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ABSTRACT

The Science and Engineering Technician (SET) Curriculum is a two-year post-secondary curriculum designed to prepare technicians to use the electronic instruments which became available in the early 1970's as a result of advances in different fields of electronics. It is an interdisciplinary program of study which integrates elements from the disciplines of chemistry, physics, mathematics, mechanical technology, and electronics technology, with a special skill focus on electronics instrumentation. This guide provides an overview of the project. It includes the following: (1) an assessment of the needs of the students, employers, and transfer institutions which are met by the SET Curriculum; (2) an outline of the sequence of courses in the curriculum; (3) a list of study guides prepared for these courses; and (4) sources of other relevant instructional materials. Case studies of individual students describe experiences with the curriculum and provide follow-up information after graduation. Other case studies of trial implementations focus on information useful to colleges considering use of the SET Curriculum. (Author/SK)

Science and Engineering Technology

Curriculum Guide

SCIENCE AND ENGINEERING TECHNOLOGY

A GUIDE TO A TWO-YEAR ASSOCIATE DEGREE CURRICULUM

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1. The Science and Engineering Technology Curriculum

1.1 Introduction

In the early 1970's a need developed for a new kind of technician to use the electronic instruments which had become available because of advances in the many different fields of electronics. These advances resulted from large scale integrated circuits which converted previously expensive and delicate instruments into inexpensive and rugged devices. Common examples of this new technology are the digital watches and electronic hand-held calculators which appeared in the consumer products area. But the impact of new electronics was not limited to consumer products. A much greater revolution was beginning that promised to affect every scientific and technological field.

As an example, consider that a pressure transducer in 1960 may have cost \$300. The necessary amplifier and signal processing unit perhaps cost \$2000. A readout device, such as a digital voltmeter, cost another \$1000. The total expenditure for measuring a pressure variable in a system by electronic means cost \$3300. Perhaps more limiting, was the fact that the electronic devices were large, heavy, fragile and frequently unsuitable for operation outside of a laboratory environment. But today, the amplifier, signal processor and digital readout are available at one-tenth the price. And thanks to large scale integrated circuits, they are contained in small lightweight and rugged packages readily adaptable to field or plant use. These developments make it practical to obtain, by electronic means, those physical data (temperature, pressures, forces, motions, etc.) which were formerly obtained manually or not at all. This means that electronic measurement and data collection techniques will be more frequently used in even the most crude industrial and field processes and procedures, as well as in the more sophisticated research and development activities.

The only important limit to the broader application of electronic transducer technology is the relative shortage of personnel skilled in its use. Many scientists, engineers and technicians are not trained to use these new electronic tools. Electronic engineers and technicians, while educated in the design and development of electronic instruments, are often unfamiliar with the phenomena, relationships and parameters outside their own particular field.

Just as the computer programming disciplines emerged following the development of large, rapid data processing devices, it seemed that a discipline would develop in the use of electronic measuring devices. The people trained for this new discipline do not need a deep understanding of the inner workings of the electronic black-boxes. Instead, they should be skilled in the use of electronic instruments and their applications. Initially, it was felt that these new technicians would be generalists in technology. Therefore, there was a call for a curriculum to prepare a "general engineering technician." A national curriculum development project was initiated to prepare a curriculum for the education of general engineering technicians. However, it soon became apparent that in addition to a broad general scientific and technical background, the required technicians needed a set of particular skills that no other technician possessed. The name of the curriculum was finally changed to Science and Engineering Technology as discussed in Section 1.3.

1.2 The Curriculum Development Project

In 1974 the National Science Foundation supported a project proposed by Bill G. Aldridge to define a curriculum for a general engineering technician and to conduct curriculum trials. This project was to extend for three years. The first year was the curriculum development year. The second and third years were curriculum trial years. In 1977, another year of activity was funded in order to complete more curriculum trials, conduct an evaluation and thoroughly document the curriculum. This curriculum guide is part of that documentation.

The project was centered at St. Louis Community College at Florissant Valley, but that College was only one of the 19 institutions of higher education that participated. Over 24 educators and 11 representatives from business and industry across the United States were involved in this curriculum development project. More information about the project and participating institutions is included in Appendix III.

The sciencists and engineers involved in the project worked to identify the topics to be included in a general engineering technician curriculum. These topics did not include circuit theory, discreet component theory, communication theory, power, machines, radio, TV or audio. However, amplifiers, transducers, logic devices and readouts of all forms were repeatedly mentioned as important things for general technicians to understand. Principles and applications of physics were heavily emphasized. Many manual skills such as drawing and materials fabrication were thought to be important. Applied chemistry was to be included. Of course, mathematics and writing skills were valued for the general engineering technician. It became apparent that this curriculum must be centered on the understanding of principles and use of tools and instrumentation rather than upon design, development or mathematical analysis of systems.

1.3 The Name of the Curriculum

The project group struggled with the name. Surveys indicated that neither potential students nor employers were attracted to the name "General Engineering Technician." There had to be something more specific. No employer was interested in a hodgepodge of courses without some skill focus. Students did not understand the adjective "general."

The name Science and Engineering Technician was finally negotiated rather than chosen. It was attractive to employers who, because of the perennial shortage of trained high technology personnel are interested in any graduate bearing such a name. Curiously, the name appealed to many potential students who, while interested in science and engineering, were never interested in one specific branch. And when such potential students were quizzed regarding what the name "Science and Engineering Technology" conjures up in their minds, they report seeing dials, controls, readouts, laboratories, and plant situations. In other words, the name conveys impressions of target employment which are probably as accurate as those namesgiven by other technical curricula.

While the name, Science and Engineering Technology, is the best compromise, it is a name which only primes the potential student or employer to ask more questions. The college or university housing an SET curriculum must be prepared to field these secondary questions in a prompt, accurate and confident manner. Science and Engineering Technology is an emerging name for an emerging profession and is a long way from having any "brand" recognition of its own.

1.4 Characteristics of the Curriculum

The Science and Engineering Technology curriculum is a two-year post-secondary curriculum. It is intended to be completed in the equivalent of two academic years of full-time study. Academic years normally consist of approximately two four-month terms. The educational credential awarded at the end of the two-year curricula would be an associate degree.

Many older students who are working and/or have family responsibilities are interested in Science and Engineering Technology. These older students often wish to take the program on a part-time basis days or evenings. In such cases, the Science and Engineering Technology curriculum may be apportioned over four or five years.

The curriculum is interdisciplinary in science offerings and in engineering technology courses.

Most associate or baccalaureate programs in science or technology are focused upon a specific discipline such as chemistry, physics, mechanical engineering technology, electrical engineering technology, civil engineering technology, chemical technology or the like. SET is intended to be interdisciplinary with a balanced offering of chemistry, physics, mathematics, mechanical technology and electronics technology.

SET has a skill focus in electronic instrumentation.

Although SET is not an instrumentation technician curriculum, it has the educational components which can be used as a basis for instrumentation. SET concentrates on electronic instrumentation, as opposed to pneumatic instrumentation. Electronic instrumentation is rapidly becoming the common thread binding together the disciplines of chemistry, physics, mechanical technology and electronics technology.

Physics is, among other things, the study of phenomena upon which electronic transducers are based. Electronics is a means by which transducer signals can be gathered and translated into some usable form. Modern mechanical technology and chemical technology are in the continual process of conversion from manual to electronic means of measuring and controlling.

SET is a new engineering technology curriculum for non-traditional students.

The usual engineering technology student is seen to be a young man coming directly from high school. Such students normally have interests in such things as auto mechanics, electronics, or building.

Most of the non-traditional students are older students. Many are already employed or have been employed and are seeking to upgrade themselves. Some are "second career mothers" whose children are in school and now have the time and the desire to prepare for entering the work force. In the engineering technologies, young women directly from high school are considered non-traditional because they have failed to develop interests in mechanics, electronics or building.

Non-traditional students often have latent scientific interests. Frequently, this scientific or technical interest is not so specific as to make them committed to one of the traditional fields of engineering technology. They may want to get into some scientific work, but often are unwilling to invest the 4 to 6 years in academic studies which are required for employment in the pure sciences.

The SET curriculum appeals to the non-traditional students because it is not overly specific in interests and because it can lead to employment in the equivalent of two years of post-secondary education.

SET leads to employment at the associate degree level.

The SET curriculum is a career program intended to provide an employable skill at the associate degree level. The employable skill in SET is a general knowledge of science and math, plus some specific knowledge of electronics and fabrications. These components allow the graduate to perform in many interface areas between the traditional specialities of science, engineering and technology.

SET may lead to transfer to a baccalaureate curriculum in science, engineering or technology.

A survey of about 250 educational leaders of ECPD accredited engineering technology curricula across the nation[1] indicated a perception that more than 20 per cent of the associate degree engineering technology graduates decide to continue their education immediately after graduation, and that more than 50 per cent continue their education some years after graduation. Even though engineering technology students may be in a two-year career program, they do desire transferability to a four-year degree. SET is designed to have partial transferability to science and engineering baccalaureate programs, and complete transferability to engineering technology baccalaureate programs.

[1] Lawrence J. Wolf, "Articulation Between Associate and Baccalaureate Programs in Engineering Technology Education," Engineering Education, Annals Issue, December, 1977, p. 267.

1.5 The Science and Engineering Technician Curriculum

The courses of the curriculum are listed below. These are descriptive titles only. Colleges implementing the curriculum normally use their own course titles and credit hour values. There are some variations in course sequences. Study guides are available for each of the courses preceded by (SET).

FIRST YEAR

First Semester*	Second Semester
(SET) Materials & Fabrication Methods I	(SET) Materials & Fabrication Methods II
(SET) Computer & Calculator Techniques	(SET) Electronic Components, Transducers & Basic Circuits
(SET) Mechanical & Electrical Drawing & Interpretation	(SET) Organization and Expression in Writing
(SET) Physics of Mechanical, Gaseous, & Fluid Systems	(SET) Physics of Electromagnetic, Optical, & Solid State Systems
(SET) Algebraic & Trigonometric Equations with Appls. OR **Analytic Geometry & Calculus I	(SET) Functions, Analytic Geometry, Probability & Statistics OR **Analytic Geometry & Calculus II
Physical Education (if required by college)	Physical Education (if required by college)

SECOND YEAR

Third Semester	Fourth Semester
(SET) Analog & Digital Electronics	(SET) Electronic Instrumentation: Calibration, Measurement & Control
(SET) Chemical Science & Technology I	(SET) Chemical Science & Technology II
Technical or Applied Science Elective	Technical Communications in Written and Oral Reports
American History, American Civilization OR other Social Science	Human Relations, Personal Relations, or alternative course
(SET) Boolean Algebra, Differential & Integral Calculus OR **Calculus III	Technical or Applied Science Elective
Research, Development, Testing OR Engr. Applications Practicum (or equivalent exper.)	Research, Development, Testing OR Engr. Applications Practicum (or equivalent exper.)

*The Science and Engineering Technician Program is also offered on a quarter system by some colleges. **For those intending to transfer for a degree in Engr. Science, this math alternative may be preferable.

1.6 Needs Filled by the SET Curriculum

The Science and Engineering Technician Curriculum is intended to fill several unique needs.

Needs of Students

Technical educators tend to view the employer as the consumer of a product, the graduates. But such an analogy isn't accurate. The student is the consumer rather than the raw material. The students' investment in terms of direct costs and forfeited income as they pursue their educational programs is quite large when one adds it all up. In many institutions of higher education, the student in the 1970's emerged as a mature and selective investor seeking not only the long-term accumulation of his or her human capital, but also the potential of dividends along the way. This investor is dissatisfied with academically "respectable" degrees which are non-negotiable in the job market. But he or she is equally put off by technical degrees which lead to a job but are academically a dead-end.

Salary surveys by the Engineering Manpower Commission show that although associate degree technicians initially earn more than technicians with no degree, the associate degree person, in several years, reaches a ceiling which is essentially no higher than that of the non-graduate. This is why so many technicians seek to continue their education beyond the associate degree after they are in the job for several years. In order to earn more, they sense that they must move out of technician job classifications. Many of them do. There is a feeling held by many teachers of engineering technology at the associate degree level that their graduates frequently move out of the position for which they were trained in a relatively short period of time. Associate degree technicians probably will need more education for the roles they are likely to assume in the future. Transferability is therefore of substantial value to a student of engineering technology. SET is a curriculum which, because of its greater mathematics, physics, and chemistry content, is intended to have a greater amount of transferability than most traditional engineering technology curricula.

