to protect workers from injury.

3. All cranes, hoists, steam or electric shovels, plant railroads, and other apparatus or devices used for moving, lifting, lowering, and transporting material shall be designed, constructed, equipped, and operated as to eliminate dangerous conditions.

4. The point of operation of all saws, planers, jointers or other power driven woodworking machines and all power presses, planers, shapers, and other power driven machine tools, and dangerous parts of any other machines or devices shall be provided with guards approved by the Pennsylvania Department of Labor and Industry. Laundry machines, extractors, washers, ironers, and other machines or apparatus shall be provided with guards where, because of accident hazard, they are required by the Department.

5. All toxic and noxious dusts, fumes, vapors, gases, fibers, fogs, mists or other atmospheric impurities, created in connection with any manufacturing process, emitted into or disseminated throughout areas where persons are employed in such quantitites as, in the opinion of the Department, would injure the health of employees or create other dangerous conditions, shall be removed at the point of origin, or, where this is impractical, personal protective devices shall be provided and worn by persons subjected to such hazards.

6. When employees, due to the nature of employment, are subject to injury from flying particles, falling objects, sharp or rough surfaces or materials, hot, corrosive or poisonous substances, acids or caustics and injurious light rays or harmful radioactive materials, they shall be provided with, and shall wear, goggles, other head and eye protectors, gloves, leggings, and other personal protective devices (as last amended by the Act of July 13, 1953, P. L. 438).

Section 3. Lighting, Heating, Ventilation, and Sanitary Facilities.

All establishments shall be adequately lighted, heated, and ventilated. Proper sanitary facilities shall be provided in sufficient number for the persons employed, and shall include toilet facilities, washing facilities, dressing rooms, retiring rooms for women, and wholesome drinking water of approved quality.

Section 5. Floor Space.

The floor space of workrooms in any establishment shall not be so crowded with machinery as to thereby cause risk to the life or limb of any employee. Proper, clear aisle space shall be maintained where necessary for employes to walk between machines, equipment or material. Machinery shall not be placed in any establishment in excess of the sustaining power of the floors and walls thereof.

Section 6. Removal of Guards.

No person shall remove or make ineffective any safeguard, safety appliance or device attached to machinery except for the purpose of immediately making repairs or adjustments, and any person or persons who remove or make ineffective any such safeguard, safety appliance or device for repairs or adjustments shall replace the same immediately upon the completion of such repairs or adjustments.

Section 7. Prohibited Use of Dangerous Machinery.

If any machinery, or any part thereof, is in a dangerous condition or is not properly guarded, the use thereof may be prohibited by the Secretary of Labor and Industry or his authorized representative, and a notice to that effect shall be attached thereto. Such notice shall be removed only by an authorized representative of the Department after the machinery has been made safe and the requirement safeguards are provided, and in the meantime such unsafe or dangerous machinery shall not be used.

Section 8. Air Space for Workroom.

The owner, agent, lessee, or other person having charge or managerial control of any establishment, shall provide or cause to be provided not less than two hundred and fifty cubic feet of air space for each and every person in every workroom in said establishment where persons are employed.

Also, the Pennsylvania Fire and Panic Act, No. 299, adopted in 1927, contains safety provisions pertaining directly to the facility. The basic requirement of this Act is located in Section I and is as follows:

General Requirement.

Every building enumerated in this Act, erected or adapted for any of the purposes of several classes of building covered by the act (schools and colleges are Class I), shall be so constructed, equipped, operated, and maintained, with respect to type of construction and materials used, fireproofing, number and type of ways of egress, aisles and passageways, stairs and fire escapes, wall openings, exits and exit signs, doors and doorways, shaftways and other vertical openings, emergency lighting, automatic sprinkler systems, fire alarm systems, fire drills, electrical equipment, inflammable and explosive materials, heating apparatus and fuel storage, number of occupants, ventilation, arrangment of seating and standing space, construction and equipment of stages, projection rooms, and dressing rooms, and all other fire and panic protection as to provide for the safety and health of all persons employed, accommodated, housed, or assembled therein. . .

OSHA

The Williams-Steiger Occupational Safety and Health Act (OSHA) or Public Law 91-596 was passed in December 1970 and became law on April 28, 1971. As it states, the law was enacted in order to:

> ..."assure so far as possible every working man and woman in the Nation, safe and healthful working conditions and to preserve our human resources..."

The law recognizes employee safety and health as public problems rather than private or individual concerns.

The OSHA standards contain four major categories: general industry, construction, maritime, and agriculture. Implementation is to be conducted in the following six ways:

1. Encouraging employers and employees to reduce hazards in the workplace and start to improve existing safety and health programs.
2. Establishing employer and employee responsibilities.
3. Authorizing OSHA to set mandatory job safety and health standards.
4. Providing an effective enforcement program.
5. Encouraging the states to assume the fullest responsibility for administering and enforcing their own occupational safety and health programs that are to be at least as effective as the federal program.
6. Providing for reporting procedures on job injuries, illness, and fatalities.

Pennsylvania public schools are not presently covered by OSHA because no state plan has been developed. However, many of the OSHA standards have been adopted and enforced by insurance companies and other agencies. Thus, many of the OSHA standards are being enforced even without formal adoption.

Areas of operation in which school districts can and should voluntarily attempt to comply with OSHA standards include:

1. <u>Hand-tool, Machine, and Equipment Safety</u>.

   The design and physical condition of every item included in an industrial arts/technology education laboratory must be good. Substandard items should be renovated or replaced by pieces known to be well designed and constructed.

2. <u>Safety in Working with Hazardous Materials</u>.

   Exposure to hazardous materials must be minimized and, if necessary, eliminated. Appropriate protective equipment, such as paint masks, should be available and its use enforced.

3. Training in Safety and Health Requirements.

Teachers and students should be taught to recognize work hazards and potentially dangerous environmental conditions.

4. Fire Protection.

All necessary fire protection devices and services, including fire extinguishers, sprinkler systems, and fire department assistance, should be available.

5. Physical Plant Design.

The physical plant in which an industrial arts/technology education program is carried on must be planned so that it is free of safety and health hazards. Key design features of such a structure include adequate space, proper storage of materials, a good arrangement of rooms, and an effective organization of equipment.

6. Physical Plant Condition.

The floors, walls, partitions, ceilings, windows, doors, and other parts of a laboratory must be kept in good repair.

7. Air Environment.

Students and teachers must be able to work in air that is clean, fresh, safe, and comfortable. Effective heating, air conditioning, mechanical ventilation, and exhaust systems are necessary.

8. Visual Environment.

Natural and artificial lighting systems must be properly designed and maintained so that people working in a laboratory can see clearly and comfortably.

9. Auditory Environment.

Sound intensities must be reduced to a level at which hearing will not be damaged. It should be noted that hearing damage is a factor determined by both the intensity of the sound and the duration of exposure. Since instructors can not realistically limit lengths of exposure, it is most important that they seek preventive measures to reduce noise levels. These measures may include the use of noise absorbing materials and/or utilization of hearing protection devices that may reduce the risk of work-related hearing losses in the future.

10. Utility Service Systems.

Electrical, water, gas, and compressed air systems must be planned and constructed so that hazards related to the use of these utilities are minimal.

11. Housekeeping.

Laboratories must be kept clean and in good order at all times. Adequate storage of materials, especially waste products, is of major importance to laboratory safety.

12. Sanitary Facilities.

Drinking fountains, wash facilities, and restrooms must be well designed, in good operating condition, and cleaned regularly.

13. First Aid and Emergency Procedures.

Teachers, students, and civil service employees should be trained in basic first aid and emergency procedures.

14. Class Discipline.

Failure to have students abide by safety rules and safe practices can promote an unsafe work environment. Teachers must require the needed classroom/laboratory discipline to ensure a safe industrial arts/ technology education program for all students.

EMERGENCY ACTION

Emergency situations can arise anywhere in the school environment and the procedures for dealing with these events should be developed and approved by the individual administrative unit (district or building) prior to the start of the school year. These procedures should be reviewed and revised periodically to determine their effectiveness and to make necessary modifications. The following information is provided to serve as a guide for the individua district to develop their own emergency procedures.

WHEN AN INJURY OCCURS

There are two aspects of emergency procedures. The first concern is the activities that must be done immediately following the injury. The second concern is the actions that must be taken after the confusion has subsided and the injured party is treated.

PRIMARY CONCERNS

These relate directly to the injured party and the reduction of hazard to that person. The degree of emergency care would be dependent on the injury and the qualifications of the person administering the care. If the teacher is not qualified in first aid, he/she must only do the things that will assure no further damage to the injured personnel and immediately seek trained help. This might be limited to stopping the bleeding or covering a person in shock with a blanket. Although every teacher should be trained in basic emergency first aid, many are not. Serious damage to the injured can sometimes result when they are treated by a nervous, untrained, and panic-ridden teacher. The following basic steps are recommended as the first steps when an injury occurs:

1. Determine the extent and type of injury. If this is not possible, immediately obtain professional help.
2. Restore breathing, restore heartbeat, and stop bleeding if trained in these areas; if not, send for help.
3. Apply only the first aid that is necessary to preserve life. Do no more until trained help arrives.
4. Disperse crowd and keep injured and the surrounding area as quiet as possible.
5. Notify school nurse, principal, and immediate supervisor by sending other students to these people. Do not leave the injured alone.
6. If the injury is minor, (splinter, slight cut) send the student to the school nurse accompanied by another student. Do not send the injured student alone.
7. If a foreign particle has entered the eye, seek professional help. A teacher should never try to remove something from a student's eye. If a liquid has entered the eye (acid, etc.), immediately wash the eye in an eye wash and contact the nurse.
8. Notify parents and school officials.

It is the responsibility of the teacher to know what to do in case of an accident and also to know what not to do. This kind of information is best obtained through a variety of first aid courses offered through the Red Cross or other agencies. The first few seconds or minutes of a pupil's injury are sometimes the most critical and the action or inaction that the industrial arts/technology teacher may take could be crucial to the student's life.

SECONDARY CONCERNS

When the injured student has been administered to by professional help (nurse, ambulance crew or doctor) the concerns of the teacher are focused on the remaining students and the follow-up procedures in regards to the injury. Some action is necessary in the following areas:

1. Calm the other members of the class. Restore the situation to a safe environment. If the accident was serious, discontinue instruction for the period. The students will be too upset to perform effectively and may in fact be "accident repeaters" due to the accident.

2. Complete accident report in triplicate; one for school nurse, one for the principal and immediate supervisor, and one for the teacher's <u>permanent</u> file (to be retained until the injured pupil reaches age 18 or graduates or if the pupil is a special education student, retain permanently).

3. Analyze cause and effect of the accident and make <u>written</u> recommendations to the principal for corrective measures to be taken. (Retain a copy of this communication and subsequent action.)

4. Review and record safety practices, procedures, instruction, and student evaluation concerning the cognitive, psychomotor, and affective instruction that was delivered, and was intended to prevent this type of accident from happening.

5. Check on the results of the treatment of the injured pupil.

6. Follow-up in your classes with a discussion and instruction regarding the safe practices that were violated and contributed to the accident.

The procedures mentioned should also be followed for "almost accidents" to assure that the conditions that almost caused an accident are treated and eliminated from the laboratory environment.

EMERGENCY COMMUNICATIONS

Procedures established for emergency situations and accidents must contain the approved method of "who tells what to whom and when." To facilitate this communication, each industrial arts/technology education room should have access to a telephone with a direct outside line (for ambulance, fire, and police emergencies.) In addition:

1. All students should know the location of the telephone and be familiar with the emergency procedures and numbers.

2. All personnel in the laboratory should have access to the phone for emergency communications. (The telephone should not be locked in the teachers office.)

3. Emergency procedures and police, ambulance and fire department numbers and the procedure for dialing an "outside" line should be posted at each phone location.

COMMUNICATING SAFETY TO PARENTS

For years, industrial arts/technology education teachers have used "permission slips" to be sent home and signed by the parent permitting their child to participate in the laboratory. Many teachers believed that this "permission slip" relieved them of some or all of their responsibility and liability should an accident occur. IT DOES NEITHER OF THESE. The purpose of this type of communication is to:

1. Inform the parent of his/her child's participation in industrial arts/technology type activities.

2. Outline the safety instruction and procedures that are followed by the teacher and the district.

3. Obtain from the parent relevant information regarding any health problems that may have a bearing on their child's performance.

4. List the parents' telephone number(s) where they can be reached during school hours and list the name of their family doctor.

An illustration of what this communication to the parents might look like is included on the following page.

CIVIL RIGHTS MANDATE

The Rehabilitation Act of 1973, Section 504, was initially enacted into law to protect the civil rights of all handicapped Americans. The implementation regulations and enforcement provision did not become law until June 1977. Now, however, it provides greater opportunities for physically or mentally handicapped individuals.

The basic requirements of the law are summed up in the following section:

GENERAL PROVISION AGAINST DISCRIMINATION
Section 84.4

> Any program or activity which receives federal financial assistance (1) may not exclude qualified handicapped persons from aids, benefits or services; (2) must provide equal opportunity to participate or benefit; (3) must provide services as effective as those provided to the non-handicapped, and (4) may not provide different or separate services except when necessary to provide equally effective benefits.
>
> Services need not be identical to those provided to the nonhandicapped, but must be the equivalent to them and must afford an equal opportunity to achieve results in the most integrated setting appropriate to the person's "needs."

Mainstreaming is the result generally associated with Section 504. It puts students in a "least restrictive environment," usually a regular classroom or lab situation. When one or two special needs students are mainstreamed into a regular class, special safety considerations and/or precautions must be taken by the teacher. Such situations will have to be adapted to the individual needs of the student and the program.

GENERAL STATEMENT

The responsibility for safe working conditions in a school laboratory is the prime concern of the teacher and all the students who work in the facility. With this in mind, the instructor of industrial arts/technology education subjects should make a special effort to teach safety to the disadvantaged and handicapped students enrolled in his or her program. Many special students such as these will need added instruction in safety with emphasis on personal responsibility to themselves and others with whom they work. Initially, instruction should be given in a classoom setting for short periods using an abundance of visual aids to explain proper safety procedures. Small group demonstrations can also be very effective while using the actual machines and tools. Individual instruction should follow the small group demonstrations before the students actually use the equipment in the laboratory. In addition, safety reviews should be repeated at intervals to help reinforce safety procedures.

Industrial arts/technology education teachers must be alert at all times during the working sessions for unsafe conditions and actions by the special students, and should be ready to take remedial steps if needed. Other sections of this manual list specific safety procedures and lessons that the teacher should follow to instill safe working habits in the student with special needs.

SUGGESTED TEACHING TECHNIQUES

1. Be sure that eye protection is worn. Have the students remind each other that safety glasses must be worn.

2. Check out each student on the power tools that he or she is about to use. Review the safety rules from time to time with each student -- especially after a vacation or prolonged absence of the student. Be sure to document the reoccurance of this instruction.

3. Medical records should be checked to determine if any special students are subject to seizures, fainting spells, etc. If the teacher finds someone who has one of these conditions, that individual should be given additional monitoring while using all equipment.

4. Make students aware of the potential dangers of cleaning agents, cutting fluids, solvents, thinners, lubricants, etc.

5. Remind students periodically of the importance of keeping work areas clean and free of hazardous objects.

6. Proper discipline must prevail. The amount of horseplay will depend on the professional personnel and the rules established for the laboratory. If students are kept busy and supervised, discipline for the special student will not be a major problem.

7. Isolation of a special student when rules of the laboratory are violated has been found to be one of the most effective methods of discipline. Keeping the student separated from the rest of the group should last no longer than one class period.

8. Special students may have a tendency to wander about the laboratory area. They must understand that they have an area to which they are assigned and must stay there.

9. Testing of the special student's abilities should be done by continual observation by the teacher, and demonstration by the student. Evaluation should not be limited to tests requiring reading, writing, and comprehension.

10. The teacher should design jigs and fixtures that serve to promote a higher level of student success while using tools and machines.

11. Individualize the program of instruction as much as possible to modify the instructional method to meet the needs of the student.

12. Plan to reserve a portion of your facility that can be made free from noise, physical stimuli, and visual stimuli. This may help those students who are easily distracted by them.

13. Minimize access barriers to sinks, tool cabinets, doorways, machines, workbenches, sheives, desks, etc.

14. Accept the child as he or she comes to you. Keep in mind that the student's success depends not only upon his or her own characteristics and abilities, but also upon the teacher's attitude and the quality of the learning environment.

15. Employ the aid of the special education resource people on your school staff. These people are specialists who can provide you with valuable information in dealing with the problems of the special needs students enrolled in your program.

16. All students, including special needs students, respond very favorably to frequent verbal praise and reinforcement. A "hands-on" environment provides positive feelings of success and also offers reinforcement through the finished product.

17. Encourage heterogeneous grouping with the classroom. Placing the special student within a small group of students with various abilities will provide him with models for behavior in a laboratory or other industrial-type facility.

HEALTH EFFECTS OF HAZARDOUS SUBSTANCES

Many of the materials used in the industrial arts/technology education laboratory have to be considered hazardous because of their potential for causing acute and chronic health effects on both teachers and students. The extent of these health effects can range from such problems as a simple skin rash or headache to disorders of the lungs, blood, liver, kidney, eyes and central nervous system.

A hazardous substance includes any element, chemical compound, or mixture of elements or compounds which can cause personal injury and/or physical damage to equipment.

ROUTES OF ENTRY

Because we do not usually associate illnesses with chemical exposure, many signs and symptoms may be attributed to medical causes with which we are more familiar. However, chemicals in the form of unseen vapors, fumes, mists, gases, or dusts, can enter the body through the following routes:

1. inhalation,

2. absorption through the skin, eyes or mucous membrane,

3. ingestion.

Painting, gluing, and welding are just a few of the processes that produce air contaminants that can be readily inhaled by anyone in the laboratory. Absorption of chemicals is most likely to occur due to direct contact with products such as solvents and stains. However, some compounds used in painting and plastics are so toxic that they can be absorbed through the skin or even the eyes. Ingestion of chemicals is not very common in a school setting unless you eat or drink in the laboratory while someone is using toxic substances.

Proper handling, ventilation and/or respirator selection can control dangerous levels of toxic chemicals but teachers must be able to recognize when these substances are present and identify the correct means of controlling exposures.

MATERIAL SAFETY DATA SHEETS

In the right quantity and with the proper controls, any chemical can be used "safely." Unfortunately, some teachers lack the respect or knowledge of certain chemicals to assure safe use. However, information is available on every chemical used in the school laboratory. Chemical manufacturers and vendors are required to provide customers with this information in the form of a Material Safety Data Sheet (see sample MSDS). It should be noted that the Pennsylvania Worker and Community Right-to-Know Act requires school districts to keep MSDS's on file. Industrial arts/technology education teachers should request a copy of each form to be kept on file in the laboratory where used. The school's purchasing agent or other designated person responsible for gathering all the MSDS's will have to refer to an inventory of current chemical holdings in order to identify specific needs. Future purchases of chemical supplies should include a specific request for the appropriate MSDS to accompany shipment with a copy going to the laboratory where used.

While the quality of information on the MSDS varies, a properly written "Data Sheet" could be a valuable resource for preventing unnecessary injury and illness and for identifying actions to take in the event of exposure to a hazardous material. In addition to the health hazard data, the MSDS should contain the following information which should not be overlooked:

a. chemical name
b. formula
c. hazardous ingredients
d. physical data
e. fire and explosion data
f. health hazard data
g. reactivity data
h. spill or leak procedures
i. special protection
j. special precautions.

HEALTH HAZARD DATA

Improper use of, and over exposure to, chemicals frequently found in the industrial arts/technology education laboratories can lead to serious health hazards. In order to emphasize this fact, a list of materials, with possible health hazards and methods of protection, is presented below. When possible, general categories have have been used. However, because some substances are so toxic, they are also listed. In no way should this list be construed to identify all the toxic materials, health hazards or preventative measures which should be of concern to industrial arts/technology education teachers.

Substance (sample uses/sources)	Health Hazard	Protection
ACIDS - (storage batteries, printed circuit board etchent, electroplating chemicals)	Irritation of skin, nose, eyes, throat & respiratory system	Protective clothing, ventilation, avoid contact (flush eyes & skin with water for at least 15 minutes)
ADHESIVES - (contact cements, bonding agents)	Skin & respiratory problems	Ventilation, gloves, respirators
ASBESTOS - (brake linings, clutches)	Asbestosis, cancer	Respirators, disposable clothing, special purpose vacuums

Note: Products or operations involving asbestos should be avoided in the school laboratory.

Substance (sample uses/sources)	Health Hazard	Protection
CARBON MONOXIDE - (by-product of internal combustion engines)	Headache, nausea, confusion, also affects central nervous system, & cardio-vascular system	Ventilation (extreme caution recommended for indoor auto repairs)

Note: Even short term exposure to carbon monoxide can cause the above health hazards and/or asphyxiation.

CLEANING AGENTS - (parts de-greasing & housekeeping)	Irritation of eyes, nose, throat, skin	Ventilation, gloves, respirators

Note: Possible toxic by-products may occur when cleaning agents are heated or mixed with other chemicals, e.g., products with chlorine bleach should not be mixed with ammonia.

CUTTING FLUIDS - (machining)	Dermatitis, irritation of nose & throat, exposure to bacteria	Gloves, frequent washing, avoid contact with skin & eyes
FORMALDEHYDE - (plywood, particle board, insulation)	Irritation of eyes, nose, throat, respiratory problems, cancer	Ventilation, avoid contact with skin & eyes
METAL FUMES/DUSTS - (welding, cutting)	Respiratory problems, flu-like symptoms	Ventilation, respirators
PAINTS, STAINS, VARNISHES - (woodworking, graphics)	Symptoms vary according to specific ingredients but may include headache, insomnia, fatigue, dermatitis, lung & liver damage	Ventilation, respirators, avoid contact with skin & eyes
PETROLEUM DISTILLATES - (fuel)	Irritation of eyes, nose & throat, narcosis, cumulative blood effects	Proper storage, ventilation, avoid contact with skin & eyes
PLASTICS/RESINS - (plastic, manufacturing, special adhesive)	Headache, nausea, respiratory problems	Ventilation, respirators, avoid contact with skin & eyes
SOLVENTS, - (cleaning & degreasing of parts or equipment)	Cumulative systemic effects, narcosis, damage to liver, central nervous system	Ventilation, respirators, avoid contact with skin & eyes
WOOD DUST - (woodworking)	Respiratory problems, dermatitis	Ventilation, respirators, housekeeping

In order to identify specific symptoms, consult the Material Safety Data Sheet on each individual product. Remember that all the above signs and symptoms can be prevented through the use of proper handling procedures, ventilation and personal protective equipment.

Material Safety Data Sheet
May be used to comply with
OSHA's Hazard Communication Standard.
29 CFR 1910.1200. Standard must be
consulted for specific requirements.

U.S. Department of Labor
Occupational Safety and Health Administration
(Non-Mandatory Form)
Form Approved
OMB No. 1218-0072

IDENTITY *(As Used on Label and List)*	*Note: Blank spaces are not permitted. If any item is not applicable, or no information is available, the space must be marked to indicate that.*

Section I

Manufacturer's Name	Emergency Telephone Number
Address *(Number, Street, City, State, and ZIP Code)*	Telephone Number for Information
	Date Prepared
	Signature of Preparer *(optional)*

Section II — Hazardous Ingredients/Identity Information

Hazardous Components (Specific Chemical Identity, Common Name(s))	OSHA PEL	ACGIH TLV	Other Limits Recommended	% *(optional)*

Section III — Physical/Chemical Characteristics

Boiling Point		Specific Gravity (H_2O = 1)	
Vapor Pressure (mm Hg.)		Melting Point	
Vapor Density (AIR = 1)		Evaporation Rate (Butyl Acetate = 1)	

Solubility in Water

Appearance and Odor

Section IV — Fire and Explosion Hazard Data

Flash Point (Method Used)	Flammable Limits	LEL	UEL

Extinguishing Media

Special Fire Fighting Procedures

Unusual Fire and Explosion Hazards

(Reproduce locally)

OSHA 174, Sept. 1985

Section V — Reactivity Data

Stability	Unstable		Conditions to Avoid
	Stable		

Incompatibility (*Materials to Avoid*)

Hazardous Decomposition or Byproducts

Hazardous Polymerization	May Occur		Conditions to Avoid
	Will Not Occur		

Section VI — Health Hazard Data

Route(s) of Entry: Inhalation? Skin? Ingestion?

Health Hazards (*Acute and Chronic*)

Carcinogenicity: NTP? IARC Monographs? OSHA Regulated?

Signs and Symptoms of Exposure

Medical Conditions
Generally Aggravated by Exposure

Emergency and First Aid Procedures

Section VII — Precautions for Safe Handling and Use

Steps to Be Taken in Case Material Is Released or Spilled

Waste Disposal Method

Precautions to Be Taken in Handling and Storing

Other Precautions

Section VIII — Control Measures

Respiratory Protection (*Specify Type*)

Ventilation	Local Exhaust	Special
	Mechanical *(General)*	Other

Protective Gloves | Eye Protection

Other Protective Clothing or Equipment

Work/Hygienic Practices

* USGPO 1986-491-529/45775

This Is Your New ABCD's Of Portable Fire Extinguishers

A fire extinguisher is a storage container for an extinguishing agent such as water or chemicals. It is designed to put out a small fire, not a big one

An extinguisher is labeled according to whether the fire on which it is to be used occurs in wood or cloth, flammable liquids, electrical or metal sources. Using one type extinguisher on another type fire can make the fire much worse. So learn how extinguishers are labeled and used

Traditionally the labels A B C, or D have been used to indicate the type of fire on which an extinguisher is to be used

Recently pictograms have come into use. These picture in blue the type of fire on which an extinguisher is to be used. Shown in black with a red slash are pictures of fires on which the extinguisher is not to be used. For example, on a class A type, the following label would appear

NFPA 10, Standard for Portable Fire Extinguishers recommends that extinguishers be labeled with pictograms. However the user may find the traditional A B C D labels, or both the pictograms and the A,B C,D labels on an extinguisher

You need an extinguisher at home.

If you plan to buy one extinguisher, a multi-purpose dry chemical labeled ABC puts out most types of fires – wood, paper, and cloth, flammable liquid, or electrical fires.
If you buy more than one you might want to get a BC for the kitchen an A for the living room, and an ABC for the basement and garage

Fire extinguishers where you work.

It is management s job to have extinguishers available for use and your job to know how they work

Buying and maintaining an extinguisher.

1. Extinguishers come in dry chemical, foam, carbon dioxide, water, or halon types. Whatever type you buy, it should be labeled by a testing laboratory

2. The higher the number rating on the extinguisher, the more fire it puts out. High rated ones are often (not always) the heavier models. Make sure you can hold and operate the one you might buy for home use or be required to use at work

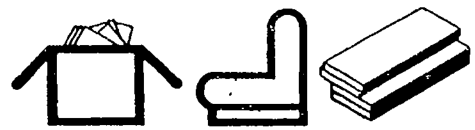
3. Ask your dealer how to have your extinguisher serviced and inspected. Recharge it after ANY use. A partially used one might as well be empty.

4. Extinguishers should be installed away from potential fire hazards and near an escape route.

5. For more details, see Standard for Portable Fire Extinguishers, NFPA 10.

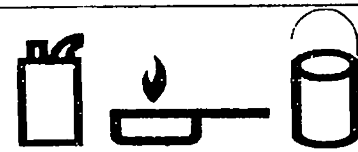
Ordinary Combustibles

Fires in paper, cloth, wood, rubber, and many plastics require a water type extinguisher labeled A.