Needs of Employers

Many of the future jobs for technicians will not lie within the traditional disciplines of chemical, civil, electrical and mechanical technology. Such engineering technology disciplines are patterned after engineering disciplines which date back to the industrial revolution. Jobs in modern technological industry do not necessarily conform to these disciplines. Some technicians educated in a traditional discipline find that they do not use much of what they learned. In many employment areas they seem to be subject to rapid obsolescence. Technological developments overlap traditional disciplines. In order to provide a more inter-disciplinary education, the Science and Engineering Technician Curriculum provides a firmer and broader foundation in physics and chemistry than does a more traditional engineering technology program.

Design analysis and design skills which form a large portion of traditional engineering technology programs, were omitted in order to bring in more science. Mechancial engineering technology contributes courses in graphics and materials and fabrication methods. Electrical engineering technology adds to the curriculum the knowledge of electronic instrumentation, transducers, controllers, recorders and microcomputers. If there is a focus to the curriculum, it is the skill of applying electronics to a variety of scientific and industrial applications. This intellectual skill is seen as being something quite apart from circuit development and analysis as done by the electronic technician. It involves combining knowledge of the physical principles upon which transducers operate with knowledge of the "black box" electronics necessary to process and use the signal.

Needs of Transfer Institutions

Formerly, transfer institutions were inclined to scrutinize the student from the community or junior college on a course-by-course basis. Now it is being recognized that the associate degree graduate is one who has completed a package of higher education and is less apt to be an academic drifter than the transfer student without the associate degree. This is true even when the associate degree is in a career rather than a university parallel program. Many transfer institutions have now become aware that a two-year college program is labeled "transfer" or "career" on the basis of employability in a given field at the associate level. This labeling may have nothing to do with the level of education. Some "career" programs demand a level of instruction higher than that of some "transfer" programs.

Transfer institutions, nevertheless, have difficulty with the placement of technician graduates. There are few equivalent courses to aid in proper placement. Often there are concerns about institutional integrity and/or prestige. SET should transfer completely into a baccalaureate level engineering technology curriculum at most upper division colleges and universities.

2. Components of the Science and Engineering Technician Curriculum

The Science and Engineering Technician Curriculum contains five basic scientific and technical elements: mathematics, chemistry, physics, mechanical technology, and electronic technology. Because of its importance to the science and engineering technician, writing was also considered in the curriculum design. It is expected that non-technical courses from such areas as humanities, social studies, and physical education will be included in order to meet institutional and/or accreditation requirements and to broaden the education of the technician.

2.1 Mathematics

The mathematics courses in the science and engineering technician curriculum include:

Computer and Calculator Techniques.
Algebraic and Trigonometric Equations with Applications.
Functions, Analytic Geometry, Probability and Statistics.
Differential and Integral Calculus.

Those students who have adequate mathematical backgrounds when they enter the curriculum and have some rather firm plans for transferring to a four-year degree program soon after earning their associate degree, should be encouraged to substitute a mathematics sequence consisting of engineering or science calculus.

Mathematics is included in technician curricula for two reasons: first, to be able to learn and understand quantitative fundamentals associated with science and technology, and second, to be able to use mathematics to perform job related calculations.

The Science and Engineering Technician has a greater need to use mathematics on the job than other technicians. Science and Engineering Technicians are often active in the gathering and reduction of laboratory and test data. Much of this data is acquired using modern electronic instrumentation. The data can be digital or analog and sometimes cyclic and/or time variant. SET's must learn to recognize trends and relationships. They must be familiar with harmonic functions and ultimately understand the effects of filtering upon spectral content, phase and transients. Mathematics is the basis for the concepts involved in accuracy of measurement, significant figures, scientific notation, sampling and reliability. Skill in the use of calculators and computers to relieve the drudgery of routine computations is needed. As technology is affected by microprocessors it will be necessary for Science and Engineering Technicians to have some knowledge of digital logic.

The SET must have a broad range of mathematical abilities. Since they will be working under the direct supervision of scientists or engineers, SET's do not need to be trained to do mathematical modeling or analysis. They should be expected to gather, reduce, and present quantitative information in a wide variety of forms.

Many persons entering technician programs either have not taken the proper mathematics courses in high school, or did poorly in the math courses they have studied. The typical entering student is anxious about math, is uncomfortable with abstraction, and has had very few positive experiences with mathematics. However, if the materials are at the proper level, if the instructor is willing to meet the student as his/her level, and if there are parallel specialty courses which reinforce the mathematics with related practical experiences, such students can very soon be converted to a mathematical way of thinking. Selection of teachers and text materials are very important. Some schools have mathematics learning labs which can be of great value in supplementing the technician course work. It is not necessary that the SET start directly with Algebrai and Trigonometric Equations if more elementary mathematical work is needed.

2.2 Chemistry

The chemistry component of the curriculum consists of two courses in Chemical Science and Technology. The purposes of these courses are to become familiar with materials and their properties, to develop a scientific vocabulary, to understand some techniques of sampling and control, and to be familiar with safe handling skills.

The Science and Engineering Technicians are not trained as Chemical Technicians to work in an analytical or quality control laboratory. However, SET's may be called upon to make temperature, pressure, and flow measurements in chemical, food, petroleum or pharmaceutical industries. They should understand safety practices and be familiar with hazardous materials. Chemical or petroleum terminology should be familiar to SET's if they are going to work effectively in these settings.

SET's working in the transportation or manufacturing industries will need to understand materials classifications. Furthermore, they might require knowledge of various parameters and tests involved in the specification of materials. SET's have been sought after to work in areas such as non-destructive testing and numerical control programming. The chemistry courses should support additional learning in these areas.

Advisory committee members have suggested technical elective courses in industrial hygiene, energy conversion and conservation, non-destructive testing, and process instrumentation and control. Again chemistry is needed as part of the foundation for study in those areas.

Courses designed for chemistry majors are usually inappropriate for SET's. Many SET students will have inadequate preparation in chemistry. They will have different learning goals for their studies in chemistry. Learning experiences involving the latest electronic chemical analysis equipment have proven to be very valuable for SET's. On the other hand, classical qualitative and quantative analysis techniques are outside the goals of the SET program. Unit operation concepts have been suggested as valuable for many SET jobs but such laboratory experiments are usually part of third or fourth year curricula in chemical engineering.

As a basis for further development in technology, SET's need an understanding of solutions and concentrations, stoichiometry and reactions, and the gas laws. Electrochemistry can be very important as a basis for understanding corrosion. Such knowledge is needed for jobs in non-destructive testing and corrosion inspection. While there is no room in the SET program for the traditional courses in organic chemistry, the SET should have some background in selection and classification of plastics and adhesives; the hazards and properties of fuels, lubricants and the common organic solvents, intermediates and products.

2.3 Physics

Physics is the foundation of the SET curriculum. Most of the current curriculum coordinators are physics teachers. This curriculum was proposed by physicists. In SET, physics plays more than the supporting role that it plays in other technologies. A uniqueness of the SET program is the emphasis on transducers. A transducer is any device which changes some physical parameter into an electrical signal. Transducers are used in most industrial and scientific applications.

The physical phenomena used in transducers such as the Hall effect, the Thompson effect, and the Seebeck effect are studied in physics. Furthermore, the variables which transducers measure, such as force, acceleration, temperature, and pressure, are defined and given units in physics. The technician who is skilled in transducer technology must be thoroughly grounded in the fundamentals of physics. In the SET curriculum, physics courses are considered a technical specialty.

SET's need the broad coverage of the fundamentals of physics including forces and motion, heat, sound, light, optics, electricity and magnetism, and quantum and nuclear physics that form the basis of all technologies. However, it is necessary that the SET have a better understanding of the physics of transducer technology. This is usually accomplished by teaching transducer fundamentals in the physics department or by using physics teachers as practicum supervisors.

2.4 Mechanical Technology

The mechanical technology courses included in the SET curriculum are Materials and Fabrication Methods I and II and Mechanical and Electrical Drawing and Interpretation.

The materials and fabrication methods courses are not intended to make a craftsman out of the SET. Such learning objectives would require many more hours than could be devoted to it in the two-year SET curriculum. On the job the SET will have to work with craftsmen in the performance of his/her technician duties. Rather than concentrate on machine tool operations, for example, the SET learns what operations can be performed on the various machine tools, and what these operations can accomplish.

SET's do have learning objectives in the use of hand tools and power bench tools such as hand-held drills, sabre saws, and circular saws. It was also determined that SET's should have some facility in gas and arc welding. Also, they need basic skills in tubing, electrical and plastics fabrication. There are many creative industrial jobs for technicians which, while not calling for precision machining or certified welding, do require the building of prototypes or models. The fabrication skills included in the SET curriculum are necessary for such jobs.

Most trial colleges have used some of their standard shop or manufacturing processes courses to fulfill this requirement. But it should be recognized that this is an expediency rather than a desirability. Trial implementation has shown that the SET student is really quite different from the student who usually enrolls for the traditional shop courses. Therefore, the SET needs to be taught differently and sometimes by different teachers. The non-SET student who enrolls in a college level shop course has normally achieved a rather high level of craft knowledge and skill. The non-SET student expects to see a great amount of skill on the part of the instructor and expects to be challenged accordingly.

Many SET students, to the contrary, may never before have held a power tool in their hands. For example, one female SET student complained to a dean that she was truly terrified of the electric welding equipment and was receiving little empathy from her highly skilled instructor. SET students may need to be approached at a different starting point. Many SET's welcome instruction which has as much of a reassurance component as a knowledge component. SET's benefit from peer level instruction gained by grouping more skillful students with those less experienced.

The purpose of the Mechanical and Electrical Drawing and Interpretation course is to teach the symbolism of engineering drawing. This includes the principles of orthographic projection. SET's must be very competent as communicators not so much as draftsmen. Employers should be advised to seek graduates of more specialized curricula rather than SET's for drafting and design jobs. However, many employers of SET's expect them on occasion to render a decent engineering drawing. Those students electing SET seem to have fairly good spatial comprehension although they may lack a drafting background. Instructors who have taught mechanical and electrical drawing courses have reported that SET's, while needing to start at a more basic level, often learn more rapidly than other technical students.

2.5 Electronics Technology

The unique job skill that is offered by the SET curriculum is "transducer technology." Transducer technology is the intellectual skill involved in applying transducers to the measurement of physical variables. Transducer technology includes the knowledge of appropriate electronic black boxes necessary for converting an electrical signal into some output device such as a meter reading, a time graph, a tape recording, or a digital or analog input to a computer or controller as shown in Figure 1.

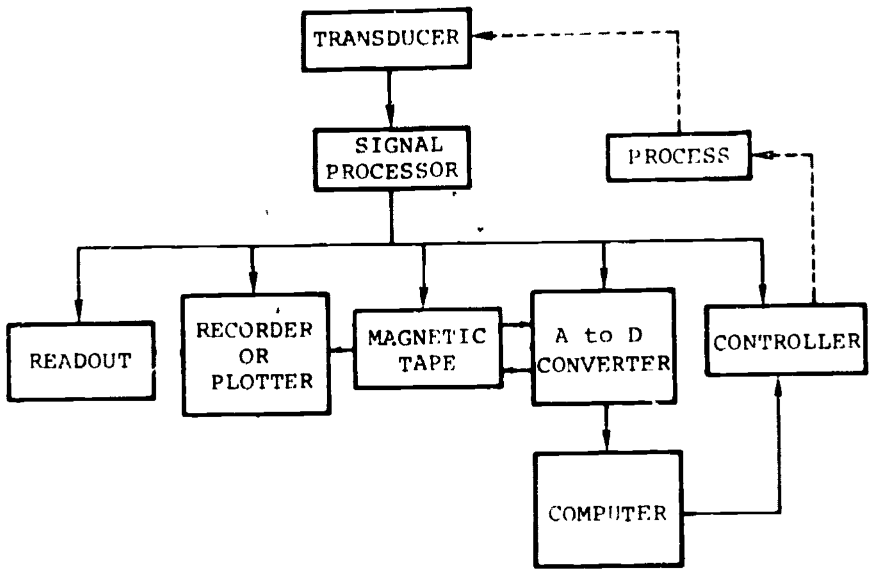

Figure 1 - Transducer Technology

Transducer technology, although involving electronics, is something quite apart from electronics technology as studied by electronic engineering technicians. Upon entry, the SET students tend to express general interest in science and technology but they do not necessarily possess specific interest or ability in electronics. SET's are best educated in electronics by first teaching the use of transducers, followed by the study of electronic systems and finally electrical components. Electronic engineering technicians are usually educated with the opposite sequence. However, such differences in sequencing also match their differing employment roles. From the employers' point of view, the instructional needs of the SET in relationship to the Electronic Engineering Technician are shown in Figure 2.

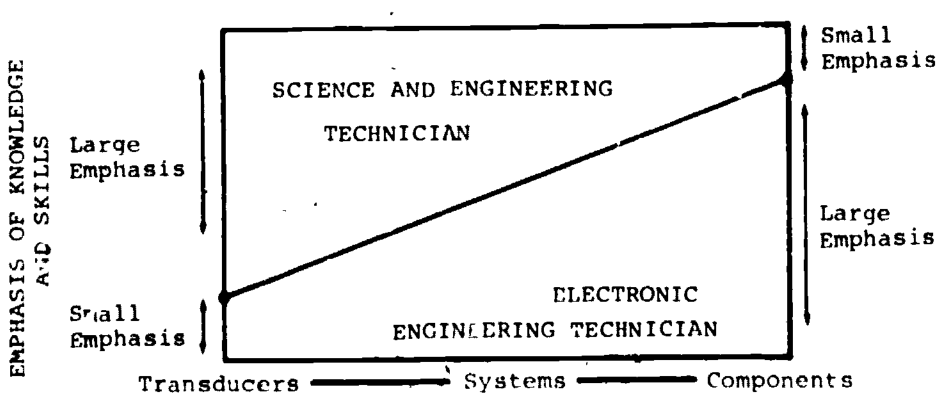

Figure 2 - KNOWLEDGE AREA

In terms of specific activities involving electronics, the employment objectives of the SET curriculum are as follows:

Activity in order of "Sophistication"	Science & Engineering Technician
1. Develop	1*
2. Design	3
3. Modify	3
4. Troubleshoot	5
5. Calibrate	5
6. Operate	5
7. Maintain	5
8. Repair	2
9. Build	2

*1 - low degree of involvement
5 - high degree of involvement

The instructional objectives in the area of electronics for the Science and Engineering Technician curriculum can be stated in the following way.

1. Given a time variant physical parameter (such as item a below) the student should be able to design a simple system for measuring that parameter within acceptable specifications (such as b) by selecting an appropriate, commercially available transducer, and sequence of electronic building blocks (such as c).

a)	Sample Physical Parameters:	Temperature Pressure Displacement Velocity Acceleration	Force Flow Sound Light Strain
b)	Sample Design Specifications:	Sensitivity Accuracy Range Frequency Response	Linearity Signal to Noise Operating Condition
c)	Sample Building Blocks:	Output Device Control Device Amplifier A/D and D/A Convertor Filter Power Supply Multiplexor	Oscillator Bridge Circuits Microprocessor Counter Digital Computer Integrator Differentiator Sample and Hold

2. Given a system designed for performing Objective 1, the student should be able to modify its performance characteristics by determining which building block(s) of the system should be changed and selecting appropriate replacement blocks.

3. Given a malfunctioning system designed for performing Objective 1, the student should be able to troubleshoot the system by determining which of the building blocks is not working properly.

4. Given an operating system, the student should be able to calibrate the system to within design specifications.

5. Given an operating instrumentation system for measuring a physical parameter, the student should be able to properly interface it, to accurately obtain data and to present the data in a form suitable for interpretation.

6. Given an instrument system, the student should be able to properly maintain that system by following the manufacturer's recommended procedures.

These objectives should be met by the three SET courses in electronics: (See list of topics below.)

Course Key	SET Courses in Electronics
1.	Electronic Components, Transducers and Basic Circuits
2.	Analog and Digital Electronics
3.	Electronic Instrumentation

The necessary topics can be sequenced among these courses according to the list below.

Topic (Electronic-Electricity Fundamentals)	Course Key (Above)
Charge, voltage, current, power	1
Ohm's Law	1
Safety	1
Kirchoff Laws (2 loops)	1
Test Instruments	1
Hardware	1
AC Topics	
Frequency	1
Amplitude	1
rms	1
Impedance	2
Transients	2
Phase	2
Interfacing	1,2,3
Instrumentation System Basics	1,2,3
Transducer	1

Topic	Course Key
(Analog Electronics)	
Amplifiers	
Operational Amplifier	1
Power Amplifier	1
Instrumentation Amplifier	1
Bridge Circuits	1
Transducer	1
Meters	1
Recorders	1
Power Supplies	1
Control Devices	1,2
Oscillators	2
Noise	1,2,3
Integrators-Differentiators	2
Filters	2
(Digital Electronics)	
Logic	2
Memory	2
Digital Output	2
Counters	2
Codes and Conversion	2
Communication	3
Analog/Digital Converters	3
Arithmetic	3
Microprocessors	3
Data Logging	3
(Instrumentation Systems)	
Design Specifications	3
Maintenance	3
Block Diagrams	3
Systems Problems	3
Sources of Supply	3
Troubleshooting (Schematics)	3
Calibration	3

2.6 The Practicum

Throughout the design of the Science and Engineering Technician Curriculum there was much discussion about the practicum. One of the objectives of the Project was to include a Practicum. The reason for this objective was that a Practicum would allow the student to use more up-to-date equipment in an actual working laboratory. Also, since the curriculum is designed to place students in technician jobs at the associate degree level, it was felt that some work experience would be very helpful for these students. The Project was started on the premise that a work experience would make the graduate more employable.

But as the curriculum evolved, it seemed that there was no commonality of opinion regarding the specifics of the Practicum. Some participants felt that a series of field trips would accomplish the objectives of the Practicum. Others looked upon a Practicum as a cooperative education experience. There was one module written in an effort to arrive at a Practicum which was based on student use of industrial equipment. Unpaid internships were also proposed. But no single method of providing the Practicum could obtain a consensus among the designers of the curriculum. As a result, the trial colleges were left more or less on their own to come up with a Practicum that would meet some general curriculum objectives. This freedom was obtained through default, rather than through intent.

Curriculum trials showed that many students had already met the Practicum requirement through previous employment. Some already had jobs as draftsmen, for example. Other students were employed while in the program on a part-time basis. In some cases, the employment was of a technical nature and fulfilled all of the objectives of the SET practicum. Other students had part-time or summer employment that was not in any way technical in nature. But this non-technical employment was rather high paying and was necessary for the student to remain in school on a full-time basis. It would be absurd to force the student to quit a good paying job in order to take an internship. Such students were perfectly willing to get their technician experience after they had completed all of the academic requirements of the program. The trial implementation showed that the students' backgrounds and needs were diverse.

As an example of a Practicum course, see the discussion of trial implementation at St. Louis Community College at Florissant Valley--Section 6.1 of the Curriculum Guide.

3. Study Guides

Study guides have been prepared for the following courses in the SET curriculum:

Algebraic and Trigonometric Equations with Applications
by Roger Melton

Chemical Science and Technology I
by Jack Ballinger and Lawrence J. Wolf

Chemical Science and Technology II
by Jack Ballinger and Lawrence J. Wolf

Computer and Calculator Techniques
by Daniel Davidson and Jim Wesselmann

Differential and Integral Calculus
by Roger Melton

Electronic Components, Transducers and Basic Circuits
by Donald R. Mowery

Functions, Alalytic Geometry, Probability and Statistics
by Roger Melton

Materials and Fabrication Methods I
by Andrew Lindberg, Richard Stevens, Robert Bay and Rudy Walker

Materials and Fabrication Methods II
by Andrew Lindberg and Robert Bay

Organization and Expression in Writing
by Marian McClintock

Physics of Electromagnetic, Optical and Solid State Systems
by Peggy Dixon, Bernard Schrautemeier and Gary Waldman

Physics of Mechanical, Gaseous and Fluid Systems
by Peggy Dixon, Bernard Schrautemeier and Gary Waldman

Science and Engineering Graphics I
by Jerry Craig and Jerry Stapleton

SET study guides state the principles or give the information in an abbreviated manner. Example problems are included to convey not only the topics, but the level of problem solving ability expected. Also, there are some problems and exercises for the students. The study guides are not intended to be textbooks or laboratory manuals. The SET study guide contents are in appendix IV.

Study guides are available at cost of reproduction at the present time from the:

Physical Science Department
St. Louis Community College at Florissant Valley
3400 Pershall Road
St. Louis, MO 63135

4. Instructional Materials

The Science and Engineering Technician Curriculum Project did not develop any curriculum materials other than the study guides. However, there are some relevant materials which have been, or are being developed under other projects, and are available for use in SET courses.

4.1 The Physics of Technology Modules

The Physics of Technology Modules were developed for teaching physics to technicians through the study of practical everyday systems. For example, the Automobile Ignition System is used to teach capacitance, inductance and electrical transients. Students learn sound and wave motion through experiments in the Guitar module.

The Physics of Technology Modules series consists of the following titles:

Analytical Balance
Automobile Collisions
Automobile Ignition System
Bicycle
Binocular
Camera
Cathode Ray Tube
Cloud Chamber
Electric Fan
Fluorescent Lamp
Geiger Counter
Guitar
Hydraulic Devices
Incandescent Lamp
Laser
Loudspeaker
Multimeter
Photodetectors
Pile Driver
Power Transistor
Pressure Cooker
Slide Projector
Solenoid
Spectrophotometer
Stroboscope
Toaster
Torque Wrench
Transformer

The Physics of Technology Modules are available from McGraw Hill Book Company, 1221 Avenue of the Americas, New York, NY 10020.

4.2 TERC Electronics Modules

Technical Education Research Centers of Cambridge, 575 Technology Sq., Cambridge, MA 02139 has developed a series of very practical electronic instrumentation modules intended for technician students. The following is a list of titles available in the TERC series:

Introduction to Contemporary Electronics
Direct Current Instruments
Alternating Current Instruments
Microcomputers
Direct Current Transducers
Alternating Current Transducers
Transducer Catalog
Amplifiers
Special Amplifiers
RF Techniques
Analog/Digital Conversion
Signal Generators
Bridge Circuits
Modulation and Demodulation
Digital Concepts
Digital Interfacing
Filter Concepts
Noise Reduction Techniques
Communication of Data
Frequency Analysis
Cooling Curve
Metal Detector
Pulse Height Analyzer
Nuclear Lifetime
Anemometer
Radiometer
Micrometeorological System
Geological Sounding
Goldfish Conditioning
Oxygen Concentration

4.3 The MIT Technical Curriculum Development Project

Introduction to Electronics and Instrumentation is a new and contemporary approach to the introductory electronics course. Designed for students with no prior experience with electronics, it develops the skills and knowledge necessary to use and understand modern electronic systems. The course takes full advantage of the dramatic changes in electronics that have resulted from the development of the integrated circuit. Emphasis is shifted from mathematical circuit analyses and detailed semiconductor characteristics to using electronics to perform useful tasks. ICs are introduced very early and each new device and concept is immediately applied to the construction of a working system to solve a real measurement problem. A burglar alarm, electronic thermometer, audio amplifier and mixer, smoke detector, motor speed control are among the many systems constructed. Various electronic components, semiconductor devices, ICs, transducers and output devices are introduced as they are required to build the systems, and instrumentation concepts of calibration, range, accuracy, sensitivity, time response, and feedback are developed to describe system behavior. After completing this program, a student has used a broad set of contemporary components and built dozens of practical electronic systems that can be adapted to a wide range of measurement and control problems. The program consists of eight modules of instruction:

DC Current, Voltage, and Resistance
Basic Circuit Networks
Time Varying Signals
Operational Amplifiers
Power Supplies
AC Current, Voltage and Impedance
Digital Circuits
Electronic Measurement and Control

For ordering and pricing information, write:

Dr. John W. McWane
Massachusetts Institute of Technology, Rm. 9-216
77 Massachusetts Avenue
Cambridge, MA 02139

4.4 Some Suggestions of Curriculum Materials From Trial Colleges

At this point in the development of the SET curriculum, it is too early to recommend a comprehensive list of materials and equipment. Some of the courses have only been taught one time at any given college. The attached list consists of materials and equipment which have been used successfully in SET courses. The list is rapidly expanding as experience is gained. More equipment than is listed herein will be required for the successful implementation of an SET curriculum.