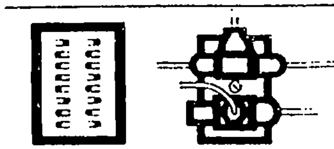
Flammable Liquids

Fires in oils, gasoline, some paints, lacquers, grease in a frying pan or in the oven, solvents and other flammable liquids require an extinguisher labeled B.



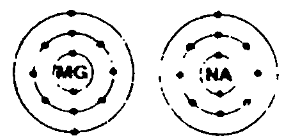
Electrical Equipment

Fires in wiring, fuse boxes, energized electrical equipment and other electrical sources require an extinguisher labeled C



Metals

Combustible metals such as magnesium and sodium require special extinguishants labeled D



BEST COPY AVAILABLE

This Is How Most Fire Extinguishers Work

1. Although the majority of extinguishers work with our directions, there are exceptions. Read the instructions on your extinguisher for variations.

Fix a picture in your mind that will fit the instructions on the extinguisher you will be using.

2. If there's a fire, get everyone outside. Call the fire department. Then fight a small fire only. If the fire gets large, get out. Close doors to slow the fire spread. Stay between the fire and an exit. Don't let fire block your escape path in case it goes out of control.

3. Make sure you don't use one type extinguisher on another type fire—it may make the fire worse. Common errors (they can be fatal) are using water (A) on a grease or on an electrical fire (B or C).

Learn How To Pass

1. Pull

Pull the pin. Some units require the releasing of a lock latch, pressing a puncture lever, or other motion

2. Aim

Aim the extinguisher nozzle (horn, or hose) at the base of the fire

3. Squeeze

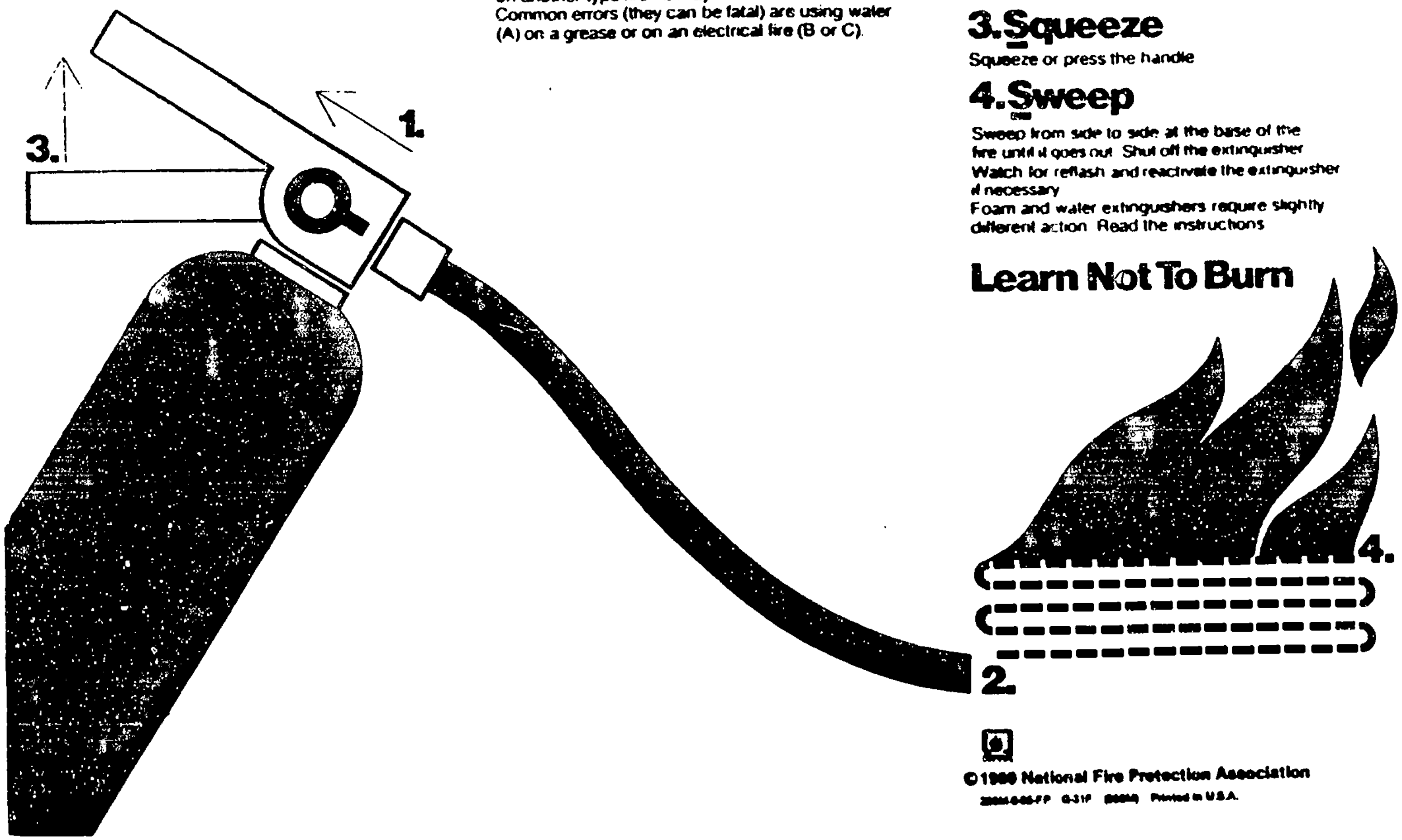
Squeeze or press the handle

4. Sweep

Sweep from side to side at the base of the fire until it goes out. Shut off the extinguisher. Watch for reflash and reactivate the extinguisher if necessary.

Foam and water extinguishers require slightly different action. Read the instructions

Learn Not To Burn



PERSONAL PROTECTION

1. Head

   a. Confine long hair so that it is not exposed to machinery.

   b. Provide hard hat where appropriate.

2. Eye-face

   a. Wear appropriate eye-face protective equipment in areas of known danger (See Eye-Face Protection Chart).

3. Respiratory

   a. Provide appropriate respirators for use where inhalation hazards exist. (See Respirator Chart).

   b. Ensure adequate ventilation for dusts, mists, fumes and vapors.

4. Body protection

   a. Loose clothing should not be worn in the laboratory.

   b. Rings and other jewelry should not be worn while working in the laboratory.

   c. Provide leggings, foot protection, armlets, gloves, aprons, and shields where appropriate.

5. Hearing

   a. Where noise levels are excessive over long periods of time, ear protection should be worn. (See Permissible Noise Exposure Table).

   b. Engineering solutions should be sought out to remedy excessive noise problems.

   c. Monitor noise levels with a Type 2 sound level meter using the "A" scale.

EYE PROTECTION

1. The law of the Commonwealth of Pennsylvania requires that eye protection programs be developed and implemented in all areas where there are activities potentially hazardous to the eye. (See "Act No. 116"). A procedure for adaptation for school districts is as follows:

   a. All administrators and teachers shall assess the eye exposures for which they are responsible and recommend the appropriate protection. This recommendation shall protect students, staff members, and visitors. (See Selection Chart - American National Standards Institute Z87.1-1968)

b. It is the responsibility of industrial arts/technology education instructors to see that eye protection is worn AT ALL TIMES in those areas that have been identified as exposure areas.

c. Eye protection shall be supplied and maintained by the school district and loaned without cost to students, staff members and visitors.

d. The physical inspection and periodic review of the eye safety program shall be the responsibility of a designated school district administrator for insuring the effectiveness of the eye protection program.

Reference is also made to the "American National Standard Practice for Occupational and Educational Eye and Face Protection", ANSI Z87.1-1968.

This program shall be rigidly enforced and monitored by all concerned. There should be no deviation from the program once it is accepted and put into use.

2. Students who require corrective lenses shall be encouraged to obtain prescription safety glasses. When plain prescription glasses are worn, the student should be required also to wear an appropriate cover goggle.

Caution: Most shatter-resistant glasses do not meet the standard of ANSI and many "safety glasses" also fail the tests and design features listed.

Contact lenses, even though covered by approved eye protection, shall not be worn in a laboratory setting at any time. If contact lenses are medically necessary and corrective glasses cannot be substituted for the lenses, a physician's statement and a parental release of liability shall be required.

3. Storage and sanitation facilities shall be provided within the classroom for all eye protection. School district's have found that they had better eye protection programs when individual glasses had been provided for each student enrolled in the industrial arts/technology education class.

Good eye protection devices require clean lenses. Lenses shall be cleaned daily.

Pitted or scratched lenses shatter easily and impair vision and should be replaced. If a protective device is to be worn by more than one student, it will require a means of disinfection. The most effective method of disinfecting eye protective equipment is:

a. Use ultra-violet sanitation cabinet.

b. Thoroughly clean with soap and warm water,periodically.

c. Carefully dry with non-abrasive tissue.

4. School officials who are charged with the purchase of eye protection equipment should be aware of the various accident classifications and purchase the appropriate eye protection for each exposure. The following four groups represent the classification of all eye accidents:

   a. Potential Hazards From Impact:

      Possibly the greatest danger to the eyes is their accidental collision with flying objects. Chips from the chipper hammer or the metal working tool, the waste particles from grinding or woodworking, a broken tool or grinding wheel, or an improperly driven nail are all eye exposures that must be protected against. Plastic frame safety glasses with side shields afford maximum eye protection against impact damage.

   b. Potential Hazards from Chemical Splash:

      Protection is needed that absolutely seals the eye against any possible entry. For these conditions, flexible vinyl jumbo plate goggles with splash-proof indirect ventilators should be worn.

   c. Potential Hazards From Dust:

      Where extreme dust hazards exist, plastic frame flexible goggles are more desirable. Safety glasses with side shields are also recommended.

   d. Potential Hazards From Light Ray and Glare:

      (1) The light rays cast from welding and cutting operations can be highly injurious to unprotected eyes. Heat treating, metal pouring, steel and glass furnaces, and LASER beams are other sources of glare.

      (2) In gas welding, cup type welding goggles with green filter lenses are most commonly used.

      (3) For electric welding, helmets are necessary to protect the head and eyes from infra-red and ultra-violet radiation burns, hot metals, chips and flying sparks.

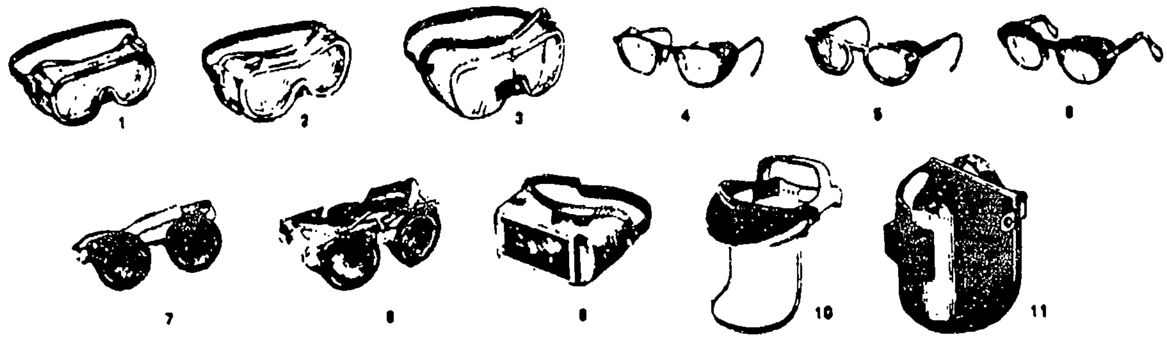
      (4) Contact lenses present specific hazards in the laboratory setting. The use of contact lenses is not permitted in the laboratory setting.

      (5) Photochromatic and phototropic (photosun-photogray) lenses must not be worn as protective eyewear where hazardous infra-red or ultra-violet radiation is present.

EYE AND FACE PROTECTION

Selection Chart

Recommended Eye and Face Protectors for Use in Industry, Schools, and Colleges



1. **GOGGLES**, Flexible Fitting, Regular Ventilation
2. **GOGGLES**, Flexible Fitting, Hooded Ventilation
3. **GOGGLES**, Cushioned Fitting, Rigid Body
*4. **SPECTACLES**, Metal Frame, with Sideshields
*5. **SPECTACLES**, Plastic Frame, with Sideshields
*6. **SPECTACLES**, Metal-Plastic Frame, with Sideshields
** 7 **WELDING GOGGLES**, Eyecup Type, Tinted Lenses (Illustrated)
7A **CHIPPING GOGGLES**, Eyecup Type, Clear Safety Lenses (Not Illustrated)
** 8 **WELDING GOGGLES**, Coverspec Type Tinted Lenses (Illustrated)
8A **CHIPPING GOGGLES**, Coverspec Type, Clear Safety Lenses (Not Illustrated)
** 9. **WELDING GOGGLES**, Coverspec Type, Tinted Plate Lens
10. **FACE SHIELD** (Available with Plastic or Mesh Window)
11. **WELDING HELMETS

*Non-sideshield spectacles are available for limited hazard use requiring only frontal protection.
**See appendix chart "Selection of Shade Numbers for Welding Filters."

APPLICATIONS		
OPERATION	HAZARDS	RECOMMENDED PROTECTORS: Bold Type Numbers Signify Preferred Protection
ACETYLENE–BURNING ACETYLENE–CUTTING ACETYLENE–WELDING	SPARKS, HARMFUL RAYS, MOLTEN METAL, FLYING PARTICLES	7, 8, 9
CHEMICAL HANDLING	SPLASH, ACID BURNS, FUMES	2, 10 (For severe exposure add 10 over 2)
CHIPPING	FLYING PARTICLES	1, 3, 4, 5, 6, 7A, 8A
ELECTRIC (ARC) WELDING	SPARKS, INTENSE RAYS, MOLTEN METAL	9, 11 (11 in combination with 4, 5, 6, in tinted lenses, advisable)
FURNACE OPERATIONS	GLARE, HEAT, MOLTEN METAL	7, 8, 9 (For severe exposure add 10)
GRINDING–LIGHT	FLYING PARTICLES	1, 3, 4, 5, 6, 10
GRINDING–HEAVY	FLYING PARTICLES	1, 3, 7A, 8A (For severe exposure add 10)
LABORATORY	CHEMICAL SPLASH, GLASS BREAKAGE	2 (10 when in combination with 4, 5, 6)
MACHINING	FLYING PARTICLES	1, 3, 4, 5, 6, 10
MOLTEN METALS	HEAT GLARE, SPARKS, SPLASH	7, 8 (10 in combination with 4, 5, 6, in tinted lenses)
SPOT WELDING	FLYING PARTICLES, SPARKS	1, 3, 4, 5, 6, 10

ACT NO. 116

No. 116

AN ACT

HB 159

Providing for the use of eye protective devices by persons engaged in hazardous activities or exposed to known dangers in schools, colleges and universities.

The General Assembly of the Commonwealth of Pennsylvania hereby enacts as follows:

Section 1. Every teacher, student, visitor, spectator, and every other person in any shop or laboratory in public or private schools, colleges and universities who is engaged in or is within the area of known danger created by

(1) the use of hot liquids, solids or gases, or caustic or explosive materials, or

(2) the milling, sawing, turning, shaping, cutting, grinding or stamping of solid materials, or

(3) the tempering, heat treatment or kiln firing of metals and other materials, or

(4) gas or electric welding, or

(5) the repairing or servicing of vehicles,

shall wear industrial quality eye protective devices at all times while engaged in such activities or exposed to such known dangers.

Section 2. Schools, colleges and universities shall have the power to receive Federal, State and local moneys and to expend the same to provide such devices and shall furnish such devices to all visitors and spectators and all other persons required under the provisions of this act to wear them.

Section 3. Enforcement of this act shall be in accordance with standards, rules and regulations promulgated by the State Board of Education.

Section 4. For the purposes of this act, "industrial quality eye protective devices" [1] mean devices meeting the standards of the American Standard Safety Code for Head, Eye and Respiratory Protection, Z2.1—1959, promulgated by the American Standards Association, Incorporated.

Section 5. This act shall take effect immediately.

APPROVED—The 19th day of July, A. D. 1965.

WILLIAM W. SCRANTON

The foregoing is a true and correct copy of Act of the General Assembly No. 116.

W. Stuart Helm

Secretary of the Commonwealth.

LESSON PLAN FOR EYE SAFETY

GOAL: To help students understand the need for eye safety equipment in the classroom.

OBJECTIVE: This lesson is intended as a general guide for the instructor at the very beginning of the course. It should be useful in making certain that every student becomes aware of potentially hazardous power equipment, tools, processes and chemicals in vicinity, and that he or she thereby learns and follows good eye safety practices.

CONTENT: The class is expected to learn the reasons for wearing eye protection through lecture, demonstration, and visual aids.

EQUIPMENT: Safety glasses, goggles, face shields and welding helmets when necessary. Safety glass monitor. Visual aids (see below) and audiovisual equipment. Eye safety posters and booklets.

PROCEDURE: Introduction - Point out the power tools, machines, chemicals and processes that are potentially hazardous to the eyes in case of accident. Explain how eye injuries from such mishaps can be avoided through the use of proper eye protection. Show the actual eye safety products that provide this protection.

Fit and Cleaning - Explain how various eye protection is adjusted for proper fit and comfort. Also, demonstrate the proper techniques for cleaning eye protection and discuss the need for clean, scratch-free glasses.

Visual Aids - Show one of the 16 mm motion pictures developed for classroom use, such as:

"The Windows of Your Soul"
"The Smartest Kid in Town"
"It's Up to You"
"Everything To Lose"
"Expedite School Eye Safety"
"Don't Push Your Luck"

These films, generally in color, have been prepared by such interested organizations as the National Society for the Prevention of Blindness and the National Safety Council. They are available for purchase or for rent.

DISCUSSION PERIOD: Tell the class about proper maintenance of eye protection products, including storage and sanitation. Here show the safety glass monitor and start assigning glasses and storage positions.

Explain safety rules of this classroom and appoint a student "Safety Director" to help with enforcement.

Follow with questions and answers.

TEACHER LIABILITY IN SCHOOL LABORATORY ACCIDENTS

As in industry and commerce, the possibility of accidental injury is a specter that haunts us in public education. This manual has been prepared in the hope of lessening the frequency and severity of injury to students by providing advice on safe practices for use in industrial arts/technology education classrooms and labs. For a number of reasons as complex as human beings themselves, it will be impossible to eliminate accidents entirely from industrial arts/technology education activities. It is with this knowledge that the following section has been prepared for your information. It describes the rights and duties of teachers, their supervisory responsibilities, and the degree of liability that they may be subject to when an accident occurs.

Teachers must in many situations exercise greater care to prevent injuries to their students than an ordinarily reasonable and prudent person may be expected to exercise. This occurs partly because the Pennsylvania School Code provides that teachers stand "in loco parentis" (in place of the parent) and are personally liable for acts of negligence while performing their duties as a teacher. Set forth below is Section 1317 of the School Code from which this authority stems:

> Every teacher, vice principal and principal in the public schools shall have the right to exercise the same authority as to conduct and behavior over the pupils attending his school, during the time they are in attendance, including the time required in going to and from their homes, as the parents, guardians or persons in parental relation to such pupils may exercise over them.

An act of negligence may be one directly committed by a teacher such as operating a piece of equipment during a demonstration without all safety devices in full functioning order and thereby injuring a student; or, negligence may be the failure to adequately supervise students during class activities or the omission of complete and thorough instruction in correct safety procedures for a given assignment. Either way, by omitting or committing an action, a teacher may be negligent.

The occurrence of a negligent act may give rise to a court proceeding for the purpose of establishing the liability of the teacher for any resultant injury. However, negligence may not be a sufficient reason for a finding of liability where the careless act is not a substantial factor in the injury or where the injury is an act of God. Liability is the legal conclusion that a negligent act was a major factor in causing an injury. A note of caution: exposure to liability is increased by industrial arts/technology personnel because the teaching of safe practices is an integral part of the curriculum.

It has already been stated that Section 1317 of the School Code imposes heavy responsibility on teachers. Section 320 of the Restatement of Torts goes even further:

> One who is required by law to take or who voluntarily takes the custody of another under circumstances such as to deprive the other of his normal power of self-protection or to subject him to association with persons likely to harm him is under a duty to exercise reasonable care so to

control the conduct of third persons as to prevent them from intentionally harming the other or so conducting themselves as to create an unreasonable risk of harm to him if the actor:

(a) knows or has reason to know that he has the ability to control the conduct of third persons, and

(b) knows or should know of the necessity and opportunity for exercising such control.

Obviously, the two statutory provisions cited potentially give rise to many situations in any school day where a teacher may be unconsciously negligent. This can only be interpreted as a clear mandate for thorough and complete concentration on the job of teaching during student contact hours. Anything less than this can carry heavy penalties.

The following are a few general recommendations to avoid negligent acts:

1. Supervise students to prevent them from injury to themselves or from injury caused by others.

2. Instruct students in proper manner of conducting inherently dangerous activities. Emphasize and periodically review all safety procedures.

3. Warn students of the specific dangers inherent in each classroom activity.

4. Keep machinery in proper working order, especially its safety devices. If a machine is defective, do not use it and render it inoperable if possible.

5. Use discretion in the selection of participants for activities not under direct personal supervision.

Another section of the School Code that is pertinent to this discussion is Section 510:

> The board of school directors in any school district may adopt and enforce such reasonable rules and regulations as it may deem necessary and proper, regarding the management of its school affairs and the conduct and deportment of all superintendents, teachers, and other appointees or employees during the time they are engaged in their duties to the district, as well as regarding the conduct and deportment of all pupils attending the public schools in the district, during such time as they are under the supervision of the board of school directors and teachers, including the time necessarily spent in coming to and returning from school.

Teachers have this additional responsibility to enforce local policies and regulations adopted pursuant to this section. Familiarity with such policies as they pertain to the industrial arts/technology education areas and the school district in general is imperative. Where a teacher is unaware of a rule, regulation, or policy governing his or his students' behavior and an accident occurs where ignorance of a rule pertinent to the behavior that resulted in the accident can be shown, the teacher has greatly increased his or her liability.

What are the consequences of liability for student injury? The first one that occurs to most persons is financial. The size of a financial settlement in a liability claim is generally dictated by the extent of any disability sustained and compensation for its consequent pain and suffering. A broken arm will heal in a relatively short time with a minimum of discomfort and inconvenience. A reasonable settlement might be the cost of treatment and some compensation for the period of disability. Where the disability will be lifelong and may result in a loss of potential earning power as in the loss of a limb or vision, the settlement may easily run to hundreds of thousands of dollars.

A teacher who is found to be liable in a major accident has probably failed to practice his or her profession in such a way as to meet the expectations of his or her employer and society. The consequences for this may not end with a financial settlement with the victim. Section 1122 discusses causes for termination of contract:

> The only valid causes for termination of a contract heretofore or hereafter entered into with a professional employee shall be immorality. incompetency, intemperance, cruelty, persistent negligence, mental derangement, advocation of or participating in un-American or subversive doctrines, and persistent and willful violation of the school laws of this Commonwealth on the part of the professional employee.

At least four charges may be brought against the hapless teacher at this point: incompetency, intemperance, persistent negligence, and persistent and willful violation of the school laws. Real concern should be given to the fact that these charges may be brought prior to any judicial determination of liability or following the judicial dismissal of a liability claim. Note that Section 1122 does not concern itself with the question of liability; it is concerned with the expected conduct of a professional employee.

If the 1122 charges are sustained and the employee is dismissed the terrible tide of retribution may continue to roll even further with Section 1211 - annulment of certificates:

> All State certificates or endorsements of the certificates of other states may be annulled by the Superintendent of Public Instruction for incompetency, cruelty, negligence, immorality or intemperance, after hearing, of which reasonable notice in writing must be given to the parties interested.

Incorporation of this discussion in this manual is not done for the purpose of intimidating teachers; it is here to clearly set out the responsibilities that they have and to clearly explain the consequences of failing to fulfill those responsibilities.

There are some steps with which every teacher should be familiar to lessen the possibility of an unwarranted finding of liability when an accident occurs.

1. Report all injuries to your building administrator in writing with all details including a full description of the accident, time, place, names of injured persons, and names of any witnesses.

2. Have all injuries, regardless of severity, examined by the school nurse.

3. Notify the appropriate person wherever a local teacher organization has liability protection for you.

4. Know and follow all local procedures for the reporting of injuries.

Protect yourself! All information and notification of an accident should originate from you.

LABORATORY PRACTICES LEADING TO LIABILITY

Malpractice	Recommended Practice
Absence of the teacher from the laboratory when students are working therein.	Never leave the laboratory while students are working.
	Have a clear understanding with your principal and/or supervisor that you are not to be called from the laboratory during a class session.
	Only under extreme necessity should an instructor absent herself/himself from the laboratory. When this occurs, lock the main switch box and provide a sedentary or reading assignment to students during your absence.
Teachers leaving the laboratory under the supervision of a teacher who is not certified to teach laboratory activities.	Teachers are liable to be absent for a period of time due to illness or attending a teachers meeting or conference. It is the practice of school administrators to staff the laboratory with most any instructor, providing he/she has a free hour available.
	Do not permit a substitute teacher to conduct laboratory activities unless he/she is a certified industrial arts/technology

instructor. If none is available, prepare written or reading assignments in advance, or some type of sedentary activity where they will not be utilizing the machines and equipment in the laboratory. Instructional movies or similar aids are practical if they fit into the instructional program.

Permitting students not enrolled in the class to use laboratory and tools.

Permit only those students who have participated in your laboratory program or who are participating to use the laboratory and equipment therein. No exceptions should be made to this practice. Do not take the word of a student that he/she has had previous instruction on the tool or has had experience in their use.

Permitting students to use machines or tools or to perform activities for which instruction has not been given.

Make sure that proper instruction is given relative to each basic operation to be performed by a student in the laboratory class.

Permit no student to utilize a machine or tool in performing an operation for which instruction has not been given.

Keep an accurate instructional log as to those materials, machines and tools, and opertions pertaining thereto in which instruction has been given.

Pupils using equipment in the laboratory which has not been approved by the administration and board of education.

Allow no student to bring in any item of equipment for use in the laboratory.

Permit students to use only those items of tools and machines that have been purchased with the approval of the board of education and school administration.

Permitting students to work in the laboratory free periods, particularly when the laboratory is not supervised.

Do not be absent from your laboratory when students are working, even during unscheduled classes or periods.

	Permit students to utilize equipment and work in the laboratory during designated periods when proper supervision is given.
Permitting students to use dull blade and/or cutting devices on hand tools.	Periodically inspect all cutting tools, edges of power tool devices and machines.
	Keep all items of equipment properly maintained and sharpened.
	Demonstrate the proper maintenance and care of cutting edges of safe hand tools, particularly those jobs within the ability of the student to perform.
Permitting students to perform operations on machines without guard, particularly when one could have been used.	Provide proper instruction as to the use and adjustment of guards, emphasizing the necessity and functions of such a device.
	Set an example yourself, by using guards and safety devices at all times, and perform operations as you would want them performed by students.
	Require that students use guards at all times on machines when such devices can be used.
	Have students secure permission to use any item of equipment. This will permit you to check on the machines to see that all guards and safety devices are properly adjusted.
Allowing use of equipment by students who are careless or who possess physical abnormalities that may cause an accident.	Be familiar with the work habits of students and with those who possess physical abnormalities which may necessitate restrictions being placed on their use of equipment.
	Require all students to secure permission before the use of any item of equipment.
	Limit such students to the use of machines which are within their capabilities and commensurate with whatever physical abnormalities they possess.