Analog and Digital Electronics

G. Williams, Digital Technology, Science Research Associates, Inc.
P. Cunningham, Introduction to Digital Electronics,
Allegheny County Community College

Equipment Item	Model	Manufacturer
Oscilloscope	1320A	Hewlett Packard
Circuit Designer	DD-1	E & L Instruments
Digital Design Experimenter		Heathkit
Computer Trainer	70	Hickok
Oscilloscope	D52	Telequipment
Microprocessor	M6800	Motorola

Chemical Science and Technology

Seese and Daub, Basic Chemistry
American Chemical Society, Modern Chemical Technology, Volumes 1, 2, 3, 4 and Guidebook
Shugar, Bauman, Chemical Technicians Ready Reference Handbook

Equipment Item	Model	Manufacturer
Gas Chromatograph	400	Antek
Gas Chromatograph	90P	Varian
ph Meter	Zenomatic	Beckman
ph Meter	701	Orion
Spectrophotometer	20	Bausch and Lomb
Analytical Balance		Mettler
Melting Point Apparatus		Thomas
Recorder	680M	Hewlett Packard

Computer and Calculator Techniques

Brent, Introduction to Computer Programming "Basic"
Programming in Basic, Schaum's Outline Series

Equipment Item	Model	Manufacturer
Time Share Computer	200E	Hewlett Packard
" " "	Access 40	" "
Teletype and MODEM	ASR 33	Com-Data
Minicomputer	PET/2100	Commodore
Programmable Calculator	9100 A* or B*	Hewlett Packard
" "	HP 25	" "
Calculator	SR 30	Texas Instruments
Calculator	SR 5111	" "
Calculator	TI 1200	" "

Electronic Instrumentation

Johnson, Process Control Instrumentation Technology, Wiley
P. Cunningham, Instrumentation Manual, Community College of of Allegheny County
Biomed Modules (EKG, Cardiotachometer, Blood Pressure Measurement), PASCO

Equipment Item	Model	Manufacturer
Oscilloscope	1220	Hewlett Packard
Circuit Designer	DD-1	E & L Instruments
Bio Medical Experiments		PASCO
Stripchart Recorder	204	Heath Kit
Microcomputer	KIM-1	Mos Technology
Mini-Computer/Time Share	Access 40	Hewlett Packard
Universal Testing Machine	UMT-2	Vega
Heat Treating Oven with Control		L & L Furnace

Electronic Components, Transducers and Basic Circuits

Schrader, Electronic Communication, McGraw-Hill
P. Cunningham, Linear Op-Amplifier, Allegheny County Community College
P. Cunningham, The Diode in Electronic Circuits, Allegheny County Community College
P. Cunningham, The Transistor in Electronic Circuits, Allegheny County College
B. Aldridge, Bridge Circuits, Technical Education Research Center

Equipment Items	Model	Manufacturer
Oscilloscope	1220A	Hewlett Packard
Sine-Square Generator	EVW-27	Heath Kit
Amplifier	AA 18	" "
L.V. Power Supply		" "
VOM	60	Simpson
Power Supply	8000	PASCO
Operational Amplifier	8001	"
Differential Amplifier	8002	"
Power Amplifier	8003	"
Function Generator	8013	"

5. Case Studies of SET Students

A college curriculum is only useful to the extent that it helps students achieve realistic goals that they set for themselves. In a career curriculum such as SET, these goals are defined in terms of employment with continuing education as a secondary objective. Although employment is a necessary reason for starting a new career curriculum, it is not a sufficient reason. Therefore, employment surveys, while done early in the project, are not seen to be as valuable as student experiences in entering the curriculum, completing it and then entering the career field. The progress of the students enrolled in the experimental SET curriculum was carefully followed to determine to what extent this program leads new kinds of students to new kinds of jobs. This, after all, is the final justification for a new career curriculum.

Following are four case studies of students who chose the Science and Engineering Technician curriculum and saw it through to completion and placement. In each case the individual is described, along with initial aspirations, and follow-up information one year after graduation. Each of these students entered the experimental curriculum in the Fall of 1975 at St. Louis Community College at Florissant Valley. They were full-time students and graduated in the Spring of 1977. Their experiences with the curriculum were affected by a combination of personal circumstances and professional interests which : typical of Science and Engineering Technicians. Their expe iences, cicumstances and interests are quite important to teachers and administrators contemplating the implementation of a Science and Engineering Technician curriculum.

Greg Hall

Greg graduated from high school a full year before entering the Science and Engineering Technician curriculum. He ranked in the upper fourth of his high school graduating class and had two years of chemistry and three years of mathematics. However, he had not been a "science bound" student, having chosen courses in crafts, pottery, and sculpture along the way. Indeed, when he made application to college he entered liberal arts as his curriculum choice. Greg's experiences and performance in high school characterized him as a person of wide ranging interests and abilities. On his Scholastic Aptitude Tests, which he took upon entry, he ranked high both in verbal and quantitative skills. This is unusual for technician students.

After spending a year studying liberal arts, Greg considered the Science and Engineering Technician curriculum when he saw a brochure on this "new" curriculum. He sought more information on SET and finally made a switch to SET after seeing the faculty advisor for the program. His decision was based on several things. Greg thought that he wanted to get into engineering some time in the future but he had difficulty choosing among the many specific fields. SET seemed to be at his level of ability at that time. SET led to employment at the associate degree level which was important to him for financial reasons. He could work toward a job after the associate degree yet build up some credits for transferability into engineering at a later time.

Greg did well in his SET studies, graduating with a very high average after earning many A and B grades. Because he had a long-term goal of transferring to a bachelor degree program in engineering, he substituted transfer engineering mathematics courses for SET math courses whenever possible. Some of his liberal arts courses will also serve as humanities and social studies electives in an engineering curriculum. He had accumulated 87 credits by the time he earned his associate degree in the SET curriculum two years after entry to that particular program.

Upon graduation, Greg accepted an offer of employment from the motor division of a large electrical manufacturing company where he is a technician in motor development. In this capacity, he reports to an engineer and receives specific assignments involving changes in motor design. He writes lab requests and coordinates between the test lab and design. His supervisor reports one year later that Greg has worked out very well. He is particularly valued for his knowledge of electricity and skill with blueprints. His supervisor describes the department's activity as catering to the needs of about 250 high volume manufacturers who order fractional horsepower motors for their various products. As their products change and as new products are developed, changes must be made in the motors. That is where Greg gets involved.

He feels that the SET curriculum generally fulfilled the goals he held at the outset. He has a solid job involving engineering which is giving him that "necessary first step" which he needed to choose a specialty and to give him confidence. Greg now knows that he can achieve scholastically and professionally in the field. He intends to continue his education in engineering beginning on a part-time basis. He is satisfied with his technical position. He values highly the experience he is gaining. He has good working conditions, and he is earning an adequate salary at present.

Greg has made some constructive criticisms that have more to do with the specific college and the newness of the program rather than with the overall curriculum. He would have preferred a conventional physics textbook approach rather than the physics modules used at Florissant Valley. He feels that he needed access to more electronics equipment than was available to him at the time. He feels that he does not use enough mathematics on the job to justify the extent of its content in the curriculum, although he chose to take more sophisticated math to satisfy his future educational goals.

Luella O'Connor

Luella (Lu) O'Connor typifies the "second career women" in higher education. She completed a high school program in June of 1958. Her high school education included a heavy component of secretarial courses and very little mathematics or science. She ranked in the upper third of her class.

After high school, and before entering college, she held jobs doing secretarial and sales promotion work. She discovered that she had the personal characteristics for sales. But before long she made the transition to full-time homemaker and mother.

In the Fall of 1974, Lu took two courses at Florissant Valley. These were general education courses and were selected in order to give college a try. She did very well and chose two more general education courses for the following semester.

Having proven to herself that she could achieve in the college environment, she began the process of making a curriculum choice. When she learned of the new Science and Engineering Technician curriculum, she went to the the curriculum coordinator for more specific information. Lu wanted something that would lead to a good job and a career. She could see her way clear to invest only two years in full-time education. She knew that she had the talent and maturity for sales. She also supposed that there might be really good money in technical sales. It seemed that SET would provide a sufficient technical background for a wide choice of technical sales jobs. She faced two uncertainties. First, she had never pursued technical or scientific study before and had no developed interest in these areas. Second, women are not normally hired for the high paying technical areas of sales. She accepted the risk of discrimination when seeking employment and chose the SET curriculum. She enrolled in a preparatory math course in the summer and entered the program on a full-time basis in the Fall of 1975.

Lu performed very well in the SET curriculum. She enjoyed the courses and the college environment and was able to balance her family obligations and her studies. She never really did develop a compelling interest in any particular scientific or technical course, but achieved nevertheless. She remained a "people person" and was not deterred from her original goal of technical sales. She had earned more than a B average upon graduation and had done her practicum working in an electronics sales office. After graduation she was offered a training job by her practicum employer.

As frequently happens, her early employment was initially a letdown. There were frustrations and tensions as she was kept pretty much on the "inside" in order to learn the product lines and to prove herself. She felt that she was being held back. But in the view of the president of the company, she was being rapidly developed. By March of the following year, Lu was given a new product line and turned loose to call on customers and represent the firm by marketing a small business computer system. She was given the job title of field engineer.

The following fall, she changed jobs. She moved to another city to accept a position as a sales engineer, marketing electronic power supplies in a multi-state territory. Her earnings are consistent with other technical sales positions. It seems that she is now realizing her rather specific employment goal.

She notes that everything in industry is on a systems level rather than on a component level. She says that the curriculum emphasizes component work too much. "The overview is more important than the detail." She says that she does not feel confident of her technical knowledge for this reason.

Apparently, the premise of the curriculum in the area of transducer technology was valid. But from Lu's standpoint, the SET curriculum still needs to progress in that area. The instruction hasn't yet made the transition to systems to the extent that is needed in industry. Her comments on this part of the SET curriculum relate more to the implementation of the SET curriculum than to its overall design.

She reports using the knowledge gained in physics and chemistry and praised the style of teaching in these courses. This praise includes modular instruction which was criticized by Greg Hall. Obviously, some feedback from graduates reflects personal preferences and individual learning styles. Lu reports that she uses her technical writing most of all, although she admits to "hating" the course as a student.

Student C (This student preferred not to have his name published.)

Student C is an example of the "traditional" college student. He went to college on a full-time basis straight from high school and completed the two-year SET curriculum in two years. Although he took algebra and geometry in high school, he was not really on a college preparatory track. He did not take junior and senior math nor did he have a strong lab science. He did take some industrial arts courses. Student C was in the lower half of his high school graduating class.

His case proves that one does not have to be more mature or an outstanding student to complete the program. Student C was serious and motivated. He completed the program with no substitutions in four semesters. There are no unsatisfactory grades on his record. Furthermore, he earned some A and B grades along the way. Some of these were in the math and science courses. He did choose to take one of the English courses during one summer in the middle of his four semesters. He found that the SET curriculum is not over ambitious as a two-year program.

Student C chose SET because he wanted to do something scientific but couldn't "break it down" to chemistry or mechanical engineering technology or a more specific field. Generality was desired. He wanted a program that would lead to a job after two years of post-secondary education.

After graduation from the SET curriculum in June of 1977, Student C accepted an offer of a job as a lab technician with a manufacturer of fuel and lubricant additives. He likes his work and sees a future. He performs conductivity tests and other tests on fuel additives. He is training for "field" assignments at customer plants.

A visit to his job site and discussion with his supervisor suggests that Student C was properly educated for his job but the breadth of his education is not fully realized by his employer at this point. His group is a lab group primarily involved in physical testing, whereas chemistry is the main work of other lab groups. His supervisor is a chemist who tends to look on the job from the perspective of chemistry. He feels that Student C lacks knowledge of some things normally expected of chemists and chemical technicians. Yet, that supervisor laments the fact that chemists and chemical technicians have not worked out well in his group in the past. The group gets involved in engine test stand work.

Student C probably knows more about this kind of testing than does a person trained in chemistry. Also, there is evidence that new electronic tests are being devised, in which case his broader education should be advantageous. Furthermore, the products which the group is working on involve shipping and plant operation. Here again, he has training broader than that of a chemical technician. Although the supervisor is generally satisfied with Student C, there is some evidence of a productive tension. Student C does not reflect the supervisor's training, and the supervisor has not yet learned to use Student C's training to augment his own. An adjustment will need to take place. It is too early to determine if a successful adjustment can be made.

Student C's employment experience suggests a natural hazard of a new and multidisciplined curriculum. The graduate may find himself more broadly educated, although with less depth, than a specially educated supervisor. Successful adjustment will probably depend heavily upon the personal characteristics of the people involved.

He feels that the SET curriculum served his purposes. It opened doors and allowed him to develop more specific interests. He feels that he may one day seek to continue his education. If so, it would be in chemistry or business.

Student C says that he uses his physics often. He says the math was good but could be even stronger. He uses chemistry often. In his situation it is easy to understand why he feels that the chemistry component could be stronger. He has had little opportunity to use electronic instrumentation. He finds that the general electronics and materials and process understandings gained from the SET curriculum are helpful.

Student C suggests "beefing up" the chemistry, math and electronics components of the curriculum. However, it might be more accurate to say that in his particular situation he is feeling the pressures for more education beyond the associate degree.

Bailey Williams

Bailey Williams is an example of an employed head of family returning to school on a full-time basis in order to upgrade himself. He is a black veteran. Right after high school he attended college but dropped out after one year. He was employed in a drafting job which he lost due to a company wide lay-off.

At age 36 he decided to pool together his veteran's benefits and his unemployment compensation to return to college where he could improve his employability. As the sole sppport of a wife and two young children, he wanted a curriculum which could lead rather quickly to employment. He has had many technical interests, so he chose the SET curriculum and enrolled as a full-time student in the Fall of 1975. He felt that he might want to transfer to a bachelor's degree program later. Hence, he ~~took transfer~~ math courses and carried overloads to permit him to complete some transfer courses in electrical engineering along with the SET courses. Bailey was so well motivated that he excelled in the curriculum. He was an example to all his classmates.

In his second year his financial situation became a problem, so he contacted the placement office for a part-time job. He refused to settle for something outside his field. Because of his heavy academic load, he had severe restrictions on his working schedule. Nevertheless, the SET courses helped him land a job as a technician with a small, high technology company.

His boss is an electrical engineer. The company makes touch-tone computer terminals. Bailey uses all of his SET training. He does drafting. He designs and fabricates prototypes. Occasionally he has to make an instrument cabinet or a printed circuit board. He says, "It is the best job I ever had." He is delighted with it. He works 10 to 15 hours per week. The job made the necessary difference in his financial situation. Accordingly, Bailey decided to continue working there after graduation and also continue his education as a full-time student.

When Bailey graduated from the SET curriculum in June of 1977, he had accumulated 99 credits with a B+ average. He was admitted to a baccalaureate program in Electrical Engineering at a private prestigeous university. He was awarded a substantial scholarship upon transferring. His case represents a rather extreme test of transferability in that he transferred from engineering technology to engineering, and from an open door community college to an elite university which typically admits students only from the upper ranks of their high school graduating class. Perhaps his experience isn't even a fair test of the SET curriculum considering the extra math and pre-engineering courses which Bailey took in preparation for upper divisional work in engineering. He said that about 75% of his courses did apply to his electrical engineering program. He was accepted at the junior level, but expects that it will take him more than two years beyond the associate degree to earn his bachelor's degree.

The follow-up on Bailey showed that he was finding the university studies difficult. "SET is very practical, the School of Engineering is highly theoretical," he reports. He remains highly motivated even though, in this transition year, he had to drop some courses, and he failed a course in electronics. He says that he feels weak in math. One thing that is quite obvious upon viewing his program, is that Bailey has had to take, at the junior level, a concentration of difficult engineering specialty courses. Also, he continues to work about 15 hours each week in order to meet his responsibilities to his family. But he described how he had already purchased his textbooks for the following semester and planned to read them over the summer in order to get the jump on his next year's studies.

Bailey feels that he has strengths and skills due to his SET training which are not used in his theoretical engineering studies at the university. However, he finds that SET skills are highly valuable in his part-time job. Although he has no opportunity to use these skills now to offset the weaknesses in his studies, he feels that ultimately he will be a better educated practicing engineer because of them. He feels that he, too, will develop analytical skills to go along with the practical skills he learned as an SET. His present academic competitors will then have only their analytic ability, he reasons.

6. Case Studies of Trial Implementations

It was the intent of the SET Curriculum Project to perform curriculum trials at several colleges and universities across the United States. If success is indicated by the fact that the curriculum had staying or drawing power at the host institutions, then it would be necessary to say that SET had mixed levels of success. In some cases it has been implemented on a continuing basis and is proceeding without falter. In other cases, the SET curriculum could not get a permanent foothold in the curriculum offerings of the college. But the question of success of a curriculum is much more complex than simply one of survival. The more important criteria is what the curriculum does for students and employers. This section of the guide is a chronicle of experiences gained in the trial implementations of the curriculum. An examination of these experiences will help colleges contemplating the establishment of an SET program to assess their chances of successfully implementing a program.

The factors involved in the establishment of a new curriculum include political, geographic, financial, administrative, legal, historical and personnel aspects. These factors, together with those of pedagogy, science, technology and philosophy form an equation much too complex to analyze. It is simplistic to say that success or lack of success is due to the presence or absence of any single ingredient.

In reading these case studies, it is important to keep in mind that these trial implementations were conducted from 1975 to 1977. This was a time when higher education was suffering from declining enrollments, budget cuts, inflation, disharmony between faculty and administration, and general concern and uncertainty about institutional well-being. Philosophical disorientation prevailed, and in this vacuum, short-term business considerations became important. Almost any curriculum which could promise high enrollments and be implemented with few additions to the faculty and little equipment, could be adopted. Of course, the converse was also true. If the program couldn't attract adequate enrollment, then it would be discontinued. There was little desire to invest in the future and forge new ground in the development of tomorrow's offerings.

SET is not a panacea that can draw students to an institution concerned about sagging enrollments. The SET curriculum was not a sure thing. It was an experiment. The National Science Foundation supports research. No project funds were used to support the actual teaching of courses during the curriculum trials. It was not the intent to subsidize a particular curriculum. Such unusual support would case doubt on the validity of the curriculum trials.

Several institutions, upon learning these realities, felt that they were not in a position to participate in the Project over an extended period. The cases reported herein were selected from institutions having a clear and continuing understanding that the SET curriculum was an experimental one involving risks and costs to the institution in the form of teacher salaries, equipment and space.

These case reports are based upon three to four meetings per year between Project staff and the curriculum coordinators at the trial colleges. During the implementation years, the curriculum coordinators were convened with the Project staff twice each year. Also, someone from the Project Center visited each trial college once each year. Written progress reports were submitted each year by the curriculum coordinators at the trial colleges.

St. Louis Community College at Florissant Valley

Florissant Valley, as the Project Center, felt obliged to implement the SET curriculum almost precisely as designed by the larger group. It was set up as a model program for the Project. Few modifications were made. The curriculum was approved as an experimental program at the College for implementation during the academic year 1975-76. This was an expediency. There was no time to go through the usual district-wide and state-wide steps necessary to adopt a totally new curriculum between April 12, 1975, when the curriculum design was completed and the August, 1975, start of classes. Yet, it was desirable to enroll students and get feedback as soon as possible for the evaluation and possible redesign of the SET curriculum.

The formal curriculum proposals were made later during the first year of implementation. The curriculum was finally adopted as a regular program by the College in the Spring of 1976. Due to copy deadlines it did not appear in the college catalog until the Fall of 1977. Of course, by the time it was published in the college catalog, two entering classes had already been enrolled into the curriculum and the first graduates were working.

Lacking the usual means of informing potential students during the first year of curriculum trials, a special mailing was made to all currently enrolled students who were undecided regarding a major field of study. Other forms of publicity included some newspaper advertisements. But most response came from the rather large pool of "undecided" students at the College.

The first year enrollment was limited to those students qualified to take the first math course in the sequence and willing to complete the two years as a full-time day student.

Approximately twenty interested students met the criteria. Included in those twenty were three blacks and three women. This is a higher ratio of minorities and women than is normally attracted to the other engineering technology curricula at Florissant Valley. Of that initial enrollment of twenty, five did graduate at the end of the two-year trial period.

Some students found that the SET program was not what they wanted and transferred into other curricula or dropped out of school. Others became nervous about the fact that the SET curriculum was "experimental" with no proven placement record. Still others found that they could not continue their studies on a full-time basis and switched to part-time status. About half of the original group continued in the curriculum either on a full-time or a part-time basis. During the second year of operation, the SET curriculum was opened to part-time enrollments.

Of the first graduates, all five were placed either in relevant employment or in a continuing educational program. Four of these five are included in Section 5 of this guide, Student Case Studies.

St. Louis Community College at Florissant Valley was well established in the field of technician education when the SET project was proposed. The college has ECPD (Engineers Council for Professional Development) accredited programs in Electrical, Electronic, Civil and Mechanical Engineering Technologies. It also has an Industrial Engineering Technology program and was one of the pioneers in Chemical Technology. Due to the existence of these programs, there was a substantial pool of faculty and laboratory equipment for the SET curriculum to draw upon. The implementation of the SET curriculum did not require the addition of full-time faculty members, nor did it require any significant new investment in equipment. Most of the courses were taught by experienced full-time faculty relieved from one or two of their regular classes by part-time faculty replacements.

In trials at other colleges most of the curriculum was made up of courses already offered by the college when appropriate. But at Florissant Valley, this was done in only three courses Approximately 12 completely new courses were started for the SET curriculum. It was clear from the beginning that attrition would make advanced classes under-enrolled. But that situation was accepted because Florissant Valley was the model program and project center. The SET curriculum as originally implemented at Florissant Valley follows:

1975 SET Curriculum at St. Louis Community College

First Semester	Sem. Hrs.
Materials & Fabrication Methods I (19.130)	3
Science & Engineering Graphics (30.102)	3
Math for Science & Engineering Tech. I* (50.152)	3
Computer & Calculator Techniques (76.103)	3
College Physics I: Modules* (78.101)	4
Physical Education (90.100-90.250)	1
Total	17

Second Semester	Sem. Hrs.
Materials & Fabrication Methods II (19.131)	3
Career English * (40.100) OR English Composition I* (40.101)	3
Math for Science & Engineering Tech. II* (50.155)	3
College Physics II: Modules (78.102)	4
Electronic Components, Transducers, & Basic Circuits* (78.103)	4
Physical Education (90.100-90.250)	1
Total	18

Third Semester	Sem. Hrs.
Analog & Digital Electronics* (16.230)	3
Science & Engineering Practicum (19.256)	1
Math for Science & Engineering Tech. III* (50.158)	3
Chemical Science & Engineering I (72.106)	4
American Civil. (82.100) OR Intro. to American Politics (84.100)	3
Technical/Applied Science Elective	3
Total	17

Fourth Semester	Sem. Hrs.
Electronic Instrumentation: Calibration, Measurement, & Control* (16.231)	3
Science & Engineering Practicum (19.257)	1
Report Writing * (40.155)	3
Chemical Science & Engineering II* (72.107)	4
Social Science Elective	3
Technical/Applied Science Elective	3
Total	17

*Prerequisite needed.

The students in the original class grew to know each other very well. They were frequently the only ones enrolled in the newly created special courses for the SET program. These courses were taught in four departments and two divisions. By virtue of the fact that communication among the students was more frequent and convenient than within the faculty, the students inadvertently became more organized than the faculty. It was clear to the project staff that the group dynamics among the students were such that they could effectively de-select some topics from the courses in the curriculum. They knew each other too well. If something interested the leaders, they would all concentrate upon that topic. If the leaders chose to focus upon something else, the entire group might divert. The individual teacher would often discover this after it was too late. It became apparent that a better strategy for implementation of an SET program would be to create only a few new courses, and substitute, where practical, some of the standard courses from the college's inventory. It is anticipated that as enrollment in the program grows, the college can then decide in each case whether a special course for SET students is warranted.

After the original class completed the new offerings, it was obvious that the advantages in having all special courses for SET students were offset by the group phenomenon described in the last paragraph. Also, the enrollments were too low in those courses populated only by SET students. The continuance of the courses in the face of budget cuts was threatened.