Sending pupils outside the shop to perform activities for the school or other departments.	Do not permit any students to leave the laboratory to perform activities outside the department. Refuse to undertake projects or jobs that require the student to work away from the laboratory without your continuous supervision. Confine instructional and maintenance activities to those that can be performed in the laboratory.
Failure to keep accurate written reports relative to accidents.	Prepare an accident form for your laboratory if the school system does not have a standard form. Fill out the form as soon as possible after the accident has taken place. Make multiple copies and keep one for yourself.
Failure to secure written statement from witnesses to laboratory accidents.	Provide a place on your accident report form for the listing of witnesses. Have witnesses write, in their own words, their views as to how the accident happened. Have witnesses sign their signature to their statement.
Failure to administer safety tests to students.	Administer safety tests to students upon completion of the demonstration of a specific machine, tool or process. Keep tests on file in your office as evidence that such material has been covered and that a test was actually administered over material. Set a critical score above which students must achieve in order to utilize a specific item of equipment. Many instructors demand a "perfect paper" prior to letting students use such equipment.
Failure of the teacher to exercise the utmost of caution.	The teacher MUST anticipate where and how an accident will occur, and utilize every means to eliminate the possibility of an accident occurring.

Make every possible effort to provide the safest possible physical facilities, and implement an effective safety instructional program.

Contributory Negligence

The term "contributory negligence" can be interpreted in a very broad sense. However, the following suggestions are given with a view in mind of eliminating the possibility of a teacher being charged with "contributory negligence":

Maintain the safest of working conditions in the laboratory.

Insist on safe practices being adhered to at all times in the laboratory.

Provide complete and proper instruction in all aspects of laboratory work, with regard to the use of tools, machines and materials.

Make recommendations to superiors as to improvements that can be made to improve safety conditions in the laboratory.

Make improvements suggested by your superiors.

Establish safety rules and enforce them.

Organize and implement a "complete" and continuous safety education program.

Failure to effectively administer a comprehensive eye safety program.

Be familiar with and conversant about eye safety legislation.

Require all students to wear eye protection devices at all times for laboratory activities.

Know the appropriate eye safety device for each operation.

Set an example yourself by always wearing the appropriate eye protection devices.

258

Outcomes Activity Guide 7

1. Outcome:

   Describe Pennsylvania teacher certification requirements for Principle of Technology as they relate to teachers presently certified in Physics, General Science, and Industrial Arts/Technology Education.

2. Methods:

   Oral presentation and discussion

3. Resources and Materials Needed:

   A. Information Sheets:

      IS-11, Certification
      CSPG No. 80 (October, 1990)
      CSPG No. 71 (December, 1990)

4. Suggested Activity:

   A. Using information sheet IS-11, and CSPG Nos. 80 and 71, make a presentation on Pennsylvania teacher certification requirements for Principles of Technology.

CERTIFICATION

According to CSPG No. 80, October, 1990, Principles of Technology is classified as a Special Needs Course or Program. A special needs course or program is further defined as a course or program for which graduation credit is awarded and no certificate exists. See page 1 of CSPG No. 80, October, 1990.

Qualifying certificates for teaching a course or program in Principles of Technology include Science, Mathematics or Industrial Arts/Technology. See page 3 of CSPG, No. 80, October, 1990.

Further, as specified in CSPG 71, December, 1990, school entities are encouraged to require the teacher to:

(a) successfully complete a program of studies to prepare a person to teach Principles of Technology Education as recommended by the PDE Coordinator of Principles of Technology Education <u>or</u>

(b) demonstrate role competence to the employer

In addition to specific certification requirements as specified under PA CSPG guidelines 80 and 71, some teacher background information is also offered. During field testing and implementation studies of Principles of Technology programs coordinated by CORD and AIT, it was noted that teachers with a physics background tended to be more successful in implementing Principles of Technology. Although most students enrolled in Principles of Technology demonstrated a learning gain, those students whose teachers had some background in physics tended to have more pronounced learning gains.

The following types of teachers successfully taught Principles of Technology during field testing conducted by CORD and AIT:

- Industrial arts teachers with one to three courses in college physics.
- Physics teachers with some industrial or applications background and an interest in the Principles of Technology course format.
- Vocational electronics or electromechanics teachers and some drafting teachers with one or more courses in college physics.
- Teams of teachers consisting of a physics teacher teaching physics, a math teacher doing math labs, and a vocational teacher doing the hands-on labs. The team-teaching approach has been found to be particularly successful when teachers sit in on each other's classes--or least confer regularly.

As recommended by CORD and AIT, whomever teaches these materials should attend a Principles of Technology workshop, be given several week's planning time prior to the beginning of classes, and be given some release time during the first year of instruction to get labs organized and lesson plans prepared.

Appropriate Certification

1. Appropriate Pennsylvania certification is required of all persons who during the school day are assigned duties and functions involving: (i) responsibility for direct interaction with pupils in curricular activities or in pupil personnel services; (ii) selection of learning materials and the planning or conduct of learning experiences, or (iii) direction of other professional-level, certificated staff involved in the kind of activities described in this CSPG.

   This requirement applies to all certified, professional-level staff irrespective of: (i) the source of funds from which the employee's salary is paid, (ii) the length or duration of such assigned duties and functions, or (iii) the employee's status as a temporary professional, professional or substitute.

2. When a school entity incorporates any or all parts of a title of a certificate issued by the Department of Education into a professional assignment, such titling implies that the assignment is reserved to said certificate.

3. Professional certification is not a consideration in assigning persons to services rendered outside the regularly established instructional day (i.e., extra-curricular activities) for incremental salary on supplemental contracts.

CURRICULUM AND CERTIFICATION

4. Appropriate certification required to qualify a person for assignment is determined by the school entity through its Planned Course wherein course content is identified as a particular curriculum and matched to organizational grade level.

5. To provide consistency of interpretation, the PDE has categorized the nature of Planned Courses, programs and services as follows and has established certification policies appropriate for each category.

   A. Traditional Course
   A traditional course for which graduation credit is awarded and a certificate exists.

   B. Non-Traditional Course
   A non-traditional course for which graduation credit is awarded and a certificate exists.

   C. Special Needs Course/Program
   A course or program for which graduation credit is awarded and no certificate exists.

   D. Student Service/Program
   A service or program for which no graduation credit is awarded and a certificate exists.

   E. Special Needs Service/Program
   A service or program for which no graduation credit is awarded and no certificate exists.

Discussion and Examples of Categories

Traditional Course

The school entity has titled and designed the curriculum of this course and is awarding graduation credit in a traditional discipline area. The person assigned to teach the course must be certified in that discipline.

Example

Course	Credit Awarded	Specific Existing Certificate
Mathematics	Mathematics	Mathematics

Note:

When the syllabus of a course comprises two or more subjects and the school entity identifies one as predominant and awards credit in that subject alone, the person assigned must be certified in the predominant subject. For example: The course is biology and contains some aspects of chemistry and health and credit is awarded in biology only. The person assigned must be certified in biology.

Non-Traditional Course

The school entity has titled and designed this non-traditional course and is awarding graduation credit in a traditional discipline area. The person assigned to teach the course must be certified in that discipline.

Example

Course	Credit Awarded	Specific Existing Certificate
Applied Communication	English	Communication, English or Business Education (See CSPG Nos. 32 and 38)
Applied Mathematics	Mathematics	Mathematics (See CSPG No. 57)
Death and Dying	Health	Health
*Death and Dying	Health and Social Studies	Health Social Studies

*The following staffing alternatives are options in this particular situation:

a. Assign a person holding multiple certification which includes each disciplinary area constituting a part of the course, or

b. Develop the overall course as a series of single discipline fractional Planned Courses (minimally 30 clock hours) and assign an appropriately certified person to teach each fractional course, or

c. As a variation of the foregoing alternative, assign persons appropriately certified for the topics and activities taught on a team-teaching basis.

Special Needs Course or Program

The school entity has designed this course or program to serve the special needs common to a particular group of students and is awarding graduation credit, but not under the same restrictions which exist in a traditional or non-traditional credit awarding circumstance. No specific certificate exists for this course or program.

Given the special needs of the students to be served in such cases and to allow the school entity flexibility in providing the curricular offering to meet these special needs, PDE has listed below the acceptable courses/programs and appropriate certification and staffing information.

Reference is given to those attendant CSPGs wherein guidance is provided regarding the special training, education, experience, skills or abilities which a person in this position should possess to perform the assigned responsibilities:

Course or Program	Credit Awarded	Qualifying Certificate
Principles of Technology	Science in accordance with the Planned Course design.	Science, Mathematics, or Industrial Arts/Technology (See CSPG No. 71)
English-as-a-Second Language	English	Any Level I or II (See CSPG No. 108)
Bilingual Education	In accordance with the Planned Course design	Any Level I or II (See CSPG No. 108)
Computer Education	In accordance with the Planned Course design	Any Level I or II (See CSPG No. 113)
Gifted Education	In accordance with the Planned Course design	Any Level I or II (See CSPG No. 109)
Alternative Education	In accordance with the Planned Course design	Any Level I or II (See CSPG No. 95)
Distance Education	In accordance with the Planned Course design	Any Level I or II (See CSPG No. 76)
Vocational Education Learning Facilitator	In accordance with the Planned Course design	Any Level I or II (See CSPG No. 73)

Student Services/Programs

The school entity has designed a program or service to meet the needs of students and is not awarding credit. A certificate exists for this program or service.

Example

Program or Service	Credit Awarded	Specific Existing Certificate
Psychological Services	None	School Psychologist

Special Needs Service/Program

The school entity has designed this program or service to serve the special needs common to a particular group of students and is not awarding credit. No specific certificate exists for this program or service. The school entity may have identified special training, education, experience, skills or abilities which a person in this position should possess to provide the intended service.

Example

Program or Service	Credit Awarded	Qualifying Certificate
Student Assistance Program	None	Any Level I or II (See CSPG No. 80A)
At-Risk Student Program	None	Any Level I or II (See CSPG No. 80A)
Teen Parenting Program	None	Any Level I or II (See CSPG No. 80A)

The Department of Education has identified in the publication, Pennsylvania Department of Education Approved Certificated Assignments, those approved professional-level assignments for which certification is required and the qualifying certificate(s) to which an assignment is reserved. Together with the PDE publication, Standards, Policies, and Procedures for State Approval of Certification Programs and for the Certification of Professional Educators for the Public Schools of Pennsylvania and this CSPG publication, the Department has given official recognition to the type and scope of existing Pennsylvania certificates, defined the parameters and composition of traditionally recognized disciplines and made provision for school entities to create professional assignments for which no certificate exists. (See CSPG No. 80A.)

THIS REVISION SUPERSEDES ALL EARLIER CSPGs CARRYING THIS NUMBER AND/OR ADDRESSING THIS SUBJECT. PREVIOUS CSPG PRINTING DATES ON THIS SUBJECT, 3/75, 1/87.

Principles of Technology Education Classes/Programs Certification and Assignment Scope (7-12)

1. Principles of Technology is a course primarily designed for vocational students interested in technical careers and other secondary students wishing to further their understanding of the physical principles underlying modern technology. A typical course is interdisciplinary in nature integrating basic principles of science, mathematics, and industrial arts/technology education.

2. Certification and staff assignment shall be in accordance with CSPG Nos. 80 and 80A.

3. The school entity is encouraged to require the teacher to:

   (a) successfully complete a program of studies to prepare a person to teach Principles of Technology Education as recommended by the PDE Coordinator of Principles of Technology Education <u>or</u>

   (b) demonstrate role competence to the employer.

THIS REVISION SUPERSEDES ALL EARLIER CSPG'S CARRYING THIS NUMBER AND/OR ADDRESSING THIS SUBJECT. PREVIOUS CSPG PRINTING DATES ON THIS SUBJECT: 7/89.

OUTCOME ACTIVITY GUIDE 8

1. Outcome

   Provide and overview of Principles of Technology to students, parents, counselors, school administrators-board members and persons in the community.

2. Methods:

   Oral presentation and discussion

3. Resources and Materials Needed:

   A. Mini-Guide to Principles of Technology

4. Suggested Activity

   A. Provide an overview of the Mini-Guide to Principles of Technology

   B. Using a small or large group format, discuss the importance of providing an overview of Principles of Technology to each of the following:

      1. Students and parents
      2. Counselors and other teachers
      3. School administrators and board members
      4. The community

   C. Have participants identify resources used during the workshop that could be used to provide an overview of Principles of Technology.

   D. Have participants prepare a sample news release on their participation in the Principles of Technology training workshop for their local newspaper.

File B:Guide8

A Mini-Guide to

PRINCIPLES OF TECHNOLOGY

Local administrators, teachers, and counselors involved in introducing ***Principles of Technology (PT)*** will appreciate this handbook. It provides information about why and how the course was created; about who should take the course and who should teach it; about what instructional materials are needed, what they cost and how to get them; and about how to disseminate information about PT. Our goal is that you'll find ways to adapt the contents of the ***PT Guidebook*** to fit your local needs.

Contents of PT Mini-Guide

Information For Administrators

Technology: New Workers Equal New Modes Of Training

Rapid changes in the use of science and computers have brought about a technical revolution. This revolution has altered the way we live and work in our homes, offices, and factories. This has not been a silent revolution. Technological advances have changed the equipment and work methods for a growing number of fields, including manufacturing, energy production, information management, health care, agriculture, and transportation. These marked technological breakthroughs—this revolution—is frequently called "high technology."

Technology will continue to create new jobs, eliminate some old jobs and modify others. Today's technicians are confronted by the diversity, complexity, and rapid evolution of equipment. Fox example, 25 years ago, offices had manual typewriters, and workers who were called on to adjust or repair them were called "typewriter mechanics." They were mechanics in the literal sense—they dealt with the physical principles of mechanical systems.

Then electric typewriters—electromechanical devices—began to appear. Repairs required someone who knew more than mechanics, someone who knew at least some of the principles of electrical systems. Soon, electric typewriters were replaced by electronic typewriters that could "remember" a line or a page of what had been typed.

These electronic systems are now giving way to more elaborate "word processors," which may include optical character readers and sophisticated ink-jet printers. Such devices are remarkably efficient but cannot be repaired—much less designed and constructed—by a mechanic or an electrician.

Today's office machines are typical of complex modern equipment. Technicians who work with, or on, high-tech equipment must have a broad understanding of the technical concepts and principles that govern the behavior of the systems and subsystems that make up this equipment. Training in a narrow specialty, typical of vocational education in past years, is no longer adequate. Education now must be to prepare technicians and operators who understand the entire system with which they work and the technical principles of all the complex systems involved—systems which generally include mechanical, fluid, electrical, and thermal subsystems.

Principles of Technology helps teach the practical principles in physical science that help students understand the behavior (and misbehavior) of modern equipment.

What is Principles of Technology?

Principles of Technology is a high school course in applied science for vocational-technical students in the eleventh and twelfth grades. It is a two-year curriculum that contains fourteen units in applied physics. The units are:

1. Force
2. Work
3. Rate
4. Resistance
5. Energy
6. Power
7. Force Transformers
8. Momentum
9. Waves and Vibrations
10. Energy Convertors
11. Transducers
12. Radiation
13. Optical Systems
14. Time Constants

Each unit typically requires twenty-six 50-minute class periods. Units describe how a technical concept can be analyzed and applied to equipment and devices in mechanical, fluid, electrical, and thermal energy systems.

Materials developed and tested for ***Principles of Technology*** include 14 student texts, 14 teacher's guides, videocassettes, demonstrations, math labs, hands-on labs, and tests. Teacher's guides provide suggested presentation strategies, information about how to perform classroom demonstrations, information for problem-solving labs, and test answer keys.

As noted by the National Commission on Secondary Vocational Education, many states have responded to recent criticism of the secondary school by increasing the number of academic courses required for graduation. The Commission recommends that students who do not plan to go to college and who purposely choose a vocational program "be allowed to satisfy some requirements for high school graduation—for example, in the areas of mathematics, science, English, or social studies—with selected courses in areas of vocational education that are comparable [to academic courses] in content and coverage and rigor."

Principles of Technology was designed to:

- increase the employability of vocational students.
- emphasize principles rather than specifics of technology and provide an understanding of the mathematics associated with these principles.
- increase student interest by incorporating video presentations, demonstrations, hands-on laboratory exercises and special exercises for students requiring additional help in mathematics.
- maintain the academic rigor needed to meet some of the increased requirements for high school science.

How did Principles of Technology evolve?

Principles of Technology was developed through a cooperative activity of 47 states and two Canadian provincial education agencies in association with the Agency for Instructional Technology (AIT) and the Center for Occupational Research and Development (CORD). The education agencies provided over $3 million for the creation, field testing, implementation and revision.

Drafts of print materials and scripts of video components, prepared by CORD and AIT, were reviewed by an eight-member team of specialists in vocational education and instructional media. Materials also were reviewed by the consortium agencies. In addition, pilot-test teachers were invaluable evaluators.

CORD is a nonprofit organization established to conduct research and development activities and to disseminate curricula for technical and occupational education and training. In the past 11 years, CORD has developed fourteen major curriculum projects in advanced-technology areas. These projects were sponsored by contracts with federal and state agencies and by industrial support from the private sector. CORD products are used by technical institutes, community colleges, and vocational high schools, and in industry training programs throughout the United States.

AIT is a nonprofit American-Canadian organization established in 1973 to strengthen education through technology. In cooperation with state and provincial agencies, AIT develops instructional materials using television and computers. AIT also acquires and distributes a wide variety of television and related printed materials for use as major learning resources. It makes many of these materials available in audiovisual formats. From April 1973 to July 1984, AIT was known as the Agency for Instructional Television. Its predecessor organization, National Instructional Television, was founded in 1962.

Principles of Technology is based on a course entitled ***Unified Technical Concepts—Physics for Technicians***, which was developed by CORD for postsecondary technical training. Following ***PT***, another postsecondary text, ***Physics for Technicians—A Systems Approach***, was developed. This text is available through John Wylie Publishers in New York.

Why should Principles of Technology be taught?

We all live and work in a sophisticated, rapidly changing society that is becoming increasingly dependent upon an understanding of technology to make informed decisions about governmental policies, equipment selection for the home or office, and the operation and maintenance of complex devices and systems. But most science courses in physics and chemistry—well-written for the 25 percent of high school students who plan to pursue academic degrees at universities—do not present material at a level that can be mastered by the majority of high school students. (More than 90 percent of today's high school graduates did not complete a course in physics.)

For over 20 years, vocational education has successfully prepared students for employment. These students learn current employable skills that are directed toward a particular occupational objective to be met upon high school graduation. In some fields, this type of curriculum will continue to be effective for job training.

Modern technology requires not only currently employable skills, but also understanding that will not become obsolete as equipment and technologies change. ***Principles of Technology*** is designed to be a practical science course for vo-tech students. It does not replace technical courses that relate to job requirements, and it is not an academically oriented science or mathematics course. It is an applied physics course, oriented toward modern technology. ***Principles of Technology*** is designed to complement the existing vo-tech curriculum.

Principles of Technology is not an easy course. Scientific content and academic rigor are carefully sustained. Although the course is not easy, the two-year field test indicated that most students achieved significant learning and found the course interesting and useful.

Where should Principles of Technology be taught?

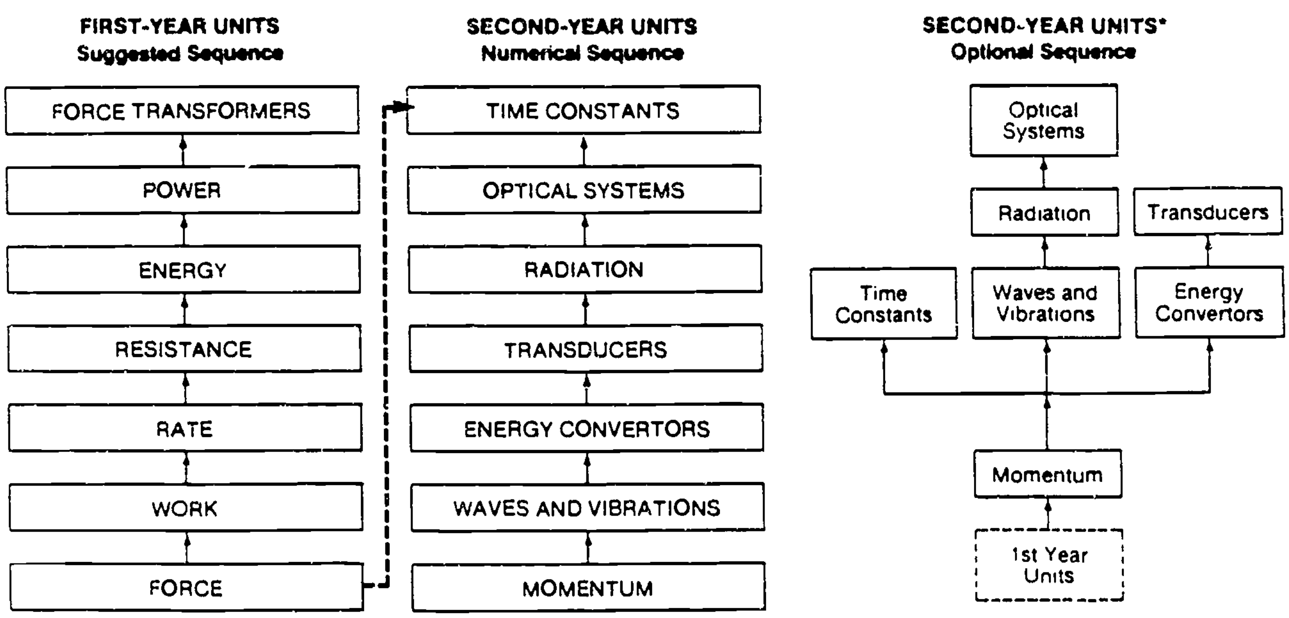
Principles of Technology is designed to be taught either in comprehensive high schools or in vocational technical centers to eleventh- and twelfth-grade students who plan to pursue careers as technicians and who do not plan to enroll in four-year colleges and universities in engineering or science programs. However, field tests have shown that the course is being used successfully for other student populations:

- vocational students in all fields (first year, or seven units, only).
- students in the tenth grade.
- students in an academic (college-bound) track.

Dr. Dale Parnell, president of the American Association of Community and Junior Colleges, has reviewed ***Principles of Technology***, and considers it to be the foundation course for a high school "pre-tech" or associate degree track for technically oriented students who plan to complete their education in two-year postsecondary associate degree programs. CORD is currently developing curricula for "2 + 2 Articulated Programs," using ***Principles of Technology*** as a foundation. Even if they aren't enrolled in a postsecondary institution, most vocational/technical students who are employed in technical occupations after high school graduation will be required to continue their education and training through company-sponsored programs. ***Principles of Technology*** also is designed to prepare students for this type of training.

How should Principles of Technology be taught?

These charts show the suggested sequencing of the units:



* In this second year, Momentum must be taught first. The order of instruction is then flexible, with some exceptions. Radiation must precede Optical Systems; Waves and Vibrations must precede Radiation; Energy Convertors must precede Transducers.

The first seven units can be used as a stand-alone course for students who need a one-year applied science course and require a background in the technical fundamentals. The second year of the course (Units 8-14) is most useful to students who plan to continue their study and to work as technicians in advanced-technology occupations. (Not all teachers complete seven units during Year One. Obviously, the teaching rate will depend on the students' entering competency levels.)

The teaching plan (see section entitled "Information for Teachers") suggests twenty-six 50-minute class periods that include:

- unit overview class and unit summary class, with readings, video presentations, discussions, and unit test.
- eight class discussions that include reading assignments (four based on subunit video segments and four based on hardware demonstrations).
- four "problem-solving" math labs.
- eight hands-on physics labs.
- four review periods (repeating the use of the four subunit video segments).

A detailed discussion of the approaches to teaching ***Principles of Technology*** is found in the section entitled "Information for Teachers."

To whom should Principles of Technology be taught?

The target audience specified in the curriculum design is eleventh-grade vocational students interested in technical careers; however, the course has been found useful and appropriate for tenth- and twelfth-graders, students with other vocational interests, and students who are in academic pursuits.

The materials assume that students have at least an eighth-grade reading level, have one year of high school general mathematics, and have—if possible—one year of algebra or concurrent enrollment in algebra.

Who should teach Principles of Technology?

Ideally, ***Principles of Technology*** should be taught by a vocational teacher with industrial experience and a strong background (two or three college courses) in physics. Practically speaking, this type of person is atypical and, in most instances, alternate selections must be made. The following types of teachers successfully taught ***Principles of Technology*** in the field test:

1. Vocational electronics or electromechanics teachers (some drafting teachers with one or more courses in college physics).
2. Industrial arts teachers with one to three courses in college physics.

3. Physics teachers with some industrial or applications background and an interest in the ***Principles of Technology*** course format.
4. Teams of teachers with a physics teacher teaching physics, a math teacher doing math labs, and a vocational teacher doing the hands-on labs. The team-teaching approach has been found to be particularly successful when teachers sit in on each other's classes—or least confer regularly.

Whomever teaches the materials should attend a ***Principles of Technology*** workshop, be given several week's planning time prior to the beginning of classes, and be given some release time during the first year of instruction to get labs organized and lesson plans prepared.

What does Principles of Technology cost?

Materials—If your state or provincial agency is a member of the ***Principles of Technology*** consortium, you have the right to make unlimited copies of the print and video materials for use at your school. You may also purchase copies of the materials at preferred prices. The section, "Ordering Materials," provides information on sources and prices for ***Principles of Technology*** teaching materials.

Facilities—***Principles of Technology*** can be taught in a high school science laboratory or a vocational lab supplied with 115-volt AC electrical power, water, drain, and gas. Compressed air is useful but not required. It is recommended that five lab stations be provided; however, implementation of the course is possible with two or three lab stations. A videotape player (VHS, Beta, or 3/4-inch) and television monitor are required.

Equipment—A complete lab equipment list for the ***Principles of Technology*** labs can be obtained from your state or provincial consortium representative or from CORD. Cost of equipment for the first year is about $18,000. For two years of ***PT***, cost is about $32,000. If you have the time and resources to make some of your own equipment, you can reduce these costs. Lab management information, technical facilities requirements, and a detailed equipment listing are in this ***Guidebook***.

Does Principles of Technology work in the classroom?

An extensive pilot test was an integral part of the developmental process for ***Principles of Technology***. Ample evidence indicates that ***Principles of Technology*** works. Effects include:

- **Learning gains:** As indicated by several hundred student pre/post-tests, the ***Principles of Technology*** units resulted in statistically significant learning gains. These gains were consistent among grade levels and sites and between male and female students.
- **Positive student attitudes:** Students were quite positive about the ***Principles of Technology*** units. They indicated that they liked the material, particularly the video programs and the hands-on labs. Students found the material relevant, most indicating that they thought the material was important for them to understand. Again, these findings were consistent among grade levels and sites and between male and female students.
- **Positive teacher attitudes:** Teachers were also positive about the material. Almost all teachers indicated that they felt comfortable teaching ***Principles of Technology***.

These positive findings do not mean that implementing ***Principles of Technology*** is easy. The field-test results indicated that certain conditions can enhance the successful implementation of ***Principles of Technology***.