The second group of students admitted to the program were not enrolled into special SET math courses. Instead, they took the standard math course closest in content to the SET course. The teachers, on an individual basis gave some special attention to those additional topics in the SET study guides. Because this practice was more effective, it was extended to the drawing course and the materials and fabrication courses. Finally, in the Spring of 1978 the SET curriculum was revised to the following form:

1978 SET Curriculum at St. Louis Community College

First Semester	Sem. Hrs.
College Algebra (50.170)	3
Computer & Calculator Tech. (76.103)	2
College Physics I (78.101)	4
Career English (40.100) OR English Composition I (40.101)	3
Engineering Drawing (30.100)	3
Physical Education (90.xxx)	1
Total	16

Second Semester	Sem. Hrs.
Trigonometry (50.173)	3
College Physics II (78.102)	4
Electronic Components, Transducers & Basic Circuits (78.103)	4
Report Writing (40.155) OR English Composition II (40.102)	3
American Civilization (82.100)	3
Total	17

Third Semester	Sem. Hrs.
Manufacturing Processes I	3
Digital Logic (16.233)	4
Technical Analytic Geometry & Calc. (50.156)	4
General Chemistry I (72.118)	5
Physical Education (92.xxx)	1
Total	17

Fourth Semester	Sem. Hrs.
Electronic Instrumentation (22.207)	3
Manufacturing Processes II (19.152)	3
Social Science Elective	3
Technical or Applied Science Electives	6
Science & Engineering Tech. Practicum (78.xxx)	1
Total	16

Suggested Applied Science Electives:

- Numerical Control Programming (19.241)
- Non-Destructive Testing I (19.xxx)
- Non-Destructive Testing II (19.xxx)
- Hydraulics and Pneumatics (19.245)
- Energy Conversion and Transfer (19.247)
- Energy and Its Conservation (78.xxx)
- Alternative Forms of Energy (78.xxx)
- General Chemistry II (72.114)

The trial implementation also exposed some organizational weaknesses within the college. The SET curriculum spanned two academic divisions, the Science Division and the Engineering Division. These divisions were separated architecturally, philosophically, and operationally. The Engineering Division had become adept at the management of technical curricula--attraction of students, faculty advising, processing of curriculum progress records, on-the-job training, relationship with industry and placement of graduates. The Science Division, in particular those departments involved in the project, had less experience with these kinds of management functions. Science departments tended to be support departments, offering courses to "other people's students." In the Engineering Division, the faculty attitude toward the SET project ranged from indifference to outright hostility. Some faculty saw the program as a threat to established curricula. There was some fear that it would drain off students and resources. The Science Division, on the other hand, saw the SET program as a way of increasing sagging science enrollments and as a means of expanding into new areas of science and technology. Science faculty weren't sure that it would work, but they welcomed the SET project as an opportunity.

Inevitably, the question was raised, "Who has the final say?" A simple answer to that question would have destroyed the interdisciplinary intent of the program. A faculty advisory committee, consisting of representatives from physics, chemistry, mechanical engineering and electrical engineering was proposed. This committee would select a curriculum coordinator for SET from one of the four departments. The curriculum coordinator would report to the faculty advisory committee and be responsible for scheduling of courses and for faculty advising. The controversy was finally adjudicated by the Dean of instruction. The proposed faculty advisory committee was established. Faculty supportive of the program were selected for the committee. The committee allowed things to progress, but there still existed an organizational separation between the two divisions, which probably is the largest single reason that the SET curriculum at Florissant Valley is not a more popular program among students.

During the academic year 1977-78, the college was reorganized, from eight to four academic divisions. It was apparent that the separation between science and engineering was impeding college response to a number of new interdisciplinary needs, not only the SET project, but also in such areas as energy and industrial hygiene. The Science, Engineering and Technology Division headed by a single Associate Dean was formed.

While the SET curriculum has not yet had a chance to be influenced by the newly organized structure, it seems that a curriculum called Science and Engineering Technology should find a favorable climate in a division called Science, Engineering and Technology.

Employer support was excellent from the beginning of SET at St. Louis Community College at Florissant Valley. St. Louis has a large and diverse industrial base. The SET graduate is seen to meet many needs. An industrial advisory committee for the SET curriculum at Florissant Valley was formed. The aircraft, chemical, electronics, and food processing industries are represented. Also, the St. Louis Chapters of the Instrument Society of America and the National Society for Non-Destructive Testing are represented. The faculty advisory committee usually meets with the industrial advisory committee.

Placement of SET students has been 100%. The weakness is that there have been far too few graduates to respond to employer requests at the college placement office.

It was decided at Florissant Valley that the practicum requirement of the curriculum could be satisfied in a number of ways. Practicum credit was to be a requirement for the associate degree in Science and Engineering Technology. However, this requirement could be fulfilled prior to entering the SET curriculum, during matriculation in the curriculum, or after the student takes the last course in the curriculum, but before receiving the associate degree. Students having previous or current practicum employment would then simply have to get that employment evaluated to see if it met the curriculum objectives. In order to do this, they would enroll in the practicum course for credit, discuss their employment with the practicum instructor and make arrangements for the instructor to visit the employment site and talk with the student's supervisor. The instructor would make an assessment of the technical content of the employment and verify that the student had indeed worked some minimum number of hours at that employment. It was decided that 120 clock hours of employment would earn one practicum credit.

Students worried about the practicum through their entire first year ~~in the~~ program. But on reflection as graduates, they unanimously report that it was of great value to them. In two cases, the practicum employment led to an offer of permanent employment upon graduation.

The fear that the SET curriculum would drain off students and resources from the traditional engineering technician curricula was unwarranted. The student case histories clearly indicate that SET students come from a new, previously unserved, group in terms of interests and backgrounds. The existence of the SET curriculum has allowed the college to provide additional utilization of specialized faculty and laboratory space and equipment. It has meant more, rather than less, resources. The placement follow-ups show that the SET's can be placed in jobs which were not those for which the traditionally trained technicians are prepared. The SET program apparently leads new students to new jobs using the <u>same</u> resources. It complements, rather than competes, with the traditional specialties.

6.2 Community College of Allegheny County

Community College of Allegheny County began its trial implementation of the Science and Engineering Technician Curriculum in the Spring of 1976. It was offered days and evenings full-time and part-time. It has also been offered on Saturdays and during the summer. The spark plug of this implementation was Pearley Cunningham, a physics instructor who has a great deal of energy and considerable interest and training in electronics. Pearley saw the need for a technician curriculum at Allegheny.

The Community College of Allegheny County is a multi-campus system in the area of Pittsburgh. The curriculum was offered on the South Campus of the system. The South Campus is in West Mifflin, PA. It is a comprehensive community college, enrolling approximately 10,000 students on this campus. Like the other urban/suburban community colleges participating in the SET curriculum, about half of the students are women. The typical student is in his/her late twenties. SET was this college's first venture into the so-called "hard technologies." SET was chosen because it was a general curriculum that could meet employment needs in many different areas of technology.

The curriculum was named Science and Engineering Technology. It appeared for the first time in the college catalog in the Fall of 1978. The college curriculum proposal was written in April of 1975, and the proposal for Vocational Education Act Funds was prepared in July of 1976.

There was little response to SET promotion through posters and newspaper advertisements. Most interest was gained through a personal letter to all vocational-technical high school graduates.

(There were about 600 in the area.) A personal interview was offered to those interested in the program.

The department of Chemistry, Physics and Technology is responsible for the SET curriculum. No new full-time faculty were required to start the curriculum. Part-time instructors were required to supplement. State vocational education funds were granted to support the part-time instructors. Due to increasing enrollment, a new full-time faculty member was added in the Fall of 1977.

The Community College of Allegheny County did not have extensive shops and labs, so these facilities had to be developed. A 900 square foot room was provided by the college. A State Vocational Education Act Grant of $8,000 per year for three years was used for capital equipment. Much of this lab facility will be used for other technician curricula which are now developing.

An advisory committee was formed which meets two or three times per year. U.S. Steel, Westinghouse, chemical companies, two transfer schools, and ERDA are represented on the advisory committee. The committee advises "as to importance of portions of the program to Pittsburgh based industry, employability of graduates, skills or equipment we should be emphasizing."

The form of the Allegheny curriculum as adapted from the SET model is shown by the table below.

SET Model Curriculum	Community College of Allegheny County--SET Curriculum
Materials & Fabrication Methods I	Project Fabrication (3 credits*)
Computer & Calculator Techniques	Orientation (1 credit) Computer System Applications (2 credits)
Mechanical & Electrical Drawing & Interpretation	Basic Drafting (3 credits)
Physics of Mechanical, Gaseous, & Fluid Systems	Tech. Physics I (3 credits)
Algebraic & Trigonometric Equations with Appls.	Tech. Math I (3 credits)
Electronic Components, Transducers & Basic Circuits	Introduction to the Science of Electronics (3 credits)

Curriculum Trials
Pittsburgh

SET Model Curriculum	Community College of Allegheny County-SET Curriculum
Materials & Fabrication Methods II	Engineering Materials (3 credits)
Physics of Electromagnetic, Optical & Solid State Systems	Tech. Physics II (3 credits)
Functions, Analytic Geometry, Probability & Statistics	Tech. Math II (3 credits)
Analog & Digital Electronics	Intro. to Digital Electronics (3 credits)*
Chemical Science and Technology I	Tech. Chemistry (4 credits)*
Boolean Algebra, Differential & Integral Calculus	Tech. Calculus I (3 credits)*
Technical Communications in Written & Oral Reports	Students take standard English courses (6 credits)
Chemical Science and Technology II	Tech. Chemistry II (4 credits)*
Electronic Instrumentation: Calibration, Measurement, and Control	Science and Industrial Instrumentation (3 credits)*

*New courses at Allegheny created specifically for SET.

At the beginning of the Spring term 1978, there were 13 second year, 17 first year, and 14 part-time students committed to the SET curriculum at the Community College of Allegheny County. Of these 44 students, six were female and two were minorities. Fifteen were over 25 years of age.

The first graduating class consisted of ten students. Of the ten, three are continuing their education to the baccalaureate; two in technology (engineering and industrial), one in electrical engineering science. In the case of the one going to engineering science, approximately 40% of his course work did not transfer. The technology students transferred 100% of their SET credits.

Four graduates had jobs immediately upon graduation. Of the remaining three, all but one have had interviews and job offers. That one wasn't seeking immediate employment. Although at this writing it is too early to say for sure, but the curriculum coordinator feels that all the graduates will meet their objectives of transfer or employment with the associate degree. He is surprised at the wide variety of scientific and technical jobs being offered the graduates.

Allegheny satisfies the practicum with a special projects course involving from one to six credits. It is now required for graduation. Practicum jobs are made available on campus and are approved by the curriculum coordinator. The student is evaluated on the basis of written reports on the finished project.

The curriculum coordinator feels that the study guides for the SET courses are a major strength. They not only give the intended content of the courses, but also help establish the required level of technical competence expected. The electronics courses have been very popular. The major weakness of the SET curriculum is that the students seem to have an identity crisis. They don't know what to call themselves, or for what kind of specific job they are preparing. Nevertheless, students, faculty, and administration are enthusiastic about the program. It seems to be leading new kinds of students to new kinds of jobs. The enrollment is solid and the trend is positive.

Community College of Denver, Red Rocks Campus

The Community College of Denver had a trial implementation which is at the other end of the spectrum from the Community College of Allegheny County. Denver is a disappointment to the project because the SET curriculum is so well suited to the diverse high technology industry in the Denver area. Nevertheless, the curriculum could not get established. The experience in Denver will give colleges contemplating starting an SET curriculum an idea of some of the organizational difficulties that can be encountered.

The curriculum coordinator at the Red Rocks Campus of the Community College of Denver was Dr. Alfred E. Bussian. Bussian is a physicist in the Division of Science and Mathematics. He was a very able and enthusiastic curriculum coordinator who was one of the people involved in the original design of the SET curriculum. He was in the project from the beginning, being one of the first to attempt a trial implementation, and stayed with the program on his campus for a total of four years.

The Red Rocks Campus is located in a suburb of Denver and is one of three campuses administered by a central authority. It has an enrollment of about 10,000 students, half female, with the average age in the late twenties. The campus organization is like many rural community colleges, divided into an academic branch and a vocational branch. Each of these branches is headed by a Dean.

There is a tendency in such organizations to evolve separately from one another so that faculty, administration, and philosophy may be quite different.

A curriculum such as SET gives the divided organization a great deal of difficulty. SET has both transfer and career objectives. Transfer programs are the province of the academic branch. Career programs are the domain of the vocational branch. The vocational branch, while having shops and electronic labs, does not have the physicists, chemists, and mathematicians needed for high technology programs such as SET. Thus, the academic branch provides many support courses for vocational programs, but control of these programs is in the hands of the vocational educators. This organizational philosophy works reasonably well for most vocational programs but is too confining for SET.

However, because of the nature of the SET program, Bussian proposed bridging the academic/vocational gap through a joint administration of the program. A curriculum was prepared which used existing or modified courses almost exclusively from the academic sector. An exception was the Introduction to Drafting and Sketching course taught by the vocational branch. The drafting instructors expended a great deal of effort to make their course compatible with the SET curriculum and were enthusiastic supporters of the program. However, because support for the program was more restrained in other vocational areas, some model curriculum subjects were forfeited in the hope that as the program gained momentum and achieved eventual approval, these courses would be created. This curriculum is given on the next page.