- **Teacher preparation time:** The majority of teachers reported spending, on average, more than 30 minutes preparing to teach each ***Principles of Technology*** class. Several reported more than an hour of preparation. This suggests that adequate preparation time should be allowed for a teacher who is initially implementing ***Principles of Technology***.
- **Teacher background:** Teachers with a physics background tended to be more successful in implementing ***Principles of Technology***. Although most students demonstrated a learning gain, those students whose teachers had some physics background tended to have more pronounced learning gains.
- **Class time:** Both a comparison of student test scores to teachers' reports of time spent in class and the teachers' own comments indicate that 50 to 60 minutes per session is optimum.
- **Lab equipment:** The problem that pilot test teachers most frequently reported was getting the lab equipment on time. Since the school's ordering system and the vendor delivery process will likely be time-consuming, lab equipment should be ordered well in advance of anticipated use.

277

Principles of Technology does work in the classroom. However, like any educational innovation, ***Principles of Technology*** requires hard work. Clearly, a well-coordinated effort among school administrators, counselors, and teachers is the best way to ensure success.

Information for Teachers

Establish priorities and follow your game plan. Although this section is addressed to teachers, there is useful information for teachers throughout the ***Guidebook***.

Teaching ***Principles of Technology*** requires that you begin by planning the procedures you will use to structure the class. Your first priority will be to look over the teacher's guide for the first unit of this two-year course. The guide begins with a preface that explains many aspects of the course. You should read the preface before you begin planning your methods of teaching the course, keeping in mind that the guide is intended only as a framework of suggestions, always subject to modification to suit your particular needs.

You may be planning to team-teach this course. If so, you'll need to consult the other members of the teaching team. To get ready to teach ***Principles of Technology***, you will need to:

- **Familiarize yourself with the components of the learning package.** These components include a teacher's guide, the student text, and the video segments for each unit of the fourteen-unit course.
- **Decide how you will structure *Principles of Technology* to fit the time frame of your institution.** The course is designed for 50-minute classes; however, the suggested teaching plan is flexible enough to accommodate a variety of learning formats. (See the preface to the Unit 1 teacher's guide for more information about this plan.)
- **Establish priorities.** The course was created with a particular target audience in mind. Students whom you recruit should be interested in a course that teaches applied science and mathematics principles in an industrial setting. Since the course is two years long, you will probably

want to select juniors as students; however, ***Principles of Technology*** has been taught to both seniors and tenth-graders successfully. The first year of ***Principles of Technology*** can be viewed as a stand-alone course if you decide to offer it on that basis. Students whom you select for the course should read on an eighth-grade level or higher, should have had at least one year of mathematics, and should enroll in—or already have taken—the first year of algebra. Data from the pilot test of ***Principles of Technology*** indicate that both male and female students do well in this course. Certainly, the job market for technicians is not limited to males. You will need to work with the counseling office to make sure that you are reaching all students—including females, minorities, and the handicapped—whose needs can be met through this course. Recruiting the right students should be your first priority.

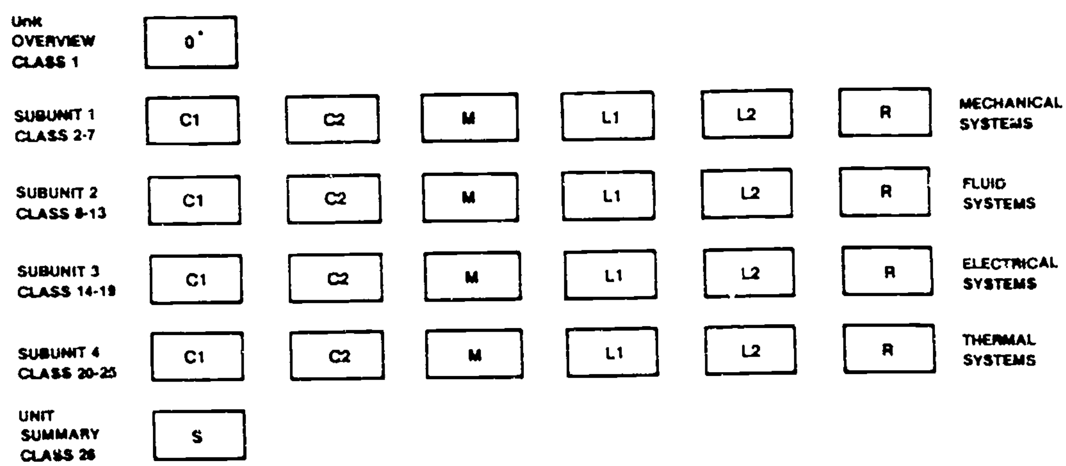
- **Order equipment.** This step should be taken at the earliest opportunity. A list of equipment is in this ***Guidebook***, as well as tips on lab management. Before you order equipment, you will want to inventory existing equipment. For example, some of the equipment may be available in a science or home economics laboratory. You may also want to look in vocational shops for useful equipment. This extra effort can save you lots of $$$.
- **Understand the academic rigor of the course.** This course is different. It's not traditional physics; the emphasis is on the industrial application of concepts. This course also is innovative in its approach to mathematics, taking a "principles" approach rather than a theoretical approach. It's important that your student understand—in the beginning—that the course is designed to enable them to function effectively in the workplace. And the bottom line is that students who take this course will be required both to read and to think. Then they will be asked to take the knowledge they have just acquired and put it to work in the applied laboratories.
- **Explain the purpose of the course to your students.** You may wish to tell your students how ***Principles of Technology*** was developed—that the course grew out of a national concern for providing physics and mathematics skills to students who will one day be responsible for developing, maintaining, and operating advanced-technology equipment. You will find the introductory video program ***"About Principles of Technology"*** a good way to overview course content for students. You may also wish to use this program to explain the course to other teachers, to counselors, to school board members, to advisory council members, to members of your community, and to the parents of your students.

- **Explain to local industry representatives that this course has been designed to meet their needs, as well as the needs of students.** The work force of the future is in today's classrooms. You may wish to invite selected industry representatives for an orientation to the course. You may wish to follow that activity by asking these industry representatives to identify those skills they see being developed in ***Principles of Technology*** that they believe will be beneficial in the workplace. In many locations, industry reps have volunteered to mentor ***PT*** students. And if you are having difficulty securing enough funds for equipment, you may wish to explain your situation to these industry representatives and ask for their support or assistance.
- **Realize that you, or the team of teachers guiding students through this course, make a difference.** It's your creativity, excitement, and ingenuity that will motivate students to study ***Principles of Technology***. As you know, it's not often that an instructor gets the opportunity to pioneer a new approach—a new course. Technology is a new frontier that's expanding every day, requiring educators to be explorers with a taste for adventure. Educational institutions are in a race with technological advancement, and teachers are the "front line" who will determine whether or not educational institutions can meet the demands of tomorrow's technological society. It is you who will give students the skills they must have to cope with the challenges on the horizon.
- **Ask for assistance when you need it.** Call the ***Principles of Technology*** staff in Waco (CORD) and Bloomington (AIT). Waco ***Principles of Technology*** staff (CORD) created the print portion of this learning package (including the laboratories) and are prepared to answer any questions you may have. The ***Principles of Technology*** staff in Bloomington (AIT) created the video segments and are prepared to answer any questions you may have about this part of the learning package. In addition, we suggest that you work closely with your administration. They will be working closely with your state consortium representatives to achieve a smooth implementation of this course. Perhaps some of the best answers and advice available to you are right in your own backyard. Other teachers who have introduced a new curriculum, teachers whose areas of expertise complement your own, and teachers with background in teaching the student population for whom ***Principles of Technology*** was designed, should be sources of practical knowledge about how to handle everyday challenges. Find out who piloted ***Principles of Technology*** in your state. (Teachers who participated in the field-test have experience with this course that can be invaluable to you.)

281

- **Remain flexible if you fall a little behind the projected schedule for the course.** Since each unit in the first year builds upon the preceding units, it's important that your students internalize the information. But you can improvise, making up time by combining two classes—putting two lecture days into one or combining laboratories, for example—and this may put you back on schedule.
- **Understand the instructional system.** Like any other curriculum, this one is easiest to implement under the conditions for which it was designed. Basically, you have three tools with which to do this teaching job:

  1. The student text, systematically divided into fourteen units. Each unit contains an overview, up to four subunits, and a summary. Each subunit has lecture material, a suggested demonstration to use with the lecture portion, a math skills lab, and two hands-on physics applications labs. Each unit covers one technical concept. Each subunit explains that concept and how it applies in one of the four energy systems.



* *Each rectangle represents 50 minutes of instruction.* Most units require 26 sessions. The first two sessions (Class 1 and Class 2) of the subunit include the video presentation and lecture/discussions; the third (M) is the math lab; the next two (Lab 1 and Lab 2) are hands-on labs. The sixth session (Review) is a review of the material.

2. **The video.** Video segments provide direct instruction about the principles and systems. They introduce and explain the ideas presented in the text, take your students to workplace settings where technicians are employed, and help put variety in the course.
3. **The teacher's guide.** This portion of the learning package gives suggestions for teaching the class on a page-by-page basis. You should keep in mind that the teacher's guide is not a set of rigid rules. It cannot substitute for the ingenuity within you—and the creativity you will continue to employ—as you teach this class.

283

SAMPLE STUDENT MATERIALS

Fig. 1-18 Earth-weight and moon-weight of the same object are different.

the astronauts weighed only one-sixth as much, and the forces that their leg muscles could exert were essentially the same as on earth, they were able to jump six times higher on the moon than they were able to jump on earth.

Mass and weight, as well as other units of time and length, are designated by certain words and abbreviations. These abbreviations will appear many times in these materials. You'll need to know them as part of your understanding of the terminology of the technician.

Some useful information on units is organized in two tables that follow. Table 1-1 lists SI and English units for length, time, mass, and weight (force). Table 1-2 lists some useful data for converting weight and mass units. You may want to refer to these tables later.

TABLE 1-1 ENGLISH AND SI UNITS

	Length	Time	Mass	Weight
ENGLISH	foot (ft)	second (sec)	pound mass (lbm)	pound (lb)
SI	meter (m)	second (sec)	kilogram (kg)	newton (N), or kilogram weight (kgw)

TABLE 1-2. WEIGHT AND MASS CONVERSIONS

1 pound = 16 ounces	1 pound mass (lbm) weighs one pound
1 pound = 4.45 newtons (weight)	1 kilogram mass weighs 9.8 N or 2.2 lb
1 kilogram = 1000 grams	

WHAT IS TORQUE? HOW IS TORQUE RELATED TO ROTATION?

Torque is a forcelike quantity in the rotational mechanical system. Gears, crankshafts, flywheels, fans, motors, bolts and screws all turn or rotate. Their turning (or rotation) is caused by torques. A torque is the effect of a force applied on a body at some distance from the axis of rotation of that body.

Since torques cause rotations, torques can be classified as those that cause either *clockwise* rotations or *counterclockwise* rotations. Clockwise rotations move like the hands of a clock. The abbreviation for clockwise rotation is "cw." Counterclockwise rotations are in the opposite direction. The abbreviation for counterclockwise rotation is "ccw."

Subunit 1 Force in Mechanical Systems 15

SAMPLE TEACHER MATERIALS

NOTE: Table 1-1 is an introduction to basic units in SI and the English system. Emphasize that technicians will need to learn units and keep them straight. When technicians measure quantities such as force, mass, voltage, pressure, temperature, etc., they'll have to record/report measurements in the correct units, or the measurements will be useless.

NOTE: Table 1-2 closes out the text material to be covered for Class C1. The subject of "How is Torque Related to Rotation?" makes up the student text material for Class C2.

NOTE: The student text material for Class C2 begins with "How is Torque Related to Rotation?". Refer to Teaching Path for Class C2 for outline of class activities. Don't forget to work in a 10- or 15-minute classroom demonstration on torque. See the instructions for equipment and demonstration details in Demonstration 10M at the back of your Teacher's Guide in the Teacher's Appendix.

Information for Counselors

New careers demand technological literacy. Therefore, technology is making enormous demands on high school counselors. Students must plan for the future and counselors are responsible for helping students make career decisions. Yet no one knows what the future holds. Since the only thing we can count on is change, we must prepare our students for whatever change holds in store as best we can.

This challenge is being answered with the development of courses like ***Principles of Technology***. These new curricula require that counselors become lifelong learners—predictors of the future who can act as a bridge between technological expansion and educational change. For it is during those sometimes harried sessions between students and counselors that important choices are made—choices that will not only influence the lives of students, but will also affect the ability of society to keep pace with the demands of the future.

That's what makes ***Principles of Technology*** a good choice for students. If you've read the first two sections of this ***Guidebook***, you already know that this two-year course offers students a broad base of practical information that they can build on in the years to come. This course helps students learn physics and apply physics principles that will enable them to respond to changes in the marketplace as their career paths unfold.

There are some prerequisites that should be considered before students enroll in ***Principles of Technology***. Preparation for ***Principles of Technology*** actually begins in the eighth or ninth grade, because:

- students must have a least an eighth-grade reading level. Those who don't will have difficulty with the academic rigor of the course. Therefore, in preparing students for this course, it's advisable that an assessment of reading levels be made. This way, students can get any remedial reading help they may need before beginning the course.
- students should have completed a general mathematics course (preferably ***Applied Mathematics***) before starting ***Principles of Technology***. Students should plan to enroll in Algebra I—either before or concurrent to—their enrollment in ***Principles of Technology***.

Because careers in advanced-technology areas are expanding every day, students interested in those careers should not have to select a specialty while in high school. That's why ***Principles of Technology*** is designed as a "core" course. The knowledge this course transmits is the basic information for an increasing variety of advanced-technology jobs—jobs which sometimes do not yet exist. However, we know now that these fields will need more workers in the future:

- Laser/Electro-Optics
- Computer Technology
- Microelectronics/Telecommunications
- Nondestructive Testing
- Instrumentation and Control
- Automated Manufacturing/Robotics
- Computer-Assisted Drafting/Design
- Biomedical Electronics

Principles of Technology prepares students to enter a postsecondary—or industrial—training program that leads to successful employment in these occupations. The technical information in ***Principles of Technology*** has longevity; laboratory experiences in the course emphasize current applications.

In modern technical careers, there are four major career slots: scientist, engineer, technician, and operator. For example, consider the activities and responsibilities of the employees in robotics and automated manufacturing. (Robotics encompasses the design, building, installation, and operation of robots in the industrial workplace.)

- **Robotics Scientist**—This person works in the design phase to produce state-of-the-art advances in artificial intelligence—that is, better "eyes" and "hands" and "brains" for new robots. The scientist might then talk with the engineer to ensure that the system designed on paper could, in fact, be built with existing computers, sensors, fiber optics, pneumatic devices, etc.
- **Robotics Engineer**—This person is responsible for turning the concept into a functioning robot. The engineer identifies precisely what parts are needed, redesigns certain parts if necessary, predicts performance limits by testing the new robot, and interacts with the scientists and the robotics technician while these activities are taking place.
- **Robotics Technician**—This person works under the supervision of the engineer or scientist and performs the actual assembly of the final robot.

The technician works from drawings and uses a variety of tools in the assembly phase of projects. Technicians fine-tune the products of the scientist and the engineer and serve as liaison between them and the robotics operator.

- **Robotics Operator**—This worker operates the robot in the workplace. A robotics operator works on the outside of the robot; workers at the other levels concern themselves with the inside of the product. Robotics operators must, therefore, be concerned with real-time operation and routine maintenance of the robot. They will need an increasing level of skill as technological advances unfold.

Principles of Technology is designed for students who are preparing for careers as technicians; however, ***Principles of Technology*** also is useful for students who wish to become scientists, engineers, and operators. Keep in mind, however, that ***Principles of Technology*** is a foundation that can grow according to the student's motivation or opportunity for further study. Our society is developing a renewed respect for those who perform operations that are crucial to the performance of objectives. The trend is toward preparing our students—who are those potential workers—with a combination of both academic and vocational/ technical skills. The trend also is moving toward lifelong skills development, rather than the cessation of formal training after traditional schooling. ***Principles of Technology*** introduces students to the kinds of changes technological advancement is bringing to society as well as the changes technology is bringing to the workplace.

More information about this course can be found by reviewing the introductory video program, ***"About Principles of Technology."*** Doing this before advising students will be extremely helpful because the overview video explains the advantages of—and need for—a course like ***Principles of Technology***. You may also wish to let parents who are assisting their youngsters in making career choices check this video out of your school library and local video shops (free).

If you'd like a little more information on careers in technology, check Section IV "Tips for Helping ***PT*** Students" under "Occupational Information."

Guide to Information Dissemination

Planning equals success. A clear understanding of ***Principles of Technology*** among students, teachers, administrators, counselors, parents, and community leaders is essential to the successful implementation of ***PT***.

Understanding is not something that simply happens. ***PT***'s pioneers must take the initiative to conduct awareness activities that will help everyone in the school's community. Understand ***PT***'s benefits. Creating this awareness can help you recruit students. Awareness can help to create a positive image of ***PT***—and vocational education in general. If properly informed, students, teachers, counselors, administrators, parents, and civic leaders will pass the word to others, inside and outside your school. This word-of-mouth can generate community and parental support—an important element for success.

You know your constituents best. These activities and materials have been designed to help you meet your audiences needs.

What's available to you?

There are several information pieces available for awareness activities in the ***Guidebook***. They can be easily localized and then reproduced for distribution. They include:

Two open news releases. One release allows you to announce the implementation of ***Principles of Technology*** in your school. The other is a feature release that probes the ideas and concepts of the project.

Radio/TV spot copy (for use as public service announcements).

An open letter to introduce the curriculum to individuals or groups.

Your state/provincial representative can provide you with sufficient quantities of hands-on information materials that when combined with the above editorial pieces will provide you with a comprehensive promotion package. The following items are available from your representative:

- *Logo slide:* To be used with the public service announcement copy for television purposes.
- *Logo sheets:* Photostatic copies of the project's logo for reproduction purposes.
- *Information brochure:* An 8 ½" × 11" brochure which fits into a large business envelope for background information purposes.
- *Orientation program:* "***About PT***," a video introduction to the course, which can be used in meetings or workshops.

What aids do you have to make planning the key to success?

Now that you know exactly what is available to help you in your promotion efforts, you can begin work. It is always a good idea to develop a simple plan of action—a laundry list of activities that you plan to conduct. Before you can sit down and develop your plan, you must answer a few questions:

- What is the objective of your plan?
- Who can help you meet your objective? (Enlist support.)
- Who is/are your audience(s) for these activities? Whose life or job will be affected?
- What will each segment of your audience see as the chief benefit of ***PT***?
- Taking into consideration your objective and audience(s), what is your schedule?
- What's your plan?
- How will you obtain feedback along the way?

Once these questions are answered, you can begin to implement your plan. (This plan does not have to be an extensive document, but it should provide you with enough detail to ensure that your efforts will be implemented in a timely fashion and will be effective. You may want to involve your support team in writing your plan.)

How can you put the information materials to work for you?

The editorial materials in the guide and the hands-on items you can obtain from your state or provincial representative should be used creatively to assist you in promotion activities. Let your imagination be your guide.

How do you "tell it, sell it, and jell it" in your community?

Consider your stockholders. Every person in your community whose life might be affected in one way or another by ***Principles of Technology*** should be "courted" with information. Key publics might include other teachers in your school, counselors, administrators, members of the business/industry/labor community, government agencies (such as JTPA), parents of students, members of the community at large—and students. Legislators, school boards, and teacher educators are other key publics.

Focusing on the big picture: marketing applied learning

In many cases, you'll be promoting more than ***Principles of Technology***. You may be promoting the idea of taking a vocational course. Therefore, you should be sure you know today's facts about vocational students and programs. For example, 10 million students are enrolled nationwide in vocationally specific programs—and another six million are enrolled in nonoccupationally specific programs. Although people often identify vocational education students as "non college-bound," the facts are that vocational students are more diverse in their backgrounds and more specific in their goals than such labels indicate. More data on vocational students can be found in CORD's publication, **New Options in Vocational Education.**

You're also promoting the idea of other new applied learning materials, including **Applied Mathematics, Applied Communication** (a set of materials from The Agency for Instructional Technology—AIT—in Bloomington, Indiana), and **Applied Biology/Chemistry**. You can request any information you need to know about these curricula from CORD and AIT. Since you'll be talking to students about their future, you also should become familiar with the concepts of curriculum blending and 2 + 2 articulation.

Moving toward curriculum blending

Curriculum blending is simple to explain, but more difficult to carry out. The basic idea is to equip students with a skill with which they can earn a living and the credentials to enter postsecondary training.

The National Center for Research in Vocational Education at Ohio State University successfully worked with a project to do curriculum blending in a Pennsylvania school. If you want more information, you can call them. (NCRVE in Ohio is now Center for Education and Training in Employment; their phone number is [800]-848-4815).

One of the difficulties in implementing this kind of blending is that the credits required for high school graduation—plus a few electives like football or band—make getting a hands-on skill with which to earn a living—at the same time—somewhat difficult.

However, students have been working out the details on this for years. What we need to do now is find ways this can be done in individual circumstances where students or their parents may not have thought about it. If you're doing something about this topic, let us know. We'll put your plan in this notebook for everyone else to see. That way, we can all benefit from your experience as we develop national models on curriculum blending.

How does two-plus-two equal success?

Two-plus-two is a way to involve students in a career-path plan that helps them see the purpose of education. The 2+2 system has the added benefit of helping you involve business/industry/labor in your programs.

Two-plus-two relates to linkages

Two-plus-two is a method of linking the last two years of high school with the first two years of postsecondary training. It allows students to get a head start on postsecondary training, to view several career paths, to develop salable skills, to see clear goals for high school training—and therefore, to see something worthwhile about staying in school.

Two-plus-two has something for schools, as well. Properly employed, the 2+2 system can help educators gain a clearer understanding of what should be taught, can promote a higher enrollment in vocational programs, can help move curricula into "blended" structures that embrace both academic and vocational education, can streamline and upgrade faculty, can promote a positive image about vocational/technical programs, and can increase student retention.

How two-plus-two relates to economic development

By acquainting yourself and others with two-plus-two, you can also become familiar with how education is related to economic development. (See "Preparing Technicians for a Competitive Workforce" in Section V of this ***Guidebook***.) You can also acquaint yourself with the technical/vocational career choices that will be available between now and the year 2000. (For detailed information on this topic, see *Workforce 2000*, published in 1988 by the Hudson Institute, and *Projections 2000*, published by Occupational Outlook Quarterly, U.S. Department of Labor, Bureau of Labor Statistics, Fall, 1987.)

You don't need anyone to tell you that change is occurring rapidly. Two-thirds of the jobs that will be available for today's five-year-olds don't yet exist. Four out of five of today's workers will need retraining between now and the year 2000. And the fastest job growth will occur in technician careers—careers that will require postsecondary training. As an educator, what you need is a plan.

How do you plan for Principles of Technology implementation?

Planning includes putting a time line into place and then developing the materials you'll need. Developing the time line for implementation is a good way to see what materials (don't forget human resources) you'll need—and when you'll need them.

A Tentative Planning Calendar—Here's a tentative general planning calendar to use for putting ***Principles of Technology*** into place:

Step	Estimated Date
1. Determine objectives.	____________________
2. Assess needs.	____________________
3. Specify measurable goals.	____________________
4. Design alternative actions.	____________________
5. Establish consequences of action.	____________________
6. Select a course of action.	____________________
7. Implement strategies.	____________________
8. Solicit evaluation.	____________________
9. Obtain feedback.	____________________
10. Revise goals/objectives/strategies?	____________________

Planning for statewide goals

Your state may want to establish a statewide plan. There are basically two approaches to such planning. One is to establish a separate plan for each of the applied learning curricula. The other is to set up a plan for coordinating several applied learning curricula.

In addition to this kind of statewide planning for curriculum coordination, many state departments of education are electing to involve representatives of business/industry/labor "up-front" by establishing an advisory board comprised of a team of people who can make implementation decisions for the state. This board's membership should include representatives from the following secondary and postsecondary groups: teachers (from both sides of the house), counselors, administrators, public information personnel and, sometimes, vocational group student leaders. In addition, there should be representatives from the state department of education (both academic and vocational), major employers and teacher education institutions. Local advisory groups can be formed based on the same basic group construction.

Those states who elect to select only a few sites for pioneering the course, or who are going to provide funding for schools who elect to teach this course, may wish to assess each school's capabilities to do so through an RFP. Some states may elect to have the RFP responses reviewed by the Advisory Committee. This committee can also help answer the questions surrounding implementation: How will the materials' availability be announced? What about policy issues—i.e., credit toward graduation, teacher certification? What teacher training is going to be available? How should the materials be used? What resources are needed to teach the materials and how can those resources be generated? What strategies, procedures, and documentation are needed to assess the effectiveness of the implementation and use of ***Principles of Technology***? (However, the committee should be made aware during the orientation phases that educators must work within the framework of state guidelines and policies on these issues.)

Making implementation decisions

A matrix for making decisions about implementation, adapted from one developed for ***Applied Communication***, by The Agency for Instructional Technology, follows:

Principles of Technology Implementation Decision Matrix*

Topics

Audience	Promotion/ Information Strategies[1]	Policy Issues[2]	Training[3]	Patterns of Use[4]	Resources (fiscal, human, physical)[5]	Monitoring/ Evaluation[6]
Students						
Instructors						
Counselors						
Administrators						
Community						
Legislators/Boards						

* See footnotes on reverse side.

1. How will ***Principles of Technology*** be announced/promoted to the audiences in the left column?
2. What policy issues apply to each audience: e.g., credit toward graduation, teacher certification, etc.? How should the issues be handled; what action is necessary?
3. What plans/procedures are needed to train various audiences to use ***Principles of Technology***?
4. How should ***Principles of Technology*** be used: e.g., as a stand-alone course taught by vocational teachers; as separate modules; etc?
5. What resources—money, people, space—are needed to implement ***Principles of Technology***?
6. What strategies, procedures, and documentation are needed to assess the effectiveness of the implementation and use of ***Principles of Technology***?

* Adopted from the document developed for **Applied Communication** by The Agency for Instructional Technology (AIT) in Bloomington, Indiana.

Marketing Principles of Technology

Marketing vocational education is a hot topic these days. That's because programs must have students to survive—and because the kinds of workers our nation will need between now and the year 2000 can be trained especially well through vocational programs. Since ***Principles of Technology*** was developed through funding obtained largely through vocational education, one of the considerations in promoting the course may well be promoting vocational education in general. Here are some general guidelines about developing a public information campaign.

First, in successfully marketing either ***Principles of Technology*** or vocational education, you must remember three things: You must tell your audience what the benefit will be for them. Advertisers call this the "unique selling proposition." Second, you want to consider who you're talking to. In public relations, this is called the "target audience." Third, you want to consider the environment in which you're talking. This is called the "image climate."

Second, you must find a way to tell a large public about your topic in a way that makes it "manageable" in your own mind. It's wise to act as if you're talking to one person. Get personal. Think about his/her needs. Listen well. And observe what works best in your particular climate and use that methodology often.

Orchestrating a public information campaign

Like all other well-thought-out things, public information campaigns take planning—what else? You should try to think of every contingency. You should have a Plan A and a Plan B, and you should remember to assess the audience reaction as you go along and make changes in your plan as you feel necessary.

There are seven steps to successful orchestration. First, find out what the community thinks of your client—which in your case, might be technology in general.

Second, you must establish your goals.

Third, consider what human and financial resources you have with which you can work. Form a committee. Look for other help.

Using this committee, take step four. Write your plan. You may want to use the PR campaign planning tips that follow, and the "Communication Grid" shown in this section.

Step five is to make as many personal contacts as you can. The first benefit is that the one-on-one interaction with you is the most memorable for others. The second benefit is that the people you meet may be able to help. Therefore, never miss an opportunity to tell others about your subject—and some of the most important "others" include business/industry/labor groups, counselors, administrators, and other teachers (particularly from postsecondary institutions), parents of students, and of course, students.

Step 6 is evaluation. Be sure to put methods of seeing the successes along the way. Make them in bite-sized chunks. Celebrate when you reach a goal! And involve others in the celebration.

The seventh step to successful orchestration of public information campaigns is simple. Say "thank you" every time you get a chance. It makes people feel that you care about the time and energy they've given—and they're likely to help you some more.

Communication Grid

INSTRUCTIONS

1. Write your current promotional activities in the spaces at the left.

2. Next write in the right who you want to reach with these activities.

3. Then put a check in the box of who will be reached by each activity.

4. This provides a graphic example of the different audiences your promotional activities are reaching.

ACTIVITY	AUDIENCE					

How do you recruit special publics?

It's hard to teach a class for which there are no students. Therefore, each person involved in implementing ***Principles of Technology*** will be "telling it" and "selling it" in order to "jell it"—to both the community at large and to students. Therefore, it might be well to remember that your potential student population includes some specific markets that might be somewhat resistant to technology instruction. Therefore, here are some tips for recruiting those students.

Getting female, minority, older, and "at-risk" students into Principles of Technology

1. Convince yourself that taking ***Principles of Technology*** will benefit the student. Sincerity is the key to motivating others. Think in terms of individual students or key target audiences of students.
2. Think long-range. Start thinking of recruiting students who are still in junior high. Think about ways to teach ***Principles of Technology*** to older adults or people in industry who need to brush up their skills. And don't just focus on recruiting—think about retention. It doesn't do any good to recruit students whom you don't think you can encourage to stay in class when the learning gets rough.
3. Don't segregate your recruiting message. For example, don't just recruit females, minorities, older, or "at-risk" students. (Can you believe we said that?) Recruit students in general, but be sure to show male, female, and minority role models in your recruiting materials. (It's good to show all people working together if you can.)
4. Find out what male, female, older, minority, and "at-risk" students think of technology. Find out what the roadblocks are in their minds. Convincing students to take ***Principles of Technology*** will require that you learn to think like they do—whoever "they" is. Think about student anxieties and counter those perceptions with "solutions" before you discuss taking ***Principles of Technology*** with them. You may want to infuse what you say with career information so that the people you talk to can understand the "why" of taking the mathematics in ***Principles of Technology***, for example.
5. Establish your goals. Give your goals "concrete"—or measurable—definitions. Make your first "success" definition a short-range goal that's fairly easy to obtain, and then establish other goals in a varying array of difficulty.
6. Find out what your community thinks of vocational education. You may do this by asking some of your best vocational education students to canvass a shopping mall or a grocery store. Warn your students about

the typical stereotypes. Prepare them with answers; see **New Options in Vocational Education** (available from CORD) for some good new data.

7. Find out what mathematics and physics skills are needed at local entry-level jobs—the kinds of jobs your students might pursue. This might be a good opportunity to get out into the community to let them know what's happening in your school.
8. Be sure that you have a thorough understanding of 2 + 2 articulation and how the applied learning curricula fit into that framework, since many parents will believe that vocational education is a "dead-end" route that doesn't leave college as an option. Furthermore, students may need to understand how the level of education they receive will have an effect on their future earning power.
9. Remember that counselors, teachers on the "academic" side of the house, and industry training directors are among your key publics. Inform them early about ***Principles of Technology*** and how it fits into the overall pattern of 2 + 2 articulation and the other applied learning curricula. This is a good opportunity for you to talk to them about the new career options available through vocational education.
10. Provide role models. Help the people you're teaching see that applied physics is useful.
11. Generate a "swap" program at your school where students are allowed to attend classes they don't normally attend just to see what they're like. A "swap" program is a ministudent exchange. Students attend a couple of classes they think they might like—or one they don't think they'd like—on an experimental basis.
12. Send commendation reports home to students who excel in classes prior to the level you're teaching ***Principles of Technology***. Invite them to take ***Principles of Technology*** the following year.
13. Make as many personal contacts with students and parents as you can.
14. Encourage publicity about your ***Principles of Technology*** class. Since this is something new, even the local TV station should be interested. Prepare a press kit.

Why have a mentoring system?

Mentoring is an excellent way to involve industry in the process of education, thereby making what you're doing in the classroom more up-to-date and helping industry representatives see that educators are attempting to meet their needs.

Mentoring also is useful as a mean for retaining students—keeping them in school and in your classroom. "Retention through mentoring" is an idea that's even catching fire within industry training programs, since many young employees leave after relatively short times with companies and go on to others. Industry is using mentoring to "protect its investment" in their young workers, since they believe that many young workers perform better with a veteran guide at their side.

For more informatio ι about mentoring, see Section IV of the ***PT Guidebook***.

How do you involve business and industry?

Business and industry are involved in most technical/vocational programs already. However, they haven't been as involved in "general" or "academic" education. Therefore, the idea of developing an Advisory Committee may be new for ***PT*** teachers who come from a science background.

However, the trick is to get a "healthy" involvement, rather than a group who rubber stamp whatever you elect to do. The Advisory Committee should have real say-so in your program. You may want to involve them first in a needs-assessment survey and then proceed to a skills or competency analysis process. This will help you have the best possible program—and may inspire the folks on your committee to donate time (guest speaking, field trips, apprenticeship opportunities for you and your students) and money (scholarships, equipment, etc.).

For more information and specific samples of communication, see Section IV, "Tips for Helping Yourself Help PT Students and Networking," of this ***PT Guidebook.***

Other sources of information about involving business and industry can be found through:

- Contacting the American Association of Community/Technical and Junior Colleges in Washington, D.C. (particularly information about the "Keeping America Working" project).
- Subscribing to the NAIE Newsletter.
- Initiating an internship or apprenticeship project.

How do you conduct local press activities?

The sample news releases in the guide, naturally, are to be used for press activities. Editors have to be sold on a story idea before they will even consider it for use. Remember, you are competing with several other news items. It is important that you make yours as interesting and "newsworthy" as you can.

There are several elements an editor looks for in a story:

A local angle—Editors are interested in items of local interest to their readers or listeners.

Scope—Editors are interested in items that have a profound effect on many people or are large in scale.

Topical Interest—They need items on topics of current interest.

The news releases in this guidebook were designed with these criteria in mind.

Once you've given the sample news releases a local slant, you can put together a press kit using your "local" news releases, photos from your site, and the information brochure. Go one step further and provide copies of photographs you've taken in your school. You'll have a much better chance for story visibility. Remember to reproduce the news releases on news release paper/letterhead that you've printed from the state provided to you. *Make sure you've included the name of a contact person, with telephone number and address. These can be typed at the top of the release before it is duplicated.*

You'll want to do a little thinking about the people you want to receive your press kit. When in doubt, send it to the city editor at a newspaper or the news director at a radio or television station. Some newspapers have an education editor. If these specific positions don't exist, send it to the top person at each outlet: managing editor or station manager. This applies to other publications as well, such as magazines, community newsletters, and school publications. (Don't forget your school newspaper and your district's professional newsletters.) You might want to make some follow-up phone calls to addressees to see if you can answer any questions or help them.

How do you place articles?

You can also use the press materials with local sources (teachers, students, and others) to develop your own article for publication. Sometimes this is more effective than a blanket press mailing. Some publications, such as magazines and school district newsletters, don't use prepared press materials.

It is always a good idea to contact the publication first to see if it will accept an article, and to find out a little bit about the slant or focus of the publication.

Who will give public service announcements?

Radio and television can be instrumental in disseminating information. The guide provides sample public service announcements.

The *radio copy* public service announcement (PSA) can be localized and reproduced and sent to the public service director or program manager at your local radio stations. Remember who your audience is when sending out these PSA's. For instance, if you are interested in recruiting students, you might want to send one to the radio station listened to by teenagers; for community support, you might want to send one to a station with adult listeners.

The *television copy* public service announcement (PSA) can be sent out with the logo slide. Again, send it to the station manager or the public service director.

Remember, broadcast outlets are required by the FCC to give public service time for community affairs. Take advantage of a station's generosity.

How do you conduct a community information meeting?

You, one of your colleagues, and/or some PT students should try to get on the agenda of periodic meetings of groups such as the PTA, Chamber of Commerce, or Rotary Club. In addition, you may be called upon to go to local businesses to talk to several people about the project. (Of course, you or one of your business/industry advisors will have to talk to groups of teachers and students for recruitment purposes.)

The first step in this process is to use the open letter in the guidebook to try to get on the agenda of these local meetings. Once they've accepted your offer, you'll want to use the following meeting format, modifying it to meet your individual needs:

Community Information Meeting (50 minutes)

Introduction (5 minutes)

Prior to the meeting, hand out the project information brochure provided to you by your state or provincial representative.

Introduce yourself and the purpose of the meeting. The following remarks may help you—or a Business Advisory Group member on your team—in this portion of the presentation:

> My name is (representative) and I represent (school, district, or agency). I'm here tonight (today) to introduce you to an innovative vocational resource that we are introducing in our school this year. Many of your youngsters or those of your friends may already be enrolled in this curriculum.
>
> I'm talking about ***Principles of Technology***. The course is designed for vocational students interested in technical careers and other secondary students wishing to further their understanding of the physical principles underlying modern technology. The brochure you have in your hand will give you an understanding of the course.
>
> We are offering the course to high school students here in (city). Our (state/province) was involved in the early development and implementation of the course. Forty-six other states and two Canadian provinces helped fund the project. It was developed under the management of the Agency for Instructional Technology in Bloomington, Indiana, and the Center for Occupational Research and Development in Waco, Texas.
>
> I'd like to show you an overview videotape program that will provide you with a good understanding of this curriculum resource.

Program presentation (15 minutes)

In this part of the meeting, you will be showing an orientation program on ***Principles of Technology***. This will give attendees an overall understanding of the project and its goals.

Question and answer (20 minutes)

Now that you know a little more about ***Principles of Technology***, you might have some questions that I (or we) can answer.

Conclusion (I minute plus . . .)

Students are involved in some pretty exciting educational activities at (school, district, or agency). I hope I've (we've) helped you to gain a better understanding of one of those. I want to invite you to visit us and learn more about ***Principles of Technology*** firsthand—and to visit our classroom at your convenience. Thank you very much.

What about Principles of Technology newsletter?

You might want to start your own newsletter to send to students, teachers, and others interested in the curriculum. You already have a pretty good start with the editorial materials in this guidebook.

How about an open house or tour?

One of the great mysteries for parents and the community is what goes on inside schools. How about showing them? Plan an open house for those interested in this curriculum. Some of your best salespersons are students. They can recite the virtues of ***Principles of Technology***.

What about awards?

You might want to initiate an award for the top ***Principles of Technology*** student, then use the award in promotion. This is called "event marketing." It requires, however, the creation of a genuine event. Fabricating and promoting an event that editors do not find newsworthy can damage your credibility with the press. Prehaps you can solicit a scholarship for the student—or assist him/her in locating a job. Of course, your most important public is your **next** year's class. Keep that in mind as you think of ways to honor your current students. Remember to involve parents and the students' "significant others" in celebrating the honorees' achievements. (A sample ***PT*** certificate is provided in this section.)

What about talk shows?

In your work with the news media, you might attempt to get informed individuals on local talk shows—both radio and television. Again, there is much public service time available. Use some for ***Principles of Technology***. Contact the station's public service director to find out how to do this in your area. You may want members of your Advisory Committee to do this for you.

Samples for Information Campaigning

Sample News Release
(Information to be filled in and local photographs attached by school district or school.)

For Immediate Release
(date)

Contact:
(Name and phone number of contact person at school district/school)

(School) Initiates
Principles of Technology

(CITY, State/Province)—They're doing something new in (name of school—maybe even name of teacher) vocational classes this year. And for good reason.

In today's rapidly changing technical job market, a worker with narrow skills—however expert—can be outdated even before finishing school. Technicians need training that is applicable to more than a single job. They must understand the physical principles on which modern equipment operates and be able to apply those principles to new tasks as the need arises.

Beginning (date), ***Principles of Technology (PT)***, an innovative course designed to meet these urgent needs, (will be/was) introduced to local students.

The new course has been developed cooperatively by (state/provincial agency) and 46 other state and two Canadian education agencies in association with The Agency for Instructional Technology of Bloomington, Indiana, and The Center for Occupational Research and Development of Waco, Texas. Education agencies provided over $3 million for the creation of ***Principles of Technology***.

Based on CORD's **Unified Technical Concepts** course, ***Principles of Technology*** incorporates the findings of field-testing in comprehensive high schools and vocational centers throughout the United States and Canada in 1984-1986. With an appealing instructional system of audiovisual presentations, tests, demonstrations and hands-on laboratories, ***PT*** provides an understanding of the physical principles of technology and the mathematics associated with those principles.

PT is both academically rigorous and practical. A typical instructional unit requires twenty-six 50-minute class sessions. Each of the 14 units in the two-year course deal with a principle as it applies in the four energy systems—mechanical, fluid, electrical and thermal. These "principles" make up both simple and complex technological devices and equipment.

'Principles of Technology'
Add 1

Students will progress from units on force, work, rate, resistance, energy, power and force transformers to units on momentum, waves and vibrations, energy convertors, transducers, radiation, optical systems and time constants.

Throughout the course, video segments present the concepts and illustrate many of their industrial applications. Math skills labs meet students at their own level. Some students need to complete preparatory work before doing the regular math lab; highly skilled students can be challenged by more difficult mathematics exercises.

(If you're involving an Advisory Committee, name them and their professional affilliation here.)

(If you're in a small community, you might want to list the names of students.)

For more information about PT, call (person) at (school) at (phone number).

Sample General Info Story

For Further Information
(your name and phone)

For Immediate Release
(date)

Industry and Education Endorse *Principles of Technology* for Tomorrow's Technicians

(BLOOMINGTON, Ind, and WACO, Texas)—U.S. and Canadian industry, engaged today in an all-out race against the other manufacturing nations of the world, has never needed—or paid—highly qualified technicians more. As our school systems upgrade themselves and reach for "excellence," will vocational education, the source of those technicians, receive its share of respect and resources?

Many industrial leaders doubt whether the vocational education taught in today's schools can prepare the ideal technicians of the future.

Educators, too, see the need to overhaul vocational education. The National Commission on Secondary Vocational Education has studied vocational classes with that aim, conducting hearings and reading testimony to produce its recommendations, published as *The Unfinished Agenda*.

An ambitious effort to meet these demands of industry and education is a course in vocational education called ***Principles of Technology***. Created over the past few years by a group of 47 state and two Canadian vocational education agencies, ***Principles of Technology*** seeks to modernize the skills of tomorrow's technicians.

The National Commission's educators and representatives of business and labor criticized schools. They particularly lambasted those which raised the number of required high school courses, but reduced the hours available for elective vocational education classes. The members thought that schools might be creating a false "head vs. hands dualism," with vocational education seen as preparing students for low-status blue-collar jobs only.

The Unfinished Agenda announced a need for special programs to bridge the gap between academic, theoretical courses and practical, vocational ones. It called on industry to help schools stay current with "robotics, fiber optics, lasers and other high technologies."

In its turn, industry has specific recommendations to make. Three people in a position to evaluate the worth of a worker's vocational background are Dave Evans, former manager of high-tech training at the General Motors Assembly Center in Wentzville, MO.; Art Peters, vice president of TII Robotics, Palatine, IL.; and Bob Walker, technical training manager of Metropolitan Edison, Reading, PA.

Industry, Education Call
Add 1

"We've got to be honest," said Peters. "We can say the schools aren't doing something right, but we have to look at how little support they've gotten from industry. As long as we in industry sit back and do nothing, we don't have any right to cry about it."

Evans agreed, saying the academic environment and the industrial environment have been "too far apart." Industry can help schools, said Evans, in keeping up with technological change, which may occur faster than schools can respond. He wants to see industrial representatives work with students in high schools, vocational schools and colleges.

Walker also advocated the reverse: programs that bring teachers into industrial settings so schools "can get up to speed on the specialized technologies" actually used in the workplace.

Technicians of the future won't work in a blue-collar ghetto, all three men agreed. With proper training, they can expect positions that are more rewarding than assembly-line work. But these elite workers must have broad, adaptable knowledge that applies to more than a single job.

Tomorrow's technicians must know how to troubleshoot, said Evans, "whether it be for a computer or a robot or some other piece of the operation." They must "know how to learn, how to change as technologies change," according to Walker. And communications skills cannot be ignored, added Evans. "As a technician, you must be able to talk problems out with fellow employees, express to them what you're seeing and what you recommend for change. And listen to what they recommend," he emphasized.

A vital link between the Commission's call for change in vocational education and industry's interest in better-skilled technicians is ***Principles of Technology***, a two-year vocational education course now being taught in over 200 high schools in the United States and Canada. The course, taken mainly by high school juniors and seniors, teaches a practical understanding of the physical principles of technology and the mathematics associated with them.

Principles of Technology bridges the head-vs.-hands gap the National Commission on Secondary Vocational Education criticized. And it gives students the broad education they will need to adapt themselves to the changing demands of the work force.

Mary Hatwood Futrell, retiring president of the National Education Association, told 50,000 vocational educators that ***Principles of Technology*** is a "promising new curriculum initiative," a way to "recharge vocational curriculums." And industrial manager Evans called ***Principles of Technology*** "a step in the right direction," one that gives future technicians the right kind of educational background.

Industry, Education Call
Add 2

Modern equipment often involves a combination of mechanical, fluid, electrical and thermal systems, so ***Principles of Technology*** is organized in 14 units of physics applied to all four systems. Unit One, for example, shows students how one technical principle, force, applies in all these systems. These relations are explored in two days of lecture/discussion, a math skills lab, two days of hands-on physics applications labs and a review. Six video programs—an overview of force, one dealing with force in each of the four systems and a summary—introduce the classroom activities.

Educational leaders endorse ***Principles of Technology*** because it helps vocational education students—and others interested in applied science—meet high school science and mathematics requirements that are becoming increasingly demanding. Industry leaders are enthusiastic about how the course highlights up-to-the-minute technology. Many of its video segments were filmed in plants heavily involved with robotics and computerization.

Principles of Technology was developed through the cooperation of state and provincial vocational education agencies in association with The Agency for Instructional Technology (AIT), of Bloomington, Indiana, and The Center for Occupational Research and Development (CORD), of Waco, Texas. The consortium of states provided over $3.3 million for the creation of the course.

The curriculum was tested for two years in over 65 classrooms in participating states and provinces, and the materials were evaluated by education agencies and field-test teachers. Course designers wanted to upgrade the science knowledge of tomorrow's technicians and show vocational education students that high school has something valuable to teach them.

Peters identified the ideal technician as a person who "may specialize in a particular area, but must have broad-based knowledge of the various technologies in the workplace and be able to address them." As Evans pointed out, many of the functions once performed physically by technicians are now carried out by robotic equipment the technician must troubleshoot. And that equipment often works on mechanical, fluid, electrical and thermal principles all operating together.

A course such as ***Principles of Technology***, the three industry leaders emphasized, is needed to expand the background of the modern technician so he or she won't require expensive training and retraining on the job.

Sample Feature News Release
(Information to be filled in and local photographs attached by school district/school.)

For Immediate Release
(date)

Contact:
(Name and phone number of contact person at school district/school)

Principles of Technology
Gears Students for Tomorrow

(CITY, State/Province)—Careers in advanced technology are expanding every day, and skilled technicians are commanding salaries higher than those of many four-year college grads.

Comprehensive high schools and vocational schools are harder pressed than ever to provide skilled entry-level workers and students sufficiently prepared for postsecondary community/junior/technical colleges.

"We're in the center of high-tech industries," said Jay Wilkinson, who teaches ***Principles of Technology (PT)*** at St. Johnsbury Academy, a combined college preparatory and vocational school in Vermont. "Our employers want troubleshooters. They want their people to complete our program and then take their industry's technical training courses."

Terry Rencher, Jr., a high school student in Fort Wayne, IN, wanted to "be able to repair a burned-out computer and be able to build parts for it that are necessary—to just know, to have a real good understanding of what the circuitry is about, and all the basic parts of computers and any other types of machines used in industry today."

"They talk about high tech, but we needed to start with low tech," said Junius Toups, a small engine mechanics instructor at Terrebonne Parish Vocational Technical High School in Louisiana.

All three are enthusiastic about ***Principles of Technology***, a new kind of practical physics course now in its (first/second) year of use at (name of local school/vocational center).

The rapid pace of technological change demands that technicians not only learn skills in one narrow specialty, but also understand the entire complex systems with which they work and the technical principles on which they are based. But how best to teach those principles?

Prepares High School
Add 1

Traditional academic courses often fall short of meeting the needs and engaging the interest of high school students who purposely choose a vocational program, and who do not intend to go to college, contends the National Commission on Secondary Vocational Education in its 1984 report.

"The assumption is that more academics, which may be the best preparation for college, is also the best preparation for life," the commission wrote, concluding, "This assumption is wrong."

This 14-member commission of educators, university faculty members, and representatives of business and labor recommended that students "be allowed to satisfy some requirements for high school graduation—for example in the areas of mathematics, science, English, or social study—with selected courses in areas of vocational education that are comparable in content coverage and rigor."

Principles of Technology is that kind of course.

Developed in response to the urgent need to improve the physics and mathematics skills of high school students who will one day be responsible for maintaining, developing and operating high-technology equipment, ***Principles of Technology*** offers a practical, academically rigorous alternative for students in the mid-50% of the learner population who are interested in applied science.

Forty-seven state and two Canadian provincial education agencies cooperated with The Agency for Instructional Technology in Bloomington, Indiana, and The Center for Occupational Research and Development in Waco, Texas, to create the materials. The project's budget of over $3 million budget was provided by state vocational education agencies.

"***Principles of Technology*** does not replace all the technical courses needed for certain jobs," said Dr. Leno Pedrotti of CORD, who developed ***PT*** and worked with the participating education agencies to adapt it for secondary schools.

"It dresses applied physics in the clothes of modern technology. It strengthens needed mathematics skills and complements the existing vo-tech curriculum. It's not an easy course, but field-test results indicate that students do learn, and that they find the course both interesting and useful," he said.

Principles of Technology has been field-tested extensively in selected schools and vocational centers throughout the United States and Canada. In (state/province) the materials were tested at (schools/centers) with some (approximate number) students.

(**Note:** You might include comments from teachers and students who tested the materials in your area, administrators, science teachers or even major employers who recognize the value of such training for their potential employees.)

Prepares High School
Add 1

"It's not a problem to teach," said Bill Thomas, an instructor at Fort Wayne Regional Vocational School, which Terry Rencher attends. "The material is well-organized. It doesn't make gross assumptions about what a student knows. It tends to explain and define the areas well. And it's rather interesting. I think it gives the students a great deal of mental variety. There's a lot of very hard mental work. We've asked our home schools to send us young people who are interested in the theory, but at the same time want hands-on experience."

Toups said that his students are at all levels. "If I can teach some of my lowest ones, it must be terrific for students who are more advanced. For me, the video is the number-one plus. These kids were born and raised in front of a TV. Video doesn't scare them, and they learn. For the first two weeks, I didn't tell them what we were really doing."

Some of the students in Carolina Sylvestri's ***Principles of Technology*** class in 1987 at West Side High School in Omaha, NE, were taking physics at the same time. A chemistry teacher team-teaching with an electronics teacher, Sylvestri doubted that her students knew that they were learning the same things in both courses because, she said, with ***Principles of Technology*** "they were learning them in a direct, functional way. So much of what I teach is all foundation for higher education. This is a course from which kids can take off on their own."

Sylvestri's class visited a plastics manufacturing company. "Without ***Principles of Technology***," she reports, "they wouldn't have had the faintest idea what was going on. They asked really good questions of the personnel manager and the quality control manager. They had a good foundation and were working from it."

"I really see a need for ***PT***," said Sylvestri, who left Nebraska to go on to pioneer ***PT*** in California.

"It has a place in Louisiana education, because the requirements are going up," said Toups.

Indiana's Thomas likes ***PT*** because it gives students something between going to college and learning hands-on without theory. "The new technologies are forcing schools to rethink those old policies."

With degrees in mathematics and science, Wilkinson tried some years ago to design an applied mathematics course for his students. "I found it was a lot of work," he says. "Finally I gave up. But ***PT*** is tailor-made to help students brush up on their math skills, too."

And what do students think?

Prepares High School
Add 1

The best thing about ***Principles of Technology***, said student Terry Rencher, is that ***PT's*** divided into sections and builds on a basic idea until there is a common understanding. "The labs are wonderful."

According to Daniel Troxell, a student who had trouble with geometry and algebra due to what he called his "lack of willingness to do the work," ***PT's*** interesting.

"I like to learn the stuff I don't already know. Every now and then, Mr. Thomas will surprise us with something. He'll bring in something new and something kind of clicks in the back of my brain and I have the urge to grasp it."

Glen Boston, Daniel's classmate, put it even more simply: "***PT's*** the best thing available in the school system."

Sample Open Letter From School District/School Representative To Parents, Parent Groups, Civic Groups, or Employers

(Be sure to use PT or your official school letterhead.)

Dear (   ):

Careers in advanced technology are expanding and changing every day, while skilled technicians are commanding salaries as high or higher than those of many four-year college graduates. It is more important than ever before for high schools and vocational schools to prepare students to adapt to technological change.

Beginning (date), (name of school) (will offer/offered for the first time) a new kind of course to help them do just that. ***Principles of Technology (PT)*** is a practical, rigorous course in physics and mathematics designed especially for vocational students interested in technical careers—and for other students to whom emphasis on the application of the physical principles underlying modern technology appeals more than a theoretical approach.

Developed cooperatively by (state/provincial agency) and 46 other states and two Canadian provinces, and pilot tested extensively throughout the United States and Canada, ***Principles of Technology*** meets individual students where they are. It builds on learners' strengths and interests. ***PT*** uses an appealing instructional system of audiovisual presentations, text, demonstrations, and hands-on laboratories to teach the principles of mechanical, fluid, electrical, and thermal systems and the mathematics associated with them.

(We/I) consider it important to get the word about this innovative course out to students and to the community that will eventually depend on them to maintain, develop, and operate high-technology equipment. (We/I) (are/am) asking for your support.

(**Note:** End the letter in the way that best suits your purpose. You might want to volunteer a speaker to take video programming and other course materials to a meeting of the group to which you are writing. You might use such a presentation to recruit students, or to increase understanding among teachers and parents. You might suggest specific ways in which organizations would support the new endeavor. A business or civic group might consider stocking a laboratory station, perhaps from its own surplus. Employers might be willing to visit classrooms to help students understand how the skills taught in ***Principles of Technology*** are needed in industry.)

For more information, feel free to call or write (contact person) at (phone number, address).

Sincerely,

(Your name/or the names of your Superintendent, Vocational Director, Counselor, or Business Advisory Committee. "The more the merrier.")

Sample Letter to Parents

(date)

Dear Parent or Guardian: (Names if possible)

Your son/daughter recently attended a meeting at (his/her school)* concerning a new course, ***Principles of Technology***, which will be taught at (PT site) beginning next year.

(County) is in an area of growing high technology industries. Careers in advanced technology are expanding rapidly, and skilled technicians are in great demand. The (school or PT site) is responding to these changes by expanding its facilities and adding new courses. The addition of ***Principles of Technology*** is part of this effort to meet new high-technology demands.