Community College of Denver SET Curriculum

SET Model Curriculum	Community College of Denver SET Curriculum
Materials & Fabrication Methods I	Not offered
Computer and Calculator Techniques	Computer Methods for Scientific Studies (3 credits)
Mechanical & Elec. Drawing & Inter.	Intro. to Drafting & Sketching (3 credits)
Physics of Mechanical, Gaseous, and Fluid Systems	Applied Physics I (4 credits)
Algebraic & Trig. Equations with Applications OR Analytic Geom. & Calc. I	Inter. Algebra (3 credits)
Electronic Components, Transducers, & Basic Cir.	Princ. of Electronics for Sci. Majors I (4 credits)
Materials & Fabrication Methods II	Not offered
Physics of Electromagnetic, Optical, & Solid State Systems	Applied Physics II (4 credits)
Functions, Analytic Geometry, Probability & Statistics OR Analytic Geometry & Calc. II	Intro. to Geometry (3 credits)
Analog & Digital Electronics	Prin. of Electronics for Science Majors II (4 credits)
Chemical & Physical Prop. of Materials	Fundamentals of Chem. I (4 credits)
Boolean Algebra, Differential & Inte. Calc. OR Calc. III	Statistics (3 credits) OR Survey of Calculus (4 credits)
Electronic Instru.: Calibration, Measurement & Control	Not offered
Tech. Communications in Written and Oral Reports	English Composition (3 credits)
Chemical Sampling & Analysis	Fundamentals of Chem. II (4 credits)

An advisory committee from Denver area industry was formed for the program. It consisted of representatives from the following organizations:

C. A. Norgren Company
Coors Porcelain Company
Sundstrand Corporation
National Bureau of Standards
National Center for Atmospheric Research
United States Geological Survey
Adolph Coors Company
Honeywell, Incorporated
Ball Brothers Research Corporation
Rockwell International (Rocky Flats)
Metropolitan State College
Colorado State University

Student interest was generated by posters, contacts with high schools, and a mailing to undeclared majors. The response was good. In the spring of 1978 Bussian reported 7 SET students. Three of them were women. All were over 23 years of age. The number would have been considerably larger, but since the summer of 1976 Bussian had been turning away students, because of the uncertainty of the future of the SET program. It had been on an experimental basis and had not been officially approved.

In order to gain support for the program, Bussian gave a presentation to the President's staff in April, 1976. Support was given to the program, but on a continued experimental basis. The real hurdle, however, was approval from the State Board of Community Colleges and Occupational Education which must approve all programs in the vocational area. A proposal was made through channels to the State Board in the Spring of 1976. It was not approved.

In a last effort, Bussian called a meeting of the advisory committee. A representative of the State Board was present. The committee gave support for the program, but opposition by the State Board prevailed. Two reasons were given for this strong opposition:

1) The State Board was opposed to a program which was partially academic and partially vocational.

2) In its opinion, the use of vocational funds for a "transfer" program is illegal.

It is interesting to note that the program itself was not criticized. Regarding the use of vocational funds, other states do not see the SET curriculum in such narrow terms. It is important to point out that SET has been approved for Vocational Education Act funds and, in fact, has received such funds in the states of Missouri, North Carolina, and Pennsylvania. The purpose of the Vocational Education Act was to prepare people for real jobs. Federal law requires that Vocational Education Act funds be allocated through the States and that 15% of the money go to post-secondary vocational programs which are defined as those job-oriented programs requiring two years or less of education past high school.

Due to the action of the State Board, the SET curriculum has been dropped at the Community College of Denver, Red Rocks Campus. It is interesting to note that within a month of receiving this notification, the project office in St. Louis was visited by a corporate recruiter from a large company near Denver. He had learned of the SET program at Florissant Valley and wanted to know if there were any graduates who would be willing to relocate to Denver.

6.4 Durham Technical Institute

One of the more recent trial implementations occurred at Durham Technical Institute which is a rapidly developing institution in the tri-city area of Raleigh, Durham and Chapel Hill, North Caroline. DTI came into the SET program in the Fall of 1976. However, it did not start the program until the Fall of 1977, after it had a chance to go through the regular curriculum approval channels at the college and the state.

Durham Technical Institute is uniquely suited for this program because it has a tradition of training engineering technicians and has the faculty and facilities. An advantage held by Durham Technical Institute is its location--adjacent to the Research Triangle Park in central North Carolina. The Park is a major national center for government and industrial research. Present facilities include those of IBM, Monsanto, Burroughs-Wellcome, E.P.A., National Institute of Environmental Health Sciences and the Research Triangle Institute, a major contract laboratory.

John A. Zunes, a member of the Physics faculty at Durham Technical Institute, was interested in the SET curriculum and became a very enthusiastic curriculum coordinator. He first proposed the program for Durham Technical Institute in the Spring of 1976. A local advisory committee was established to determine the needs of industry and research laboratories in the area served by the school. The committee included representatives from:

Curriculum Trials
Durham, NC

Amcor
Department of Community Colleges, State of North Carolina
Burroughs-Wellcome Company
Owens-Illinois, Inc.
JFD Electronics Corporation
Veterans Administration Hospital
Newton Instrument Company
International Business Machines Corporation
Wright Machinery Co., Inc.
National Institute of Environmental Health Sciences
Environmental Protection Agency
Research Triangle Institute

The advisory committee recommended including biology as well as the physics and chemistry included in the pilot program at Florissant Valley. Also, a greater stress on electronics with less emphasis on mechanical skills was needed. In order to meet state requirements for an Associate Degree, English and Social Science courses were included. A decision was made to require college transfer English as well as a technical report writing course to facilitate transfer to a four-year institution for those who wished to go on for a bachelor's degree.

The first class of 22 students was admitted to Durham Tech in the Fall of 1977. The program again showed strong appeal among women and minorities. Thirty-two percent of the entering class were women. Twenty-seven percent were minorities. Most of the students had some education beyond high school. One had a baccalaureate degree. Most of the students had prior or continuing work experience in a technical field. The students ranged in age from 19 to 35 with a mean age of 27.6. The specialty courses were offered evenings because many of the potential students were employed full-time.

In order to achieve a balance between the science and engineering aspects of the curriculum, approximately the same number of courses in each field are included. The Steering Committee at Durham Tech includes representatives from science and math, electronics, mechanical engineering, as well as English and social science support courses and a representative from student services. Because only applied science courses were offered at DTI, a number of new courses had to be introduced. On the other hand, the technical math, English and some mechanical engineering courses were already available from other curricula. Although there was an Electronic Engineering Technician curriculum at Durham Tech, new electronics courses had to be formulated to meet the SET curriculum criteria of "transducer technology" and "black box" operation of electronic devices rather than circuit development and analysis. The Science and Engineering Technology Curriculum has stimulated a greater interest in microprocessor technology at Durham Tech. Recently several "home type" self-standing computers have been obtained for student use as well as access to the Triangle University Computation Center. An "Introduction to Microprocessing Technology" course has been added as well as the "Calculator and Computer Techniques."

One of the most important aspects of the SET curriculum is the practicum which prepares the student with technical experience in an industrial or research laboratory before receiving the degree. Most of the present students in the program have a number of years of experience as full-time employees, but for those who do not, a program of closely supervised part-time employment in several local industries and research labs provide the necessary experience. This not only allows the students to get hands-on experience on the job, but also gives them a chance to see the various opportunities after graduation. At Durham Tech, the last part of the program includes a number of technical electives which allow the student to become more proficient in the area of his/her particular interest.

Curriculum Trials
Durham, NC

DURHAM TECHNICAL INSTITUTE
SCIENCE AND ENGINEERING TECHNOLOGY PROGRAM

			Quarter Credit Hours
1st Quarter			
PHY	165	Physics I*	4
MAT	160	Technical Math I	5
ENG	106	Composition I	3
ELN	165	Calculator and Computer Techniques*	3
			15
2nd Quarter			
MEC	101	Machine Processes*	3
PHY	166	Physics II*	4
MAT	161	Technical Math II	5
			12
3rd Quarter			
ENG	107	Composition II	3
MAT	162	Technical Math III *	5
SSC		Elective	3
BIO	165	Molecular and Cellular Biology *	[illegible]
			15
4th Quarter			
MEC	165	Engineering Materials *	4
ELN	166	Electronic Components & Basic Circuits*	4
ENG	108	Composition III	3
MEC	114	Manufacturing Processes *	3
			14
5th Quarter			
CHM	165	Chemical and Physical Properties I *	4
BIO	166	Human Anatomy-Physiology *	5
ENG	207	Career Communications	3
			12
6th Quarter			
ELN	167	Transducers and Electronic Instrumentation *	4
CHM	265	Chemical and Physical Properties II *	4
		Technical Elective	4
			12
7th Quarter			
ELN	265	Analog and Digital Electronics *	5
CHM	266	Chemical Sampling and Analysis *	4
SSC		Elective	3
			12
8th Quarter			
DFT	265	Introduction to Drafting	4
ELN	265	Electronic Instrumentation *	5
			9
9th Quarter			
		Technical Electives *	12

*Courses developed especially for SET

A local industrial advisory committee was formed to provide input to the formulation of the curriculum so that the training provided would meet the needs of the employers. However. the committee also provided a nucleus of employers for part-time in-course experience, and also for job opportunities on graduation. Already I.B.M. has provided part-time employment for several students, and E.P.A. has a continuing program for student trainees. Additionally, the National Institute for Environmental Health Sciences is expanding its facilities and will provide increased opportunity for this experience. As yet, there are no graduates from the Durham Tech program so it would be difficult to determine future employment opportunities or salaries. However, one indication may be a recent advertisement in the local newspaper for technicians with the type of background that will be provided by the SET program. Starting salaries were from $12,000 to $14,000.

At present, the Science and Engineering Technology curriculum at Durham Tech is offered only during the evening. Hopefully, as expanding faculty and facilities allow, it can also be offered as a full-time day program. An option in the second year for a Biomedical Engineering Technician is anticipated as facilities permit.

The Durham Tech brochure for the Science and Engineering Technology Curriculum sums up the criteria and objectives of the program:

"<u>What is a Science and Engineering Technician?</u>

Science and Engineering Technicians may work in a variety of jobs. They may work in support of scientists or engineers in research, development or test laboratories of industry, education, or government. They may work in the application of new electronic instrumentation and controls to many manufacturing or industrial processes. Science and Engineering Technicians are particularly suited to the many positions which overlap the traditional fields of science and engineering. Science and Engineering Technicians are trained by physicists, chemists, electrical engineers and mechanical engineers working together to achieve the necessary interdisciplinary approach."

"<u>What are the Objectives of the Science and Engineering Technician Program?</u>

Durham Tech's Science and Engineering Technician Program is a two-year, associate degree program designed to prepare versatile technicians. Graduates of this program will be able to acquire skills very quickly in a wide range of different jobs, especially those involving modern electronic instrumentation. Durham Tech graduates will have familiarity with instruments and apparatus used for measurement, detection, or testing and control in research, development, or engineering applications. Science and Engineering Technicians will know the basic concepts, definitions, and principles of physics, chemistry and biology and how these relate to real devices or systems in technology."

"Durham Tecn graduates will be familiar with the properties of a variety of different materials used in research, manufacturing, or engineering applications. Durham Tech graduates will be able to read and interpret mechanical and electrical drawings and will also be able to prepare rough, but correctly detailed, drawings or sketches. Graduates will be able to organize and present technical reports clearly and systematically in written or oral form."

7. Steps in Establishing a Science and Engineering Technician Curriculum

During the course of the Project described in Section 1.2, eighteen colleges and universities evaluated the experimental SET curriculum for possible adoption. Of these eighteen, eleven colleges and universities actually conducted some curriculum trials in conjunction with the curriculum development project. Of the eleven, four have at this time fully approved and implemented SET curricula and three others are offering the program under another name, or as an option to a formerly existing curriculum. The names of these institutions are included in Appendix III.

A considerable amount of experience has been gained regarding the implementation of an SET curriculum. Some of this experience is contained in the four curriculum trials reported in this curriculum guide. But in addition to this, there is a great deal of experience which has been gained as the result of other curriculum trials. However, in the interest of brevity, detailed case histories were not included in this guide for all of the curriculum trials.

In an effort to convey more of the implementation experience gained by the Project, the following Steps for Establishing a SET Curriculum have been prepared. These steps constitute a step-by-step, "how to do" procedure for starting a new SET curriculum. The steps presented are probably necessary, if not sufficient, for a successful start-up. This statement is based on the fact that those colleges that today have a successful SET program performed each of these steps to a satisfactory conclusion. In those cases where one or more of the steps were omitted, or could not be completed, the SET curriculum has languished to some degree, was not adopted, or was discontinued.