Principles of Technology is designed for students interested in technical careers and other secondary students wishing to further their understanding of the physical principles underlying modern technology. ***Principles of Technology*** has a dynamic instructional system of audiovisual presentations, texts, demonstrations, and hands-on laboratory experiences. It provides an understanding of the physical principles of technology and the mathematics associated with them. Each of the seven (7) instructional units deals with one principle as it applies in the four energy systems—mechanical, fluid, thermal and electrical—that make up both simple and complex technological devices and equipment.

(School) also encourages parents and students to visit the school to see and learn more about the programs offered. ***Principles of Technology*** information is available from (name and phone number).

Students will register for ***Principles of Technology*** as part of (course name) at (PT site), and will have the opportunity to earn (credit as applicable in math or science). Additionally, students receive (vocational and other credits as applicable), now required for graduation.

Guidance counselors in the schools will register students for the (course name) and ***Principles of Technology***. Interested students should request additional information during (the pre-registration period).

Sincerely,

* **Note:** Insert local information in between parentheses.

Sample Radio Spot

(date)
Principles of Technology
Public Service Announcement

10 seconds with upbeat music intro and exit

High school sophomores! Get technical about your future. Talk to your high school counselor about ***Principles of Technology*** . . .

Sample Radio Spot

(date)
Principles of Technology
Public Service Announcement

30 seconds

High school students—if you're looking forward to a technical career, or you're more interested in applying science than abstract ideas, there's a new kind of training just for you. And it's free! Find out how ***Principles of Technology*** can help you keep up with the pace of modern industrial change. Ask your counselor, or call (name of school district/school) at (phone number) to ask about ***Principles of Technology***. That's (repeat phone number). Because we want you to get technical about your future.

Sample Television Spot

(date)
Principles of Technology
Public Service Announcement

20 seconds

(Slide: ***Principles of Technology*** title slide)	High school students—if you want a technical career and you don't want to find your skills outdated by new industrial technology, there's a new kind of training just for you. And it's free! Find out about **Principles of Technology** now at (school/vocational center). Ask your counselor. Get technical about your future. Call (phone).

Sample: Press-Generating Activity

Courtesy of

Pre-Technical Education

North Carolina

Principles of Technology

TECHNICAL DEMONSTRATION CONTEST

Purpose

To evaluate each contestants' ability to demonstrate a technical concept using the apparatus and/or a test equipment used in the Principles of Technology program.

Eligibility

Open to students enrolled in Level I or II of the Principles of Technology course and an active member of a VSO.

Equipment and Materials

1. Supplied by the contest coordinator:
   a. timekeeper
   b. all necessary information and furnishings for (3) three judges
   c. suitable facilities.

2. Supplied by the contestant:
   a. All materials and equipment needed for the technical demonstration
   b. No professionally prepared audio or visual materials will be permitted.

Scope of Contest

1. Contestants should prepare for the technical demonstration by developin. the following abilities:

   a. Prepare a 10-15 minute demonstration using props and models to illustrate points of information
   b. Understand and practice elements of informal conversation
   c. Demonstrate an effective and pleasing delivery style
   d. Pronounce words in a clear and understandable manner
   e. Demonstrate good platform deportment and personal confidence
   f. Organize demonstration in a logical and coherent manner
   g. Learn to effectively vary voice in pitch, tone, tempo, and volume
   h. Demonstrate good grooming in dress and personal hygiene

2. The demonstration is a presentation of a technical concept accompanied by a clear explanation of the topic through the use of examples, experiments displays, or practical operations.

3. Any technical concept may be demonstrated provided it is related to the Principles of Technology.

4. The contestant will present a 3"x5" card indicating the topic of the demonstration to the head judge at the beginning of the contest.

5. The demonstration shall be at least ten minutes in length but shall not exceed fifteen minutes. Penalty: Five points will be deducted for each 30 seconds or fraction thereof under ten minutes or for each 30 seconds or fraction thereof over fifteen minutes.

6. Time Limit: Time will be started when the demonstration begins. The timekeeper will signal the speaker a ten minutes, thirteen minutes, and fifteen minutes.

7. Contestants will be allowed five minutes to set up the demonstration and three minutes to clear the demonstration room. Penalty: Five points will be deducted for each 30 seconds or fraction thereof over the five minute allowance.

8. An 8'x12' space with one 110-volt (15 amp) electrical outlet and one 30"x96" table will be provided.

9. Any visual aids (signs, charts, transparencies, slides, diagrams) are to be prepared by contestants. Professionally prepared visual materials are not permitted. No sound devices of any kind may be used to transmit audible words. No compressed air, gas or flammable liquid may be used.

10. The contestant will use his or her first name only and no mention of school.

11. The demonstration is an individual performance, however an assistant may be used to set up and dismantle the demonstration or may be used as a prop or model only.

TECHNICAL DEMONSTRATION

Judges Rating Sheet

ITEMS EVALUATED	Excellent	Very Good	Good	Fair	Poor	CONTESTANT NUMBER 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Introduction clearly identified scope of the demonstration	10	8	6	4	2																						
Demonstration is organized in a logical sequence	20	16	12	8	4																						
Explanation is adequate to convey technical concept	30	24	18	12	6																						
Closing is appropriate	10	8	6	4	2																						
Demonstration is interesting and informative and contestant had a clear understanding of concept	30	24	18	12	6																						
TIME PENALTY (minus 5 points for each fraction of 30 seconds under 10 minutes or for each fraction of 30 seconds over 15 minutes)																											
SAFETY PENALTY (minus 10%)																											
TOTAL POINTS	100	80	60	40	20																						

PRINCIPLES OF TECHNOLOGY

The Agency for Instructional Technology

and

The Center for Occupational Research and Development

BESTOW THIS AWARD OF NATIONAL RECOGNITION TO

____

at

____

for outstanding achievement in Principles of Technology

Leno S. Pedrotti

Leno S. Pedrotti, Ph.D.
Principal Author
Principles of Technology

Date

322

323

PRINCIPLES OF TECHNOLOGY

Congratulations to ______________________

for providing the

FORCE

to

WORK

at a

RATE

without

RESISTANCE

and with the

ENERGY

and

POWER

to be

FORCE TRANSFORMERS

Sample certificate supplied by Ramona Anshutz, Science Coordinator, Kansas

Certificate of Completion

is awarded to

for satisfactorily completing 120 hours
of Instructor Training for Units 1 - 7
of the Principles of Technology Curriculum
at

Pikes Peak Community College
June 22 - July 17, 1987

Keith L. Ross, Instructor
Principles of Technology

Don E. Goodwin, Vice President
Instructional Services

Richard C. King, Director
High Tech Training Center

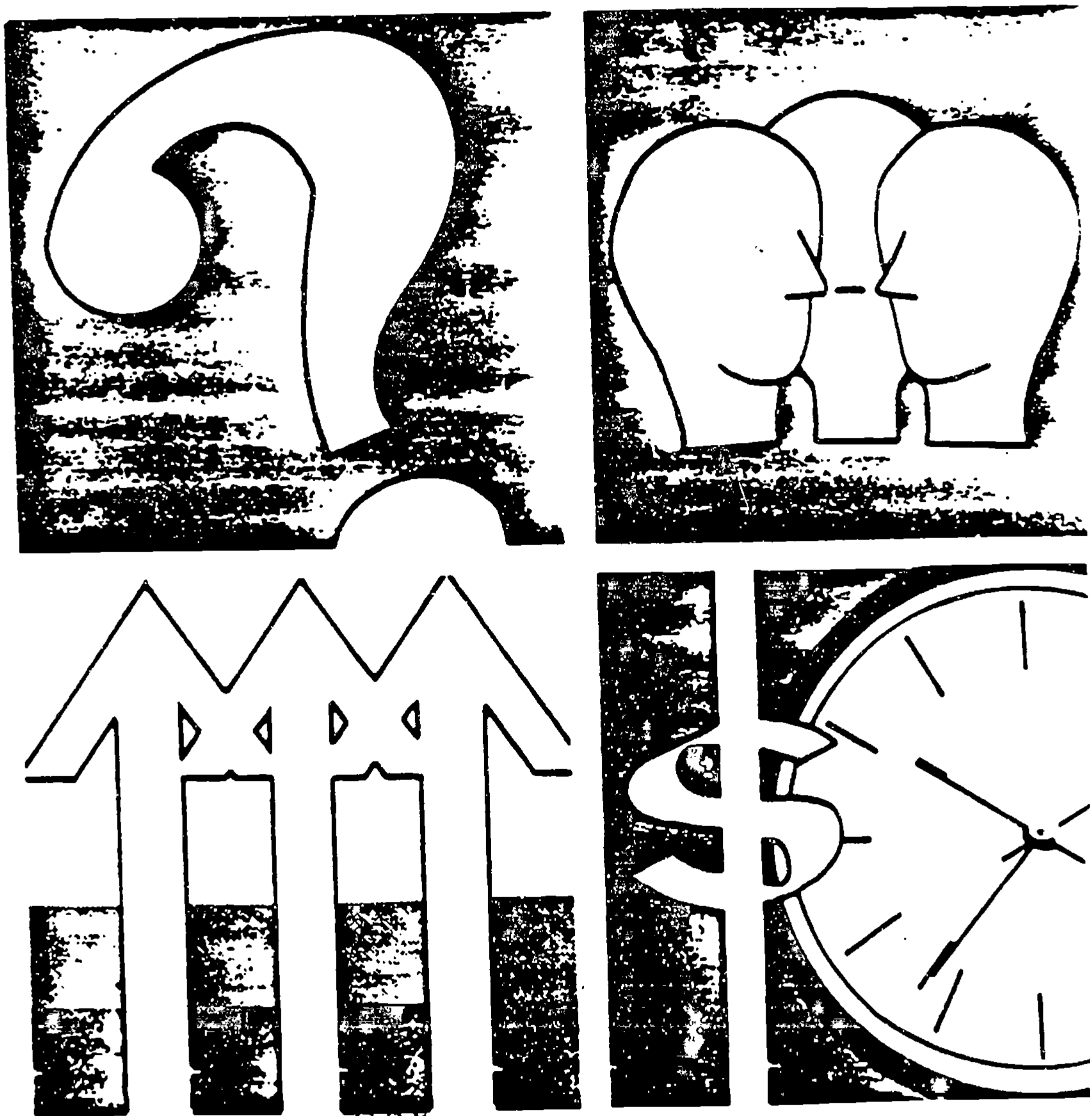
Dr. Cecil L. Groves, President

Planning: The Place to Start

A brief presentation on the importance of planning in a local program.

Sample PR Planning Guide

Reprinted with permission from Communication by Design, Illinois State Board

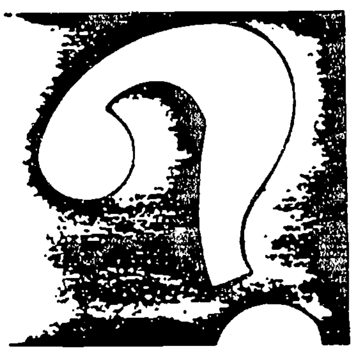


Resources

You've probably heard already, from someone who "knows", that public relations effort is wasted. They've tried it. They issued news releases, sent press announcements of new staff or programs, even published articles in journals, and no impact on their program was achieved. Clearly PR is a waste of time, effort and money. And usually they're absolutely right . . . at least in terms of their experience. Commonly these "experts" have been willing to use the tools of public relations, but unwilling to invest the time needed to establish a comprehensive plan.

PR works through consistent, cumulative effort. Its greatest dividends are paid after repeated attempts. So if you're not determined to work through the early activities when results will be minimal, you're best advised to forget it. Only rarely will your efforts be blessed with immediate and gratifying results. Your enemies: ignorance and apathy, are rarely felled by a single blast. They are worn down by a timed series of repeated blows.

Before you formulate objectives for the journey ahead, you must know where you are! You're concerned with a number of "publics" whose goodwill is important to your success. You need to know what must be done to meet each public's definition of a worthwhile activity. You want to know what each of your publics admires and believes about you now. You want to know what each would require of you before they would take action in your behalf.



Research Phase

Begin with an analysis of your student group which seeks vocational education. Why do they do so? Are they growing in number or shrinking? Why? What do they want as voc-ed students? What do they presently believe about your programs, and how committed are they to these opinions? Do they care enough about them to take action? Do they praise or criticize?

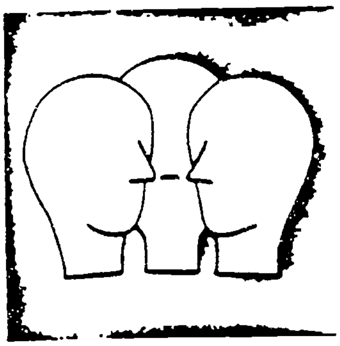
1.1
Sample Program Assessment Questionnaire

By dismissing assumptions and performing this analysis, you can know the state of vocational education's relations with these student clients. The same type of analysis, conducted in an organized survey approach, can be used with each of your publics (educators, parents, businessmen, political leaders, legislators, etc.) Then you know the current importance of each public, what its members think of voc-ed activities locally, and whether these opinions are based on fact or fiction.

Using the results from these research surveys, a report should be prepared which addresses each public. This should list concisely factors such as the public's size, importance to voc-ed, current regard for voc-ed, and perceived strong and weak points.

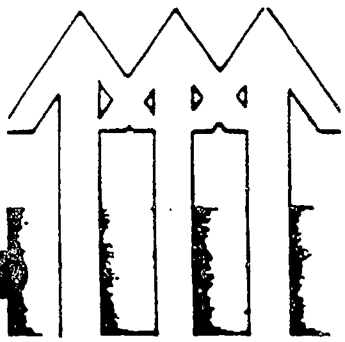
1.2
Sample Image Audit Report

This plan should list opportunities and concerns, ranked in a descending order or priority. It should list possible objectives indicating pros and cons for each.



Consultation Phase

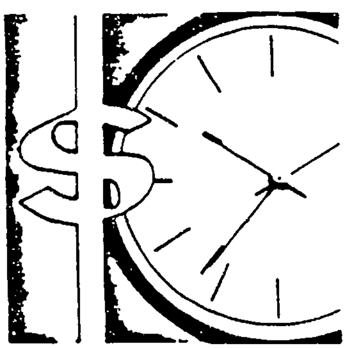
Conclusions from this report should be drawn *only* after this data is shared with a local Advisory Committee. If you have personally gathered and organized this data, and you proceed to formulate conclusions, they could be erroneous. A committee should review the report's content and challenge its accuracy and completeness. Then move to an assessment of prior efforts and current activities. Even informal or unintended communications should be analyzed. This could lead to suggestions for changes, additions and deletions.



Objective Phase

Then *you* should turn these conclusions into specific objectives. Committees don't design programs well, so plan to do this as a solo activity, or use one or two colleagues as helpers. The overall public relations plan should be established for a one-year and five-year period - and should contain the first-year objectives established for each of your publics.

1.3
Sample PR Plan Format



Plan Design Phase

Now you are ready to consider specific activity approaches to be taken, cost, resources and time needed, and the process to evaluate results. Once these elements are added, you have the foundation for a good structure of activity.

1.3
Sample PR Plan Format

Your public information plan should be monitored closely, and reviewed with your Advisory Committee annually. This monitoring involves a number of concerns. First, consider changes in circumstances affecting, or likely to affect, any of your publics. Have some of them shifted, in attitudes or importance? Then assess your progress toward your stated objectives. Cost vs. impact of various program elements should be evaluated. Now you're ready to extend your five-year plan and prepare next year's objectives. Your long-range plan and your annual plan should be a living, growing instrument which always reflects current realities.

1.4
Check Points for PR Program Planning

This is the first, the most crucial key to successful PR activities. Don't let your planning become something informal that exists only "in your head". Some sad experiences have proven this simply isn't enough to ward off the ever-present temptation to launch one-shot efforts with high hopes and low chances for success.

Summary

Before taking even the first small step in public relations activity, take time to plan. Failing to plan is planning to fail. Use these keys to good PR planning to program your efforts for success.

1. Don't attempt to reach the world. Break your world into specifically identified publics, and consider each of them separately.

2. Don't fly by the seat of your pants, because there are trustworthy instruments to guide you more surely. The efforts required to dig, ask, examine, challenge your assumptions, and test your hypotheses are definitely worthwhile. Invest these efforts in your own success, and you'll reap good dividends.

3. Test your research conclusions on an Advisory Committee. Members of a good committee can give you worlds of helpful information on the image of vocational education among your publics.

4. Take time to create a five-year plan with concrete one-year objectives. This maintains the long-pull perspective and helps avoid many errors. Address each public's circumstances in this plan, and generate objectives for each of them.

330

1.1

Vocational Education Program Assessment Instructions/Directions

The assessment form which follows is prepared for photo-reproduction, as a tool which will enable you to prepare an Image Audit. Its ten questions are designed to secure signals concerning the opinions and the feelings held by those who have, and have not had actual experience with your programs. It will also indicate the relative strength of these feelings and opinions, and show you what portion of your potential audience is potentially prepared to commit something of value to the support and/or enhancement of your programs.

Ideally, this form should be distributed to a wide segment of your audience, with the purpose of building your program plan on accurate, objective awareness of your starting point. This accuracy is heavily dependent upon sample size, as you know. To reach a 90% probability that your responses reflect community attitudes with a ±5% error margin, your total sample must contain approxir. ately 300 respondents. As the number drops below this, your accuracy drops more rapidly than your sample portion. Securing 10-20 responses from any tabulated group gives you results which are virtually meaningless.

This form should be distributed with a cover letter and return envelope (hopefully stamped and self-addressed), with some incentive appeal offered in the letter. Promise to do something worthwhile with this data, maybe including an offer to share results with certain groups. An approach which will secure much better returns would be a personal distribution and collection at a public gathering. If this approach is taken *be sure* you do not combine this process with any verbal presentation on your programs. If you have just sold an audience on yourself, your dedicated and diligent efforts, etc. they will be reluctant to tell you anything negative. Your response from the same group would be different a week later, and the results you have obtained are suspect.

Vocational Education Program Assessment

This questionnaire is not connected in any way to the process of student admissions, selections of employers for placements or cooperative programs, etc. It is simply a tool to help us determine the level of understanding you may have of our programs, and your feelings about them. Your name or identification is not needed, but your honest, thoughtful answers will help us plan better programs in the future. Thank you for your assistance. Please mark an X in the spaces which indicate your opinions.

	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
1. Local vocational educational programs are well planned to meet the realities of the local job market.	☐	☐	☐	☐	☐
2. These programs are presented in adequate facilities	☐	☐	☐	☐	☐
3. The instructional materials and supplies are adequate	☐	☐	☐	☐	☐
4. The ability and presentations of the instructors are adequate	☐	☐	☐	☐	☐
5. Completion of these programs are instrumental in helping students secure employment	☐	☐	☐	☐	☐
6. The information provided about these programs is adequate	☐	☐	☐	☐	☐
7. Student placement assistance upon program completion is adequate	☐	☐	☐	☐	☐
8. These programs are needed to support our area's economic needs	☐	☐	☐	☐	☐
9. These programs should be expanded	☐	☐	☐	☐	☐
10. I would support the expenditure of additional tax dollars to expand vocational education programs	☐	☐	☐	☐	☐

	Student	Parent	Educator	Employer	Government Worker
11. I am a	☐	☐	☐	☐	☐

	Very Positive	Positive	Have had None	Negative	Very Negative
12. My experience with vocational education has been	☐	☐	☐	☐	☐

332

1.2

Image Audit Compilation Report Instructions/Directions

This tabulation form is also ready for photo-reproduction. It can be used to assess the responses to the Program Assessment Instrument (Resource 1-1) from any given sub-group, and also from your total audience group.

As you note total raw scores of responses to each item, you may calculate % scores for easier comparison. To tabulate the mean response for each item, multiply the number of responses received for each ranking x the numerical value of that rank, i.e. 4 in "uncertain" x 3 = 12. Accumulate all the arithmetic products from this process, and divide the cumulative total by the number of responses for the item. This tells you where your respondents fall as a group on each item.

Interpretation of the data generated is a challenging undertaking. This is where the assistance of your Advisory Council will be most helpful. The more you challenge and stimulate its members, the better. Encourage them to question and qualify the data with experience and observations of their own, share assessments of the meaning and importance of the item scores, and suggest revisions of the group profiles, problems and opportunities. While you will probably choose to generate an initial set of potential activities, with respective advantages and disadvantages, their additions and comments should be valuable.

Matching identified perceptions, problems and opportunities with program goals, objectives and activities will take you into the process generated by the Public Relations Program Plan (Resource 1-3). The jump from problems and opportunities directly to proposed activities is used in this instrument because advisory groups are reluctant to engage in careful, step-by-step planning. They will typically become impatient with any efforts to formulate goals and objectives with any care, so it is more realistic to focus first on activities, then to subsequently use those proposed activities which support logical goals and objectives, and overlook those which do not.

Image Audit Compilation Report

Survey group ______________________ Group's Local Population __________

Group Influence & Importance Rank: Very high High Neutral Low Very Lo

Total Survey Group Size: ______________

Image Audit Item Scores and Arithmetic Ranking:

Item	Strongly Agree (5)	Agree (4)	Uncertain (3)	Disagree (2)	Strongly Disagree (1)	Mean Response Ra
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

% of Group Respondents basing assessments on experience __________

	Very Positive	Pos.	Negative	Very Ne
% of Respondents ranking experience as:				

Profile description of this group's assessment of local vocational education programs: ______________________

Problems and opportunities indicated by this data and other observations of this ("public") group: ______________________

334

Potential PR Program Activities	Advantages	Disadvantages

1.3

Public Relations Program Plan
Instructions/Directions

The ideal PR plan focuses on the immediate future. but still retains a view of the long pull, for a sense of perspective. The following instrument encourages the adoption of general goals, which can be concisely stated, for each of your major publics. These are five-year program goals which identify the long-range movement you want to achieve with each group. Some of these should involve behavior change, or your vision is probably too limited. Behavioral goals would include those such as:

- Improve registration in voc-ed programs from 12% to 22% of 9th graders.
- Attract 10% more parents to each year's voc-ed fair, compared to prior year.
- Increase coop employer participants from 14 to 30 within five years.
- Secure some form of program involvement by x local legislators by 19_______.

Attitudinal goals might reflect a desire to improve a certain score on a re-survey of some groups using the Program Assessment Instrument at some determined time. Information goals might involve a determination to place a certain number of news stories per year, distribute an informational filer to a certain percentage of area households, etc.

Annual program objectives should be more specific, stated in measurable terms, time-bound, achievable in one year or less, and capable of evaluation by a pre-determined standard. These should obviously support your long-range goals, and address problems and opportunities identified in the image audit. An exemplary objective, tied to the first goal stated above might be:

Activity Description: Prepare a small filer on voc-ed programs, and mail one to each 8th grade student in the district.

Resources Needed: Names from district office, with addresses. Approval of building principals and superintendent. Students who will provide testimonial copy.

Budget Needed: $290 including postage.

Anticipated Completion Date: Mailed by April 1.

Evaluation Measurement Standards: Next year's 9th grade % enrollment in vocational education will improve from 12% to 16%.

Public Relations Program Plan

Five-year Program Goals for Each Public (Consider each group's population size, importance and influence, present perceptions & attitudes, etc.):

Students

1. __________

2. __________

3. __________

4. __________

5. __________

Parents

1. __________

2. __________

3. __________

4. __________

5. __________

Educators

1. __________

2. __________

3. __________

4. __________

5. __________

Employers

1. __________

2. __________

3. __________

4. __________

5. __________

Government Officials

1. __________

2. __________

3. __________

4. __________

5. __________

Program Objectives for the Year ____________________

Activity Description ____________________

____

____

Resources Needed ____________________

____

Budget Needed ____________________

Anticipated Completion Date ____________________

Evaluation Measurement Standards ____________________

____

Activity Description ____________________

____

____

Resources Needed ____________________

____

Budget Needed ____________________

Anticipated Completion Date ____________________

Evaluation Measurement Standards ____________________

____

333

Check Points for PR Program Planning

The final responsibility for planning and executing a long-range public relations program rests with you. These check points will help judge an existing prograr initiate a new one.

1. In planning a public relations program are you careful to:

   ____ a. Allot an equal amount of time to planning and instructional presentation of your program?
   ____ b. Involve staff in planning, preferably through a committee of teachers and non-teaching personnel?
   ____ c. Tailor a program to meet your community's unique needs and characteristics instead of adopting some other school's program'
   ____ d. Keep the plan simple, and on paper, so that it is easily understoc and operable?
   ____ e. Move slowly, not stirring up community and staff suspicion?

2. Do you indicate the importance you place on good public relations by:

   ____ a. Your own attitude, actions, and time devoted to this area?
   ____ b. Providing the time, materials, and facilities needed to carry out th responsibilities?
   ____ c. Assuming responsibilities for all activities that can best be handl through the school?
   ____ d. Developing policies, rules, and procedures that promote good puι relations?

3. In working with community do you:

   ____ a. Conduct a continuous survey of its needs and attitudes?
   ____ b. Keep people regularly informed on all phases of the program? Successes and problems?
   ____ c. Provide channels for school-parent relations?
   ____ d. Enlist the assistance and cooperation of community organization:
   ____ e. Maintain regular contacts and flow of information with the local newspapers, radio, and TV stations?

Suggested Communication Calendar

Time	Action
Summer	Make overall PR Plan & Annual Objectives Develop Slide Presentations Design Brochures Write Speeches Visit radio & TV stations and newspapers Develop student handbooks Plan career guidance week
Aug.-Sept.	Make presentations to internal publics Begin Program Assessment Research
Oct.-Nov.-Dec.	Attend Regional & State Workshop Implement Career Guidance Week Program
Jan.-Feb.-March	Make presentations to External Publics Interim Evaluation - check to see if your PR plan is working
April-May-June	End of Year Evaluation and complete Program Assessment Report to Advisory Council
	Recycle

Implementation Time Line and Key Issues

This is a suggested time line for key activities in the implementation of ***Principles of Technology***. It's an "ideal" scenario. You should alter it to meet your needs. Some schools, for example, may wish to begin instruction mid-year and will need to alter other activities accordingly. Others will find they must organize more quickly than they'd like. The advantage to a time frame that begins at the spur-of-the-moment is that you can begin by involving students in your awareness campaign.

September (one year before use)	Make decision to implement. This should be a joint decision by administrators, teachers, counselors, school board members, an Advisory Committee, etc. Early involvement will instill a sense of pride in all those involved.
October	Hold a "feasibility" planning meeting to prioritize and sequence such activities as selecting teachers, training teachers, recruiting students, and obtaining equipment. Discuss such topics as how the course will fit into existing curricula, what student's needs and interests are, and how the course relates to postsecondary training.
November	Identify teachers and/or other key players.
November	Determine budget needs.
January	Begin public awareness activities using "Guide to Information Dissemination."
January	Meet and discuss relation of course to postsecondary training with appropriate audiences (academics, community colleges, etc.).
January	Order equipment.
January	Begin recruitment of students.
January-July	Conduct teacher training.
September	Begin instruction.

What are the main implementation issues?

The critical issues fall into three domains: state level, school level, and teacher/counselor level. Here, they're discussed as "action" steps.

What are the state level issues?

- Select school sites.
- Consider funding strategies to assist schools that want to pilot the materials.
- Create a statewide information dissemination/exchange network for teachers, counselors and administrators.
- Create a statewide public information program about applied academics courses and the changing options in voc-ed programs.
- Distribute the project materials as necessary.
- Communicate with administrators, counselors, teachers, parents and members of the community about equity issues.
- Provide summer workshops for general "academic" and vocational teachers/counselors and administrators.
- Work with teacher trainers at colleges and universities to inform them of the infusion of applied academic courses into secondary vocational programs so that they can include preparation for those who will teach applied academic courses in their programs for aspiring teachers.
- Establish criteria for teacher certification.
- Keep a record of what kind of course credit is issued, (if it's local option) or determine kind-of-credit policy for ***Principles of Technology*** and other applied academics.
- Sponsor two-plus-two articulation workshops that include information about infusing applied academics into the high school curriculum and monitor two-plus-two programs within the state.
- Network with other state representatives to maintain awareness of the innovative uses of applied academic materials and courses in other states.

What are the school level implementation issues?

- Select teachers. Consider team-teaching possibilities.
- Inform parents and the business community of the new course and career options available in vocational education. (You may want to appoint an advisory committee for this task, since generating public awarness and support can be accomplished more easily this way.)

- Set up a testing program to assess whether students meet the proper competency profiles for entering the ***Principles of Technology*** course and/or other applied academic courses. (Assessing reading level and reading comprehension is particularly important.)
- Recruit students. Consider directing a recruiting effort toward female students who may never have considered a vocational program or a technical career.
- Determine funding strategies for the laboratories.
- Identify/work with vendors.
- Host or set up in-service and other workshops for teachers, counselors, administrators, and representatives of business and industry—perhaps on a regional basis.
- Fit ***Principles of Technology*** and other applied academic courses into the school curriculum. (pre-tech? adjunct to existing vocational program? alternative academic course?)
- Engineer two-plus-two articulated programs with postsecondary schools.
- Work to bridge the gap between the "academic" and vocational forces in the school.

What are the teacher/counselor level implementation issues?

Teachers and Counselors are key players in making the implementation of new curricula possible. Therefore, in order to implement applied academic courses into the high school curricula, teachers and counselors should be asked if they are willing to:

- Become acquainted with careers in modern technology.
- Become acquainted with ***Principles of Technology*** and other applied academic courses.
- Target the mid-50% of the high school student population, as well as adults who need the math skills covered in the course, and guide them toward ***Principles of Technology*** and other applied academic courses.
- Consider placing more female students in nontraditional vocational education programs.
- Inform the community about the new options in vocational education by showing the ***Principles of Technology*** overview videotape at school board, PTA and other community meetings.
- Assist administrators and teachers with a public information campaign that includes media coverage so that the community-at-large can understand the changing options in vocational education programs at the secondary and postsecondary level.

- Use the "2 + 2 career ladder" track when helping students (parents) choose education paths. (Attend workshop that explains the "how-to" process of "2 + 2".)

What steps should top school administrators/directors take in implementating PT?

- Make decision to implement ***PT***
- Determine where course fits best
  - Full, stand alone, pre-tech course
  - Integrated with specific vo-tech course
  - Alternative science course
- Identify teachers
  - Team teachers
  - Industrial arts teacher
  - Science teacher
  - Vocational teacher
- Set entrance requirements for students
- Seek industry support for purchase of lab equipment
- Visit state sites where ***PT*** is in progress
- Provide for teacher training
- Obtain media coverage in community for ***PT*** (teachers/counselors must support)

344

COMPARISON OF ACHIEVEMENT OF HIGH SCHOOL STUDENTS IN TRADITIONAL PHYSICS AND PRINCIPLES OF TECHNOLOGY*

CASE STUDY

226 students in 8 first-year PT courses

306 students in 18 physics classes

23 teachers (15 physics teachers; 8 PT teachers)

EVALUATIVE CRITERION

Set of scores on test items extracted from a nationally recognized high school physics exam encompassing the areas of mechanics, heat, and electricity

CONCLUSION

Based on the data analysis, it was concluded that *Principles of Technology* is a sound academic course, equivalent to physics, in terms of student performance on a test of physics (mechanics, heat, electricity) items. Under that conclusion, education counselors should not hesitate to encourage (1) college-bound students (both 2- and 4-year) and (2) those students leaving high school directly for work to enroll in *Principles of Technology*.

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Principles of Technology

National Survey of "PT" Programs

Lee D. Carter and Jerry L. Atkinson

The Principles of Technology curriculum has recently made a significant impact on technology programs throughout the United States and Canada. Principles of Technology (PT) is a curriculum designed to provide students with an opportunity to prepare more effectively for technical careers. Because the world of tomorrow will demand a broader foundation of technical knowledge and skills, students need the content which is offered by Principles of Technology.

A national study of PT programs was conducted by Colorado State University in the spring of 1988. This article reveals some of the key findings identified in the survey. These findings provide an insight into the impact of the Principles of Technology curriculum.

The purpose of the study was:

- To determine the amount of PT acceptance by educators in the states and provinces where it has been adopted; and
- To identify some of the credentialing and teacher preparation that is currently being used.

The data identified in this article addresses those questions from the survey that pertained to tracking the progress of PT and to the decision to implement PT. The results were compiled from the survey responses returned by educators and administrators. As with any survey, some questions were not applicable to all respondents. The results for each question included in this report reflect only the answers of those who responded.

The rapid acceptance of the Principles of Technology curriculum into our schools should amplify the importance of this initial study. The results of this study should help those involved with teacher preparation better understand the evolutionary nature of PT. The ever-changing nature of educational systems prevents this data from being anything other than just an indicator of the future direction of PT along with a brief overview of the ongoing process of incorporating PT into technology programs.

Teachers, teacher educators, and state department administrators were included in this survey. Thus, the results reflect a broad response base. Multiple returns from each state or province were tabulated to reflect a single response or quantity for that state/province. A total of 41 states or provinces were used for this portion of the survey.

PT Programs

Operational—Some 39 states and provinces indicated there are currently some 550 secondary school PT programs now operational in the United States and Canada. The responses revealed that over 12,760 students are presently participating in PT programs.

At the post-secondary level, approximately 49 PT programs in 20 states and provinces involving 893 students. These post-secondary programs *do not* include teacher preparation programs which are generally offered in summer school courses.

Proposed—At the time this survey was conducted, there was data to indicate that PT programs would increase by 80%. This data clearly indicates the widespread acceptance of Principles of Technology in both the United States and Canada.

Certification of PT Instructors

One of the purposes of this survey was to determine how the various states and provinces were handling certification as it related to PT instructors. The findings were most enlightening.

Of the 40 states and provinces responding, only 5 presently have separate teaching endorsements or certificates required for PT instructors. The response pattern varied regarding the course requirements which are necessary for becoming an instructor of PT.

Some 11 states and provinces indicated that, on the average, 9.09 credits of science is needed, while 8 respondents stated that an average of 7.56 credits of mathematics should be required to become a PT instructor. Approximately 7.5 credits in Technology Education is recommended by 8 states and provinces for instructors who plan to teach PT. Two states recommend an average 19.50 hours of credit in vocational course.

Certification and Course/Credit Requirements

A concerted effort was made in the survey to determine the amount of non-classroom work experience as well as years of teaching experience that PT instructors have. Respondents indicated that the average number of years of non-classroom work experience for PT instructors was 7.8, and the average years of teaching experience for PT teachers was 9.5.

347

BEST COPY AVAILABLE

Thus, it generally is not the new graduate from a teacher training institution who is teaching PT but is more likely to be a seasoned instructor with nine or more years of teaching experience. This finding indicates the importance that institutions preparing Technology Education majors must include in-service workshops as well as pre-service course work in PT.

PT Teacher Training (Competencies)

The responses to this question were divided into two parts. Part one consisted of a list of areas in which the respondents felt it was important for PT teachers to have competencies. The areas that respondents indicated that PT teachers should have competencies in are:

- Physics applications and math skills as well as a variety of other skills not identified—30%
- Labs—22%
- Physics and math skills (most important)—15%
- Physics and math skills (needed)—11%
- Math labs—7%
- Physics skills—7%
- Physics and labs—5%
- Lab and video skills emphasized—1%

The second part is a summary of the written comments submitted by the respondents to this question regarding what competencies should be emphasized in a PT teacher workshop and is available upon request.

Workshops and PT Courses

One of the major goals of the investigators who developed this survey instrument was to identify the number of states and provinces that require one or more workshops or courses in PT, as well as to determine the average length and the amount of credit given for both activities.

Workshops proved to be the most popular method of training PT instructors. Out of 41 states and provinces, 24 (58%) require instructors to attend some type of workshop involving PT training. The workshops ranged in length from 15 to 210 hours, with the average being 55.6 hours in length. Two to eight credits were generally given in some 27 states and provinces for PT workshops with the average at about four credits per workshop.

Only 3 of the states and provinces participating indicated they required instructors to enroll in a Principles of Technology course. The courses ranged in length from 45 to 95 hours in length with an average at 61 hours of PT instruction. The credits offered for PT courses ranged from three to six semester credits, the average was four. One state currently requires their PT instructors to attend both a workshop and a course in PT before they are eligible to teach PT.

Required PT Workshops/Courses

A concerted effort was made to determine the amount of non-classroom work experience as well as years of teaching experience that PT instructors have. In 18 states and provinces, the average years of non-classroom work experience for PT instructors was 7.8, while 30 respondents noted the average years of teaching experience for PT teachers was 9.5.

Thus, it generally is not the new graduate who is teaching PT, but more likely a seasoned instructor with 9 or more years of teaching experience. This finding identifies the importance of PT instruction in Technology Education programs.

Of 38 states and provinces some 26 indicated that additional Principles of Technology teacher in-service training was usually offered following the completion of a workshop or PT course.

Computer Skills

Due to the complexity and rapid change of modern technology which requires training that is applicable to more than a single job, we asked respondents to identify how many of their PT programs included computer skills as an integral part of their curriculum. Of the 36 states and provinces, 27 are currently including computer skills.

Summary

It is very evident from this survey and other information that Principles of Technology is becoming an integral part of our educational system and making giant strides in both the United States and Canada. The results of this nationwide survey have provided us with some necessary information about the fundamental changes which are taking place in many schools which have or will be implementing PT programs. A second article will be needed to address the recommended grade levels, prerequisites, impact on students, background of teachers, and the PT units that are the most interesting and the most difficult for both teachers and students.

Carter is an assistant professor in the Industrial Sciences and Technology Education Department and Atkinson an assistant professor in the School of Occupational and Educational Studies, both at Colorado State University, Fort Collins, Colo. This is a refereed article.

348

Technology Creates a New Physics Student

By John Roper

Teaching physics at the secondary school level has been shaped largely by tradition. In the early years. topics studied by secondary physics students were chosen from a simple list: the topics their teachers studied at university. Technological achievements received attention in the curriculum as their importance to society warranted.

During the 1960s curriculum revisions. many references to technology disappeared as the emphasis was placed upon "pure" science and the "inquiry approach" to instruction. An era of evolution had begun in physics instruction. As with all evolution. however. some regression was to be expected. Physics teaching today bears a more than passing resemblance to that conducted during the late nineteenth century.

This is unfortunate for many of our secondary students. Certainly our graduates pursuing science and engineering studies have been well prepared and. despite their relatively low numbers. continue to provide a degree of technological leadership worldwide. For our most astute. university-bound students. we do not suggest here a problem with current physics curricula. For many other high school students. however. there is a problem. There are some students who fail to see the need to study physics. According to the National Science Teachers Association. these students represent a majority in ou secondary schools. Female students are comparative rare in physics classes. Students contemplating studie other than science and engineering usually can fin other subjects to fill their latter high school years Physics is perceived as too difficult. too mathematica and generally unfriendly to the average student.

For a long time. we physics teachers were forced t live with the problems. We reacted momentarily b developing "standard" and "basic" courses and b reducing the level and role of mathematics to the poir at which physics actually became more difficult t understand. We recruited our heads off. Then we stru gled pedagogically with the kids who took the cours for some unfathomable reason. failing early and ofter They usually ended up either dropping the class or failin academically for the year. These were our most fru trating challenges. Here we had students who felt th somehow they needed to know physics. but failed t recognize why. The percentage of students in our gradu ating class who had learned the wisdom of Newto Pascal. Ohm. and Curie was diminishing. We as teache had to remind ourselves that we were doing someth right for most of our students. conjecturing that phys probably was not the right course for most high sch kids.

John Roper, *a doctoral candidate at Boston College, began his teaching career in 1968 and taug high school science for eighteen years. Currently, he is working at the Institute for Learning a Teaching at the University of Massachusetts, Boston, where he teaches courses in curriculum a science methods.*

We can no longer afford to let opportunity pass by those students. Our society has become technologically ingrained. Paul DeHart Hurd says that "Students are no longer to be given the option of electing ignorance of science and technology and choosing cultural deprivation as a fact of life."[1] Students who once needed simply a high school diploma to get a good job. now look towards technological training at community or junior colleges. in-plant classes. and manufacturer s seminars. The "corporate campus" now has become a reality. with many companies employing teaching facilities larger than in many schools.

Technological employment also brings with it some difficulties. Developing product lines. changing market forces. and foreign competition often pressure corporate decision-makers to lay-off members of the work force who lack the background needed to render them suitable for retraining. A student with a strong technological foundation often can be retrained in a reasonable time-frame for new employment in drastically different fields. This is better for the employer. the worker. and his or her family.

Physics teachers need to make physics available to students who envision careers that do not require college. They need to encourage students to take physics despite the lack of student interest. Of course. the problem could be attacked by simply increasing required courses. demanding that every student take physics before graduation. Such a solution. however. without changing the nature of the physics courses available. would doom many to failure. It is not without reason that so many students perceive the study of physics as difficult. If we change the way physics is taught. we can communicate with those who learn in different styles. We should not drop the courses that are successful for some. Rather. we should add courses that might be successful for others.

One such course is the *Principles of Technology* physics program. This curriculum was developed over the years 1984–1986 by the Center for Occupational Research and Development. of Waco. Texas. and the Agency for Instructional Technology. in Bloomington. Indiana. Its development was supported by grants from 31 state and provincial Departments of Education. specifically for

Fig. 1. During a video segment of *Principles of Technolog*. technician Terri Robertson discdsses voltage in electric systems.

those students who would be pursuing further educatio in two-year colleges or in the workplace. It was nc intended for the traditional physics student. whos needs were being met by current programs. Rather. was designed for those eleventh and twelfth graders wh need to become the majority of physics students in th technological age. Their requirement is not for th theoretical knowledge of physics that we now provid through many commercial textbooks. but for a "workin knowledge" of physics (Figs. 1 and 2). *Principles Technology* provides such a working knowledge. PT. wit

Fig. 2. Cary Jacobson, whose job is maintaining city buses, needs to know about force transformers and how they work in energy systems.

its clear work-place orientation, reaches the majority of high school students having attained Piaget's concrete operational stage.

Our potential student market is either failing a standard physics course, avoiding physics and math in the general curriculum, or taking "soft content" courses because science graduation requirements have been met. *Principles of Technology*, while not soft on content, is occupationally oriented. During the national pilot test conducted at 43 schools nationwide from 1983 to 1985, questionnaires completed by the students reveal that close to 90% of them described the course content as "probably important for you to know." The University of Massachusetts at Boston became interested in PT when I joined the staff, bringing with me my experience as a pilot teacher at a vocational secondary school.

Principles of Technology is an applied physics course. Textbook illustrations are from the manufacturing and technological worlds rather than the academic and theoretical worlds. Laboratory exercises are built around the determination of a problem rather than the testing of a solution. Topics covered include those presented in Table I. They may at first seem similar to those taught in standard introductory physics courses, but there is a substantial difference in treatment.

Principles of Technology uses a "systems approach." Each topic is covered from the standpoint of mechanical (both linear and rotational), electrical, fluidal, and thermal forces. This holds true for a majority of the 14 units, resulting in an emphasis on the similarities between the systems. "Prime movers" become the organizing themes. In Unit 1, "Forces," the mechanical prime movers are force and torque. The electrical prime mover is voltage difference, since it moves charge the way that force moves matter. Temperature difference moves heat, and pressure difference moves fluids. For the second unit, "Work," we add the concept of distance. The third unit, "Rate," introduces time, and of course power. Unit five is the rate of doing work. Somehow, it all seems to fit.

Some physics books assume that students have taken algebra. Others de-emphasize mathematics where possible. *Principles of Technology* builds mathematical instruction into the physics course so as not to exclude anyone from the math and science exposure that might be needed later in life. Test results suggest that the differences in performance between students who had taken algebra before completion of *Principles of Technology* and those who had not, disappear statistically in many of the instructional units.[3]

Lab exercises comprise approximately 40% of the instructional time. They are unusual, to say the least. Carrying through the philosophy of a "working knowledge" of physics, the equipment is more likely to be found in a factory or a test bench than in a standard physics lab. This one factor is responsible for most of the resistance to the program. New equipment is not easy to justify in this age of the shrinking budget dollar. The good news, of course, is that like other physics programs, replacement costs are low. Once the initial equipment investment is made, the program can continue indefinitely without further expenditures. There are several state and federal programs that could help in recovering the initial equipment costs. A telephone call to your state's Department of Education could provide details for your particular state.

PRINCIPLES OF TECHNOLOGY INSTRUCTIONAL UNITS

YEAR 1	YEAR 2
Force	Momentum
Work	Waves & Vibrations
Rate	Energy Converters
Resistance	Transducers
Energy	Radiation
Power	Light & Optical Systems
Force Transformers	Time Constants

Table I. Canadian schools, rather than attempting 14 units during grades 11 and 12, often teach Force through Energy in grade 11, Power through Energy Converters in grade 12, and the rest at an articulated community college program.

In an attempt to determine the extent of achievement of PT pilot test students. we administered the physics achievement test developed jointly by the National Science Teachers Association and the American Association of Physics Teachers to two groups of students. One group consisted of 20 males and females. grade 11. who had completed 10 months of a standard physics course.[4] The group was empirically considered to be the "better" students in the school. The latter group completed the same instructional time in the *Principles of Technology* provisional curriculum. They were described by their school superintendent as "wounded sparrows." and would have been unlikely to enroll in the traditional physics curriculum available. Analysis of the test results demonstrated little significant difference between groups. The PT students had actually performed at least as well on a physics test as the traditional physics students.

We now can identify a *new* physics student. He or she is currently taking the "general" course of study. Or. taking a lower level physics course because of an intuitive understanding of the need for more math and science. but not performing well. He or she may be enrolled in an occupational education program. realizing that physics is vital but resisting the association with the academic "stars" that will ultimately provide an unflattering comparison. Our new physics student will eventually be hired in a technical position by an employer who then may provide further training. With an appropriate background in physics and mathematics. that student can be trained in-plant. awarded an associates degree by a community college. or even begin to appreciate the utility that physics presents and proceed to an engineering program at a four-year college or university. The possibilities for our new physics student are interesting and challenging. The possibilities for an increasingly technological economy are even more exciting.

Principles of Technology is currently available in 47 states[5] and 2 Canadian provinces. New York. New Jersey. and Hawaii are the last remaining non-consortium states in which a license fee is required to use the materials. The status of a state as a consortium member provides all teachers with the right to unlimited duplication of videotapes and materials developed in connection with the program. At last count. some 25 000 students were studying physics using the *Principles of Technolog* curriculum. Their experience with physics may prove fc some to be a most valuable part of high school.

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352

CURRICULUM Update

September 1991

Association for Supervision and Curriculum Development
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Vocational Education:

Applied Academics, Tech-Prep Programs Serve the 'Forgotten Half'

By Scott Willis

At no other time in history has it been so important for American schools to educate every student. So educators, politicians, and business leaders repeatedly insist. Yet, critics charge, American schools serve only one population of students well: the college-bound.

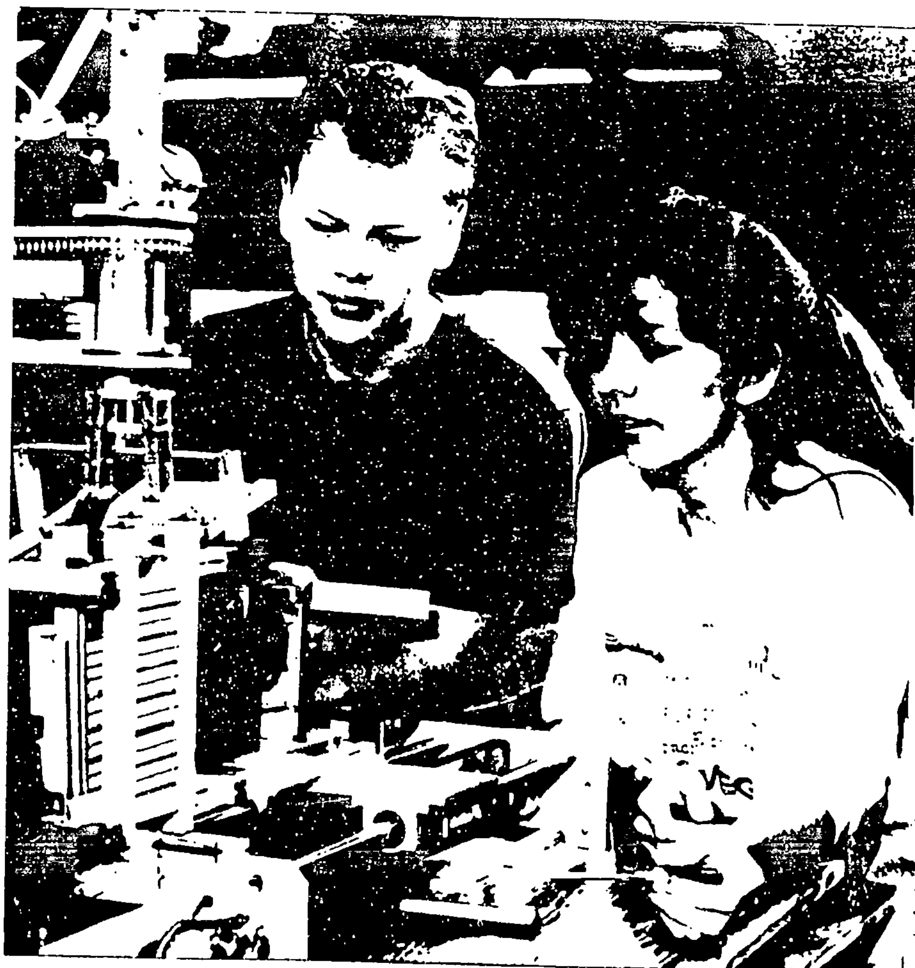
Fully half of all students do not attend college, however. These students—the so-called "forgotten half"—are allowed to drift through the system without gaining the skills that desirable jobs require.

Vocational education can give these students direction, experts in the field assert. In vocational programs, they can train for the highly-paid, skilled jobs that await them if they are qualified.

Today more than ever before, the economic health of the nation depends on the availability of a skilled workforce—and therefore on vocational education, experts maintain. "Quality vocational education is absolutely essential to the international competitiveness of this nation," says Charles Buzzell, executive director of the American Vocational Association (AVA).

The need to educate the forgotten half of students is compelling. But to help fulfill this mission, vocational education must overcome a number of obstacles: declining enrollments, a persistent image problem, and the American public's belief that only a four-year college degree is good enough for "my child."

Vocational education is responding to the challenge. Two major trends in the field hold promise, experts say: the integration of academic and vocational content, and the development of tech-prep programs that link high school and postsecondary study. ■



Students who complete good voc ed programs leave high school ready either to find a rewarding job or to continue their education, experts say. These students at Mt. Hood Community College in Gresham, Ore., are studying electronic and automation systems technology in a program designed to build on their high school studies.

Integrating Academics

Years ago, when hiring technicians for the U.S. Air Force, Leno Pedrotti discovered that many applicants had "shied away" from tough math and physics courses during their schooling. Today's vocational students are no different, says Pedrotti, now senior vice president of the Center for Occupational Research and Development (CORD) in Waco, Texas. "These kids have precious hand skills but are bypassing opportunities for getting head skills."

Vocational educators are trying to change that. To ensure that students train *both* head and hand, educators in the field are working to integrate more academic content into the vocational curriculum. The integration movement is "very rapidly growing now throughout the land," says Gerald Hayward, deputy director of the National Center for Research in Vocational Education at the University of California–Berkeley.

Vocational courses are fertile ground for academic learning, experts say. Recent cognitive research shows that learning by doing is "a very powerful educational device," says Hayward. "We all learned how to use a computer that way," he notes.

"Many people learn from the concrete to the abstract," Buzzell says. "Voc ed provides a wonderful environment to experience the concrete." Volumetric measure may not mean much to a high school freshman, he points out, but "piston displacement in his favorite automobile is very important to him; it's part of his lexicon."

Concerns over the "skills gap" are fueling the integration trend. As the skills workers need on the job grow more complex, educators and policymakers are becoming increasingly concerned about the less-than-rigorous academic content of some vocational programs. Many of today's office jobs, for example, require workers to be familiar with complicated technology, such as computers and teleconferencing equipment. In industry, workers often need to know not only how to use machinery but how to troubleshoot and repair it. Assembly line workers may even need to know robotics. Given these growing demands on workers, vocational students need a thorough grounding in math, science, and communication skills, experts say.

> **"These kids have precious hand skills but are bypassing opportunities for getting head skills."**
>
> *—Leno Pedrotti, senior vice president of the Center for Occupational Research and Development*

The U.S. Congress evidently agrees. The reauthorized Perkins Act, the federal law on vocational education, requires the integration of academic content into vocational programs.

Several states, including Ohio, Oregon, Pennsylvania, and New York, are promoting a new emphasis on academics in vocational programs. Ohio, for example, is "broadening the scope" of vocational education to integrate more academic content, says Darrell Parks, the state's director of vocational and career education. By 1994, science, math, and language arts will be incorporated into all programs, Parks says.

Enough Already?

Despite the calls for change, some experts, like Buzzell, contend that academic skills have always been part and parcel of vocational education. Students can't complete a good program without mastering the basic skills, he insists. "They're just embedded in the fabric."

He cites training for electricians as an example. "The assumption in the minds of a lot of people is that there is no math, no science, and no communication skills taught to electricians." On the contrary, he says, trainees must learn subjects such as geometry and algebra. "I was taught that you could find resistance by dividing volts by amps. That's algebra—you're solving for *x*."

Academic skills are intrinsic to all the vocational fields, Buzzell argues. "Take any quality voc ed program—food service, home economics, industrial arts, drafting, you name it. When you peel layers away, like an onion, you will find layer after layer" of academic skills. Students "aren't typically told, 'Okay, today we're going to do trigonometric functions'," but they are "absolutely" learning those skills, he says.

Other experts, however, contend that vocational students too often learn only low-level academic skills. They are typically given "minimal and diluted academic content," says Larry Rosenstock, executive director of the Rindge School of Technical Arts in Cambridge, Mass.

"The academic content of [vocational] courses needs to be beefed up," Hayward agrees. He quickly adds, however, that it is unrealistic to expect vocational programs to make the change alone. Instead, a stronger connection between academic and vocational courses is needed.

Newly developed curriculums for teaching "applied academics" are helping to provide that connection. Unlike the traditional textbook approach, in which knowledge is often presented in the abstract, divorced from everyday life, applied academics courses link theory and practice. Lab work is central, providing hands-on experiences that illustrate academic principles.

The Center for Occupational Research and Development (CORD) has developed several applied academics curriculums for high school students, says Pedrotti. These include "Principles of Technology," a two-year course in applied physics; a two-year course in applied mathematics;

Continued on **page 4**

What Do Students in Voc Ed Classes Study?