1. Name an SET Curriculum Coordinator.
   This person should be a science or engineering teacher with an interest in interdisciplinary work. Some special electronic instrumentation interest is almost a necessity. Although the Curriculum Coordinator may be appointed, in most successful cases, an interested faculty member has volunteered for this role.

2. Prepare a Draft Curriculum.
   An initial list of courses is needed to establish a basis for discussion. Use the model curriculum on page 6 of this guide. Explore existing offerings and use, at least initially, existing college courses if they are similar. It is neither cost effective nor instructionally effective to start with 15 new courses. Until SET enrollment builds, it is best not to have more than four new courses created for SET students only.

3. Call the Curriculum, "Science and Engineering Technology."
   Trial implementations using such names as General Engineering Technician, and others have not been successful. Student and

faculty identity in an interdisciplinary curriculum is difficult enough without the added ambiguity of the word, "General."

4. Conduct an Employer Survey.
Get a list of employers in your area. Contact the Chamber of Commerce for such a list. All business, industrial and government firms of over 200 employees should be included in the survey if they are engaged in research, development or the creation of products, processes, or projects. Since information from employers of over 1000 people is very valuable, such large employers should first be contacted by telephone in order to determine who is the best person in the organization to complete the survey. Telephone that person to let him or her know that the survey is coming.

Remember that the SET curriculum is new and that most employers do not have an established need or job classification so named. Employers must be given a copy of the proposed curriculum and asked if there are existing or future job classifications for which a person so trained might be of value.

Employers cannot commit themselves to hiring a specific number of persons at any given time. Don't ask how many SETs are needed. Do ask how many persons are presently employed in related job classifications. Ask salary ranges, job titles of classifications, and whether the number of persons in those classifications is expected to increase or decrease in the next five years. Ask about the turnover rate.

In reducing data, discard those responses where a graduate of another curriculum available in the area would clearly be more qualified. If the employer survey indicates more than 25 SET jobs per year, consider the demand adequate for starting the program.

A sample employer survey form is available in Appendix I.

5. Establish an Advisory Committee.

An advisory committee should be formed to review the curriculum proposal and the results of the employer survey, and to provide counsel and suggestions on the curriculum proposal. The advisory committee should be made up of representatives of employers, preferably those responding favorably to the employer survey. Other good representatives can be obtained from the local chapters of the Instrument Society of America, the Society for Non-Destructive Testing, and other non-specific engineering societies. One or two representatives of transfer institutions may be included.

Advisory committee meetings should have an agenda and minutes. Industrial persons are usually reluctant to give up a large portion of their day or an evening for such a meeting. Best attendance is usually gained when meetings are scheduled for one hour late in the afternoon so that participants feel that they are giving up neither a work day nor an evening. Faculty who might be involved in teaching courses to SET students should be invited as observers and participants. It is useful to have a campus administrator participate.

Committees should meet at least once but not more than twice a year. Contact members between meetings by mail and bring them up-to-date on curriculum transactions and progress. An example advisory committee manual from one of the trial colleges is included in Appendix II.

6. Determine the Resources Required for Implementation of the SET Curriculum.
   Normally, proposals which use existing equipment and laboratories are seen to be favorable. New full-time faculty positions should be avoided in initial implementation. There is always uncertainty as to whether a new curriculum will be well received by students. But, few committees or boards object to resource commitments which can be incrementally increased as enrollment develops.

   At this point in the development of the SET curriculum, there is consensus as to equipment inventories required. Equipment lists are not included in this guide for that reason. Contact colleges who participated in the project for advice. Remember that these colleges started with few pieces of equipment and built their inventory incrementally.

7. Determine the College Organization for the SET Curriculum.
   Trial implementations have shown that this is a most critical element in the success of an SET program. SET can be controversial. It is important that the administrator in charge of all the scientific and technical resources necessary to implement the program be supportive. Depending on the college's organization, this administrator could be a department or division chairman, a dean, etc. If that person is favorably inclined, resistance from one or two other individuals can be effectively bypassed through the use of an interdisciplinary faculty committee.

8. Prepare the Curriculum Proposal
   All colleges have an approval procedure for the establishment of new curricula. It is not unusual to require that a new program go through a faculty committee, an administrative group, a board of directors or trustees, and in some cases a state-wide

coordinating board. Sometimes this process can take more than one year. The time from initial survey to publication in a college catalog can be as much as four years in length. Nevertheless, those trial colleges who went the formal route rather than take the expediency of an experimental program, or a general education program, achieved a more successful implementation with the full support of the institution.

It is best to obtain a copy of a successful curriculum proposal. Normally, such a proposal will require: the curriculum, an employer survey, advisory committee recommendations, resource requirements and an organizational plan.

This Curriculum Guide can be referenced for philosophy, course outlines, student cases or trial implementation cases. The study guides are also useful.

It may be important to check the availability of state administered Vocational Education Act funds for equipment or faculty. SET programs have been approved for voc-ed support in Missouri, North Carolina and Pennsylvania. It was not approved in Colorado.

9. Recruit Students.
A special program for recruiting SET students will be required for several years until graduates begin to generate referrals.

All trial colleges report success with mailings targeted to special groups such as all undeclared or undecided students in the college, or all vocational/technical high school graduates in the area. In these cases, it is best to offer an interview with the curriculum coordinator rather than use the regular counseling or admissions process. Counselors and admissions people usually don't recommend curricula until they are approved and published.

Posters were reported effective in one case where the coordinator personally went out and visited high school science classes and posted the information himself. Mailings of posters to high school counselors was not felt to be effective.

Mass media advertising is expensive and has worked in only one case. In that case, the college conducted an advertising campaign based upon the introduction of three new curricula, SET being one of them. The admissions and counseling staffs were mobilized in support of that advertising campaign.

10. Use the Study Guides.
The course study guides are not intended to replace textbooks or lab manuals. They are an expanded course outline, giving some content and an indication of the achievement level. In those new courses which conform exactly with the model curriculum, the study guides can be followed exactly. They can be obtained for students until the supply runs out from the Physics Department, St. Louis Community College at Florissant Valley, 3400 Persh[illegible] Road, St. Louis, MO 63135. A complete list of study guides is given in Section 3.

11. Evaluate and Modify.
Faculties, student characteristics, geographical areas and academic institutions are not identical. It was not the intent of the SET Project to produce identical curricula at many colleges. SET programs should not be identical anymore than engineering or medical programs are identical from university to university. It is necessary for each institution to continually modify the curriculum. It is highly desirable for SET curriculum coordinators to communicate and share ideas with one another. Let the others know what you have found and what you are doing.

12. Other Steps in Establishing Post-Secondary Technological Programs.
For a more general guide to the establishment of technical programs, the following publication is recommended.
"Get Them Under Way," a Developmental Guide for the Establishment of Baccalaureate Technological Programs and other Post-Secondary Technological Programs.

National Science Foundation Project HES75-17321
Kenneth Woolf, Project Director
Wesley L. Baldwin, Assistant Project Director

APPENDIX I

EXAMPLE OF EMPLOYER SURVEY FORM

Gentlemen:

We are contemplating the initiation of a two-year curriculum leading to the associate degree for Science and Engineering Technicians. The basic content and goals of the curriculum are given on the attached page. We request the support of business, industrial and government organizations in helping us to ascertain the need and demand for potential graduates in this field.

Please complete the survey below which may be returned to

____
(Name of coordinator and college)

in the enclosed self-addressed envelope. Data from this survey will be used to establish the demand and opportunities for Science and Engineering technicians in this area.

1. Number of employees in your organization working in the ______________________ area.
   (Name of geographical)

   ____ Less than 100

   ____ 200 to 400

   ____ 400 to 800

   ____ Over 1000

2. Job classification titles in which Science and Engineering Technicians from the attached curriculum would be employable now or within the next five years.

   Titles: (Example: Lab Technician, Sales Technician)

   ____

   ____

   ____

   ____

3. Approximate number of persons employed in your organization in all of the classifications listed in 2.

____ 1 to 5	____ 20 to 40	____ over 160
____ 5 to 10	____ 40 to 80	(please estimate number)
____ 10 to 20	____ 80 to 160	

4. Approximate number of persons expected to be employed in your organization in all of the classifications listed in number 2 five years from now.

____ 1 to 5	____ 20 to 40	____ over 160 (please
____ 5 to 10	____ 40 to 80	estimate number)
____ 10 to 20	____ 80 to 160	

5. Approximate monthly pay level in the classifications listed number 2.

   Starting with no experience $________/mo.
   Average $________/mo.

6. Suggestions regarding content of the Science and Engineering Technician Curriculum____

   ____

   ____

   (Continue on Reverse Side)

7. Name of person completing this questionnaire:

   ____

8. Title:____

9. Office Telephone Number:_____________________________________

10. Name of Company or Organization:______________________________

    Address____

    ____

11. Would you be willing to serve on an Advisory Committee for this curriculum, or would your organization be willing to nominate someone? ____Yes ____No

Thank you for your time.

EXAMPLE OF ADVISORY COMMITTEE HANDBOOK

A
HANDBOOK
FOR
SCIENCE AND ENGINEERING
TECHNOLOGY
ADVISORY COMMITTEE
MEMBERS

FORT HAYS KANSAS STATE COLLEGE
HAYS, KANSAS 67601

OCTOBER
1976

(1)

PROFILE OF THE COLLEGE

Fort Hays State blends the tradition of the Old West, the ivy of education and the reality of the 1970's into a kind of higher education where excellence is the underlying theme, the motivating force and the reason for its existence.

Founded on the Fort Hays Military Reservation, the school opened its doors June 23, 1902 and operated under three different names as a teachers college for 29 years. In 1931 the institution, now a college of liberal arts, was named Fort Hays Kansas State College. The military heritage of the 4,160 acre campus is reflected today in organization and building names, activities and symbols.

The college is divided into four schools and 23 departments. The schools include Arts and Sciences, Education, Nursing and Graduate. Departments include Agriculture, Art, Biological Sciences, Business, Chemistry, Earth Science, Economics, Education, English, Foreign Language, Health, Physical Education and Recreation, History, Home Economics, Industrial Arts, Library Science, Mathematics, Music, Philosophy, Physics, Political Science, Psychology, Sociology and Anthropology, and Speech.

PHILOSOPHY AND OBJECTIVES OF THE COLLEGE

As a tax-assisted liberal and applied arts college, Fort Hays State holds one overall objective which is to provide opportunities for students to prepare themselves for constructive and responsible living in a democratic society. Specifically, the college attempts to develop understanding of man in his natural and social environment, understanding of human values, skills for acquiring additional knowledge and the learning of basic facts, and skills necessary in vocations and professions.

ADVISORY COMMITTEE POLICY

The Science and Engineering Technician (SET) Advisory Committee is to be composed of persons representing education and employers. It is the purpose of this committee to provide a two-way system of communication between Fort Hays State College and the industrial, institutional, manufacturing and production communities. The SET advisory committee will serve only in an advisory capacity and can have no legislative or administrative authority.

ADVISORY COMMITTEE FUNCTIONS

The attainment of high quality preparation of the SET student is not possible without the close involvement of knowledgeable persons from business, industry and labor. The nature of occupational change requires that educators, and particularly those who are charged with decision-making, be kept informed of the current anticipated skill needs of industry. Some specifie functions of the Science and Engineering Technician Advisory Committee are:

1. To speak on behalf of employers and employees from specific occupational areas.
2. To serve as a communication channel between the college and the industrial, institutional, manufacturing, and production communities.
3. To advise on the type of skills, knowledges, and attitudes needed to prepare SET students for entering into the job market as a science and engineering technician.
4. To recommend physical facilities and types of equipment needed for the SET curriculum.
5. To make suggestions which will promote and assure the highest quality program.
6. To recommend competent personnel with appropriate educational, business, and industrial experience as potential instructors.

7. To assist with an evaluation of the SET curriculum.

8. To suggest ways for improving the dissemination of information concerning the SET curriculum to potential students and employers.

9. To assist in recruiting potential students, providing practicums, and locating appropriate jobs for qualified SET graduates.

10. To keep the college informed on current specific needs and changes in the labor market as it pertains to the SET curriculum.

ADVISORY COMMITTEE ORGANIZATION

1. Personal Qualifications - Invitations to serve on the SET Advisory Committee depends largely upon the degree of expertise of the potential