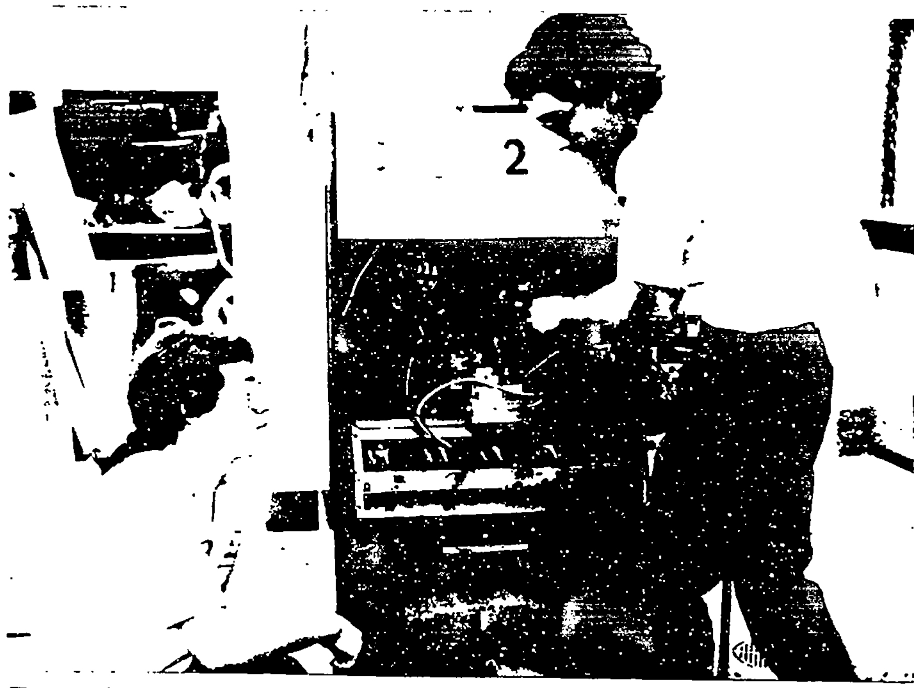
Vocational education comprises eight main areas of study, according to the American Vocational Association:

- *Trade and industrial education.* Includes carpentry, auto mechanics, metalworking, graphic arts, and cosmetology.
- *Business education.* Includes office occupations, accounting, and business management.
- *Agriculture.* Includes agricultural mechanics, horticulture, and agribusiness.
- *Home economics.* Includes consumer and homemaking education and occupations in fields such as food services.
- *Marketing education.* Includes general merchandising, apparel marketing, and real estate.
- *Technical education.* Includes communications, technologies related to engineering, and computer sciences.
- *Technology education.* Includes study of the materials and processes used in construction, manufacturing, transportation, communication, and other industries.
- *Health occupations.* Students in these programs train to be practical nurses, nurses, medical and dental assistants, and radiology technicians. ■

Do Students Need General or Specific Skills?

A perennial controversy in vocational education is whether students should be taught job-specific skills or more general, transferable skills. Some experts argue that students need job-specific skills so they will be immediately employable on leaving school. Others contend that training students for a particular job does them a disservice, because the job market is unpredictable and workers change jobs frequently. Therefore, what students really need is generic skills, such as how to think conceptually and critically, how to learn, and how to get along at the workplace.

Charles Buzzell of the American Vocational Association is a staunch advocate of teaching job-specific skills. "Is it important for an attorney, a doctor, or an engineer to have specific job-relevant skills?" he asks. "You bet it is. And [it's equally important] for the carpenter, the auto mechanic, and the laboratory technician." Buzzell considers neglecting job-specific skills a form of educational malpractice. "Do you want to dump 60 percent of our high school population into the labor market with no training?" he asks rhetorically.



Courtesy Great Oaks Joint Vocational School District

These students are learning about air conditioning, refrigeration, and heating systems. Are they being too narrowly trained? Experts disagree.

Many others in the field, however, think vocational education should be providing "broader occupational competencies," says John Wirt of the Secretary's Commission on Achieving Necessary Skills (SCANS). This view is backed by findings such as those reported in *America's Choice*, the report of the Commission on the Skills of the American Workforce: "The primary concern of more than 80 percent of employers is finding workers with a good work ethic and appropriate social behavior. . . . Although a few managers are worried about literacy and basic math skills, education levels rarely seem a concern."

Harley Schlichting of the University of Missouri claims employers don't really mean what they say. "A student needs a job-specific skill; I don't want to teach my secretary how to type or to use good grammar." Advocates of teaching job-specific skills also note that employers do very little training at the entry level. "By and large, the employing community expects workers to be trained when they arrive," says Buzzell.

Keeping Pace with Change

Yet, others contend, instruction simply can't keep pace with changes in the job-specific skills needed in the marketplace.

Buzzell refutes this argument with an analogy to medicine. "Are we going to stop giving [medical students] the skills and understandings for making a transplant with the mechanical heart we have today based on the fact it's going to change tomorrow? Of course not." Similarly, vocational students gain a great deal by learning job-specific skills, even if those skills may someday become obsolete. Buzzell scoffs at the illogical notion that "if I train Charlie as an electrician, I might damage his capacity for future learning."

"There's a place for both" job-specific and transferable skills in the vocational education curriculum, says Gerald Hayward of the National Center for Research in Vocational Education. Specific skills training is needed for the hundreds of thousands of students who go directly into jobs—from secretarial programs, for instance. But students "also need generic skills so they're not stuck in that job forever."

Those who downplay the need to teach job-specific skills are simply naive about the realities of vocational education, Buzzell believes. "We will always have students exiting the high school to work," he says. "We owe it to those students and their taxpaying parents [to ensure] that they are able to go and earn a living when they exit the system."

Obviously, critical to the debate over teaching job-specific skills is the question of whether students who have acquired such skills find jobs related to their studies.

The National Assessment of Vocational Education (NAVE) reported discouraging findings on this question: "We estimate that, for women who get no education beyond high school, about 46 percent of all occupationally specific vocational courses were used in training-related skilled jobs. The comparable number for men was 33 percent. . . . These rates are low enough to call into question the efficacy of highly job-specific forms of occupational training for many students at the secondary level."

Buzzell warns that the NAVE figures are misleading. "You've got to be sure to factor out the difference between a survey course and a concentrated sequence of courses, and the NAVE study didn't do that," he notes. He also points out that the NAVE data are skewed by the fact that some students may have taken only one or two vocational courses and therefore naturally did not find employment in a training-related job.

Buzzell offers his own rule of thumb regarding placement rates: "Find a quality voc ed program and you can expect 90 percent of the students to find employment in their trade/craft area or in a related trade/craft area," providing students are willing to relocate. But he offers the caveat that "you're not served well when you use placement as a surrogate measure of quality of instruction," because the economic climate has a marked effect on placement rates. ■

Continued from **page 2**

and a new one-year course in applied biology and chemistry.

The CORD curriculums aim to help students overcome their reluctance to confront academic concepts. Because vocational students typically have "a love of devices" and the ability to use their hands, Pedrotti says, the curriculums allow them to work often with equipment—"their trump suit." But they also introduce students to scientific principles, which are demonstrated in concrete ways. "In the lab, students begin to tolerate the abstractness of equations."

Principles of Technology, the applied physics curriculum, uses lab experiences not as ends in themselves but as a context for discussing the principles of physics, Pedrotti explains. In a traditional automotive shop, for example, a unit on brakes would cover such topics as how to raise the automobile safely, remove the wheel, and so on. In Principles of Technology, the instructor also talks about the scientific concepts involved, such as hydraulic pressure, friction, and thermal energy.

When Principles of Technology was introduced, the developers felt "a lot of trepidation" that the physics content would scare students off. Happily, students have not been intimidated. Today the curriculum is being used by 40,000 students in 49 states, Pedrotti says. But students still don't like to read the print materials, he notes with chagrin.

Principles of Technology has been a success at Pendleton High School in Pendleton, S.C., says Harriet Palmer, who teaches the course there.

Palmer's class attracts a mixture of students, vocational and college-bound, and she believes it serves them all equally well. In their lab work, students use equipment such as voltmeters, motors, winches, thermal couples, and an oscilloscope. The course gives students some freedom, Palmer says, allowing them to do problem solving. As a result, they gain confidence in their abilities. "They're enthused about it," she says.

In fact, enthusiasm runs so high that one student came in after school every day for a week to replicate a demonstration. And students are spreading the word that Principles of Technology is "a fun class," Palmer reports.

"We ought to teach the standard curriculum with more of an applications slant."

—Ken Gray, the professor in charge of vocational and technical education at Pennsylvania State University

A Two-Way Street?

While most experts agree that the movement to include more demanding academic content in vocational courses is gaining momentum, the degree to which this trend will influence *academic* courses remains unclear. Academic instruction also needs to be reshaped, some experts contend, to allow students to learn by doing as well as by reading or listening.

Rosenstock, for example, believes that voc ed should "recognize its strengths and share them with the academic sphere." A number of methodologies common in vocational education—hands-on learning, performance assessment, cooperative learning, team teaching—"need to be brought into the rest of the educational arena," he says.

"We ought to teach the standard curriculum with more of an applications slant," agrees Ken Gray, the professor in charge of vocational and technical education at Pennsylvania State University. Too often, "math and science curriculums are barren of application."

Gray considers it a "disgrace" that academic students typically have no access to the sophisticated equipment in vocational schools. "Those classes are

Ways to Integrate Academics and Voc Ed

With his colleagues, Norton Grubb of the National Center for Research in Vocational Education at the University of California–Berkeley has identified eight ways that educators can integrate vocational and academic education:

- *Incorporate more academic content in vocational courses.* This can be done informally by the instructor, or formally by adopting curriculum materials or developing model curriculums that have academic skills components.
- *Use academic teachers to enhance the teaching of academic content in vocational programs.* Academic teachers can teach lessons or modules in vocational classrooms, work with vocational teachers to develop more academic exercises, or serve as remedial teachers for vocational students.
- *Make academic courses more vocationally relevant.* Academic teachers can incorporate vocational applications, such as reading materials that describe work-related activities and job-related problems in math and science. The most common approach, however, is to introduce "applied academics" courses.
- *Align the academic and vocational curriculums.* Academic courses can be made more occupationally relevant, vocational courses more academically rigorous, and the two linked so as to reinforce each other. This approach requires teachers to work together closely to create coherent sequences of courses for students choosing the vocational program.
- *Follow the Academy model.* Academies usually operate as schools-within-schools, staffed by four collaborating teachers: one each in math, science, English, and a vocational subject. Courses are coordinated, and teachers develop special projects that cut across all four classes. Academies often develop relationships with businesses in their area.
- *Set up occupational high schools and magnet schools.* Such schools prepare students for jobs in aviation, fashion industries, business careers, agricultural sciences, and the health professions. The culture of these schools readily supports the integration of academic and vocational instruction.
- *Offer occupational majors and "career paths."* A few schools have replaced subject-area departments with departments organized along occupational lines; each department recommends specific course sequences for given careers. Students in career paths take academic and vocational courses related to their paths. They also attend career path activities, including field trips and lectures by visitors.
- *Use the senior project as a form of integration.* A senior project might consist of a written report, a physical representation of some kind, and an oral presentation. This approach requires students to demonstrate mastery of a variety of competencies, both academic and vocational. ■

Adapted from "The Cunning Hand, The Cultured Mind": Models for Integrating Vocational and Academic Education *by W. Norton Grubb, Gary Davis, Jeannie Lum, Jane Plihal, and Carol Morgaine.*

The Tech-Prep Alternative

A second major trend in vocational education also holds promise for the forgotten half of students, experts say: the development of tech-prep programs.

Based on agreements between high schools and postsecondary schools (usually community colleges), tech-prep programs provide articulated sequences of courses leading to a certificate or two-year associate degree. Because they span the last two years of high school and two years of community college study, they are also known as "2 + 2" programs.

In his 1985 book, *The Neglected Majority*, Dale Parnell advocated tech-prep programs as a way of "making winners of ordinary students." His logic has proven persuasive. Today, tech.-prep programs are "sweeping the country," says Hayward, because the idea simply "makes good sense."

Tech-prep programs have much to offer, proponents say. First and foremost, they provide an attractive alternative for students who do not plan to attend a four-year college on leaving high school. They allow students to acquire lucrative technical skills and a degree, while investing far less money and time. "For a lot of students, the idea of staying in school four more years is out of the question," Hayward says, but many are willing to study two more years to earn an associate degree.

Community colleges support tech-prep programs because, by maintaining close ties to neighboring high schools, they can ensure that students come to them better prepared, Hayward says. Business and industry also support tech-prep programs, because they need the skilled workers these programs produce.

The U.S. Congress also backs the idea. The new Perkins Act authorizes the federal government to spend up to $125 million to fund tech-prep programs. This funding represents a change in thinking, says Ken Gray of Pennsylvania State University; in the past, Congress has frowned upon the idea of 2 + 2 programs. "The federal government felt the reason they were supporting voc ed was because it was a special program" with extra costs, he explains, not an alternate means of preparing for higher education. Gray applauds the turnaround. "It's not only the right thing; it's critical."

Buzzell of the AVA also supports the tech-prep concept but emphasizes that it is not new. "It's been going on for a long time," he says. "It's been quite successful in some places." Programs will proliferate, he predicts, because the federal government is now providing "the tool-up money" to develop them.

Mt. Hood Community College in Gresham, Ore., has had tech-prep arrangements with its eight feeder high schools since 1987, says Jim Schoelkopf, a curriculum specialist in professional/technical education for Multnomah County. Students at Mt. Hood can earn associate degrees in a wide variety of fields, including accounting, landscaping, automotives, cable television, early childhood education, electronics, drafting, tourism and hospitality, journalism, and office occupations. The college and high school faculties meet at least twice a year to examine curriculum and technology issues and to ensure rigor, Schoelkopf says.

The program targets that "vast middle ground of students who are merely jumping through the hoops to fulfill institutional requirements," Schoelkopf says. It attracts these students by "giving them some recognition" (including AP credit) and "pointing them toward a higher-paying job." The program also takes advantage of the fact that the community college environment is less intimidating to many students than a university.

North Carolina first implemented tech-prep in 1986 in a pilot program in Richmond County, says Clifton Belcher, who directs the state's division of vocational education services. Today, programs are in place at about 30 sites. "We anticipate by 1995 to have the program in all of the school systems of sufficient size," he says.

North Carolina has aimed its tech-prep programs at "students who were not pursuing the college track but knew they could do better than the general track," Belcher says. These students have not been scared off by the commitment or the stepped-up academics, he reports. "It has become very popular."

Courtesy Great Oaks Joint Vocational School District

Tech-prep programs, which require two years of postsecondary study, train students for a wide variety of jobs, including dental assisting.

Belcher credits this popularity to the "avenue of visibility" that tech-prep provides these students. He also notes that students are "very excited about the kind of education they're receiving," which is application-oriented and promotes teamwork. Added incentives are the convenience and low tuition rates that community colleges offer.

"We're still in our infancy," Belcher says of the state's tech-prep effort, but he is "pleased and encouraged with results" so far.

Tech-prep has also proved successful in the South Carolina counties of Anderson, Oconee, and Pickens, says Diana Walter, going empty, and students who really should understand these things are looking at books in an academic school," he charges. Logistical and funding problems pose a barrier, he concedes; finding a way for academic students to attend vocational schools part-time is a major difficulty.

One school that has solved that problem is the Bethlehem Area Vocational-Technical School in Bethlehem, Pa. Since the school first opened its doors to students from public and private schools in its area three years ago, the program for academic students has "mushroomed," says Don Foellner, the school's director.

Courtesy Fairfax County Public Schools

Jonathan Mazurz

By integrating vocational and academic instruction, educators can show students practical applications of subjects such as geometry and trigonometry.

Last year, several honors physics students took applied engineering at Bethlehem, and several honors biology students took health-related technology. These college-bound students were attracted to the vocational courses because "so many kids have no applications base to go along with the theory they're getting," Foellner says. The influx of academic students has benefited the school, he adds, by raising expectations and providing a mix of students. Now, coats and ties mingle with blue jeans and tee shirts.

Starting this year, Bethlehem will open all 30 of its programs to students from neighboring public and private schools. Because outside students will be able to attend Bethlehem for two-period blocks of time—less than the traditional half-day program—they will still be able to take full advantage of the offerings at their regular schools, such as foreign language classes, Foellner explains.

Two years ago, enrollment at Bethlehem had "bottomed out," Foellner recalls. This year, enrollment is up almost 100 students, primarily because of the new program for academic students. The school is recognized as a model for integrating academic and vocational studies, and Lehigh University has shown interest in holding a summer practicum for mechanical engineering students at Bethlehem. "We're ecstatic about what's happening right now," Foellner says. "It's exciting times for us."

Working Together

Collaboration between teachers from the academic and vocational realms is critical to integration efforts, experts say.

Academic and vocational teachers at Tyrone High School in Tyrone, Pa., used to keep to their own; the division between them was symbolized by the heavy doors between the two parts of the school. Now, teachers from both sides are often found in each other's classrooms, says Janette Kelly, the school's vocational director.

The collaboration has borne fruit. Vocational teachers and math teachers, for example, have worked together to develop ways to introduce applied technology into math classes. "We don't have 'shop math' any more," Kelly notes. In addition, an industrial technology teacher and a science teacher are co-teaching a course for 8th graders, which is hands-on but deals with "very high-level science."

"The academic teachers are thrilled" to be sharing instructional ideas with their vocational colleagues, Kelly says, and all teachers are excited to be blending the academic and vocational. But "it's not easy to do," she cautions. "We've had this idea that if you're vocational, you're not intellectually inclined—you work with your hands." Changing that attitude is worth the effort, however, she asserts.

The Great Oaks Joint Vocational School District in Cincinnati, Ohio, has also succeeded in fostering collaboration between academic and vocational teachers, says Rosemary Kolde, associate superintendent.

Collaboration in the district started in earnest several years ago, Kolde says, when vocational and academic teachers met over the summer to write a new academic curriculum—one that meshed with the vocational curriculum and used problems and examples drawn from the workplace. Now, academic teachers get an extra planning period so they can team teach with a lab teacher. Concepts that students learn in a trigonometry class, for example, are also used in a lab class to reinforce them. Students are extremely successful in the new program, Kolde says, because they find learning more relevant. "A lot of students are really turned off by a straight academic class," she observes.

While many vocational experts are enthusiastic about integrating academic and vocational content, they also cite numerous prerequisites. "The key thing is to get the teachers to sit down together and have some time to plan," says Hayward of the National Center for Research in Vocational Education.

Teachers need staff development to help them coordinate and articulate what they teach; otherwise, the result may be a "one-sided, superficial version" of integration, says Jay Cummings, director of vocational and applied technology education for the state of Texas. "A math teacher might mention that math helps tool-and-die makers," he says. "Some people call that integration."

Staff development may also be needed to provide teachers with new skills. Some vocational teachers with backgrounds in industry are fearful of teaching academics, says Harley Schlichting, director of the Instructional Materials Lab at the University of Missouri and a former high school voc ed teacher. Similarly, academic teachers "need help with the applications side," says Gene Bottoms, director of the Southern Regional Education Board's State Vocational Education Consortium.

"If folks believe that because we now have the legislation, [integration] will automatically happen, that is a major mistake," Bottoms says. Integration will happen only if principals and teachers have a vision of what the high school could be as a result, he says.

executive director of the Partnership for Academic and Career Education (PACE) in Pendleton, S.C. The initiative in those counties has been named the top tech-prep program in the nation by the U.S. Department of Education.

Some high school students have been skeptical of applied academics courses, Walter says. A typical response is, "Hey, wait a minute—I don't do physics." But in time students adjust—and learn to like the challenge. In some cases, enrollments have doubled and tripled in applied classes, she says.

Such success does not come easily, however. Developing a new tech-prep program requires a lot of work, Belcher stresses. "You must provide a minimum of a year for design."

Staff development is also critical, experts say, to help faculty members at both institutions understand the program's aims and to help them collaborate. In addition, programs require strong support from the school board, superintendent, community college president, high school principal, and counselors.

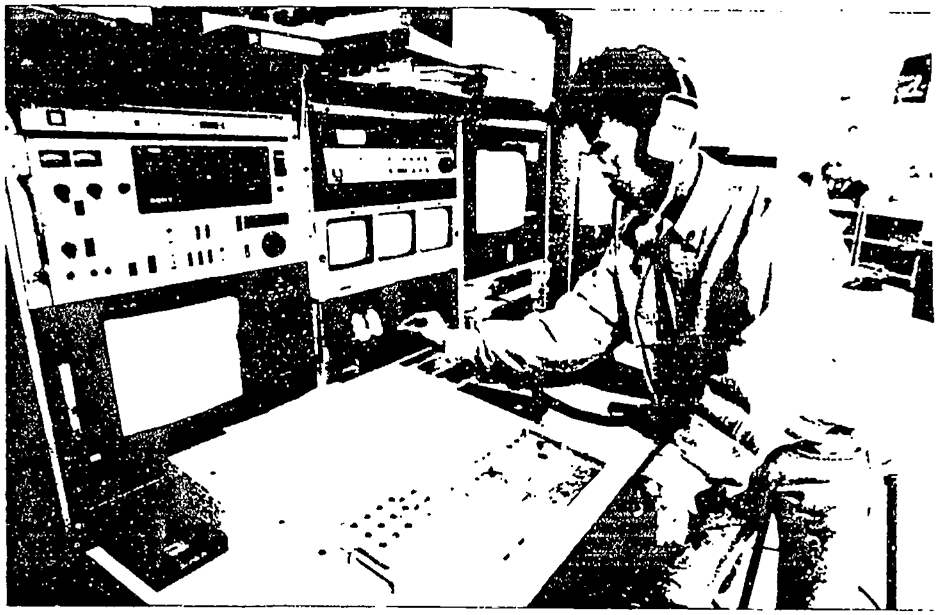
Publicizing tech-prep programs is important to their success, Belcher adds. Most schools host open houses several times during the year to explain the programs to parents, he says, but brochures and newspaper ads may also be necessary to get the message across.

Cautionary Flags

While most vocational experts agree that tech-prep programs are a promising means of educating the "neglected majority," some raise cautionary flags.

"One has to be careful that it's not seen as the silver bullet," says Buzzell. In particular, he fears that too much content might be deferred to the community

Continued on **page 8**



Mark Regan

A student in a tech-prep program might learn the ins and outs of working in a television studio, then go to work for a local station.

A 'Greasy' Image

In promoting tech-prep programs and other offerings, vocational educators are hampered by the field's persistent image as a "dumping ground" for students of low aptitude, experts say.

Charles Buzzell of the American Vocational Association is proud that some vocational programs serve low-ability students; the match is good for the students as well as for society. But he stresses that other vocational programs are geared to more capable students, who are challenged by them intellectually. He deplores the illogical assumption that "a skilled artisan or craftsperson can't be bright."

Another frustration that vocational educators have always had is the poor image of the jobs they train students for, says Roy Peters, Oklahoma's director of vocational/technical education. Parents may discourage their son or daughter from training to be an aviation mechanic, for example, because the job sounds "greasy"—although these mechanics can earn $50,000 a year.

The image problem "really has to be addressed," says Gerald Hayward of the National Center for Research in Vocational Education. Vocational educators need to do more to explain programs to parents and students, he emphasizes. At one school that made a concerted effort to explain its vocational programs, "enrollment in those courses soared almost overnight," he reports.

Educators can change the public's attitudes by strategically planning how to explain programs, Hayward says. "Parents fear that we're closing down options," he notes, whereas good vocational programs increase options for students. And, by providing "a technical program that they're going to succeed in," vocational programs can even *raise* the likelihood that students will go on to college. Parents need to hear this side of the case, he says.

The Four-Year Itch

Militating against a revaluation of vocational education, however, is the public's belief that a four-year college degree is the only worthwhile educational goal, experts say.

Because the American dream is "to send your children on to higher ed," there has been "a wholesale movement of students" into the academic track, says Ken Gray of Pennsylvania State University. As a result, the number of students taking vocational classes has been declining since the mid 1980s.

"Unfortunately, the dream is: stay in the college course, get Cs and Ds, and your life is going to be better than [if you pursued a vocational program] that you might enjoy more, see greater relevance for, and achieve a higher level in," says Buzzell.

The public simply doesn't realize that vocational training can also lead to the good life, Buzzell says. "There are great, great earnings to be had for those with the kinds of skills that are provided by public voc ed, below the baccalaureate level. And there isn't a thing inhibiting them from going on" to earn a four-year degree, he adds.

It would be "a pretty strange America if everybody went to university," Hayward says. "It would probably be hard to get anything done." Nevertheless, the feeling that "vocational education is good—for my neighbor's kid" persists, posing a formidable challenge to vocational programs. ■

Continued from **page 7**

college years. "Don't so water down the high school element that there is no employment at the end of that experience," he cautions.

Schlichting of the University of Missouri worries that tech-prep programs might force high school voc ed teachers to emphasize preparing students for further study, thereby slighting students who plan to join the workforce after high school. If high school course credits are to transfer under the program, the postsecondary school has control over accepting them, he points out.

Others caution against superficial implementation. "Many colleges say they're doing tech-prep when in fact they're [only] doing an elevated level of articulation," says Jim McKenney of the American Association of Community and Junior Colleges. These schools should be going further by "revamping the curriculum on both sides of the aisle," he says.

A major challenge, Walter says, is addressing the concerns of parents, who often ask, "What if my kid changes his mind?" (Nothing prevents tech-prep students from going on to earn a four-year degree if they choose, she notes.) Also problematic is the added work that tech-prep programs create for high school counselors, who often feel overwhelmed by the new demands.

But the benefits far outweigh the drawbacks, experts agree. One of the most important benefits, Kolde says, is that students in tech-prep programs have "a good career plan in mind." As a result, they have a greater investment in their education and are more determined to achieve. Tech-prep programs provide a clear path for students who would otherwise be wandering aimlessly through the curriculum.

Through the integration of academic content and the development of tech-prep programs, vocational educators are helping to change many students' focus from "what you have to do to get out of high school" to "how to prepare best for what's after high school." That shift in focus is perhaps one of the largest contributions that vocational education is making to the cause of educating all students—including the "forgotten half." ■

Resources

Organizations

American Association of Community and Junior Colleges
One Dupont Circle, N.W., Ste. 410
Washington, DC 20036
(202) 728-0200

American Vocational Association
1410 King St.
Alexandria, VA 22314
(703) 683-3111

Center for Occupational Research and Development
601C Lake Air Dr.
Waco, TX 76710
(817) 772-8756

National Association of State Directors of Vocational Technical Education Consortium
1420 16th St., NW
Washington, D.C. 20036
(202) 328-0216

National Center for Research in Vocational Education
Univ. of California–Berkeley
1995 University Ave., Ste. 375
Berkeley, CA 94704

Southern Regional Education Board–State Vocational Education Consortium
592 Tenth St., NW
Atlanta, GA 30318-5790

Publications

American Vocational Association. (February 1991). *Vocational Education Journal.* Alexandria, Va.: AVA. [Includes articles about the new Perkins Act, tech-prep, and vocational-academic integration]

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ASCD Curriculum Update is published four times per year as a supplement to *ASCD Update*, the official newsletter of the Association for Supervision and Curriculum Development, 1250 N. Pitt St., Alexandria, VA 22314-1403. Telephone (703) 549-9110 (switchboard hours are 9 to 5, Monday through Friday, Eastern Time).

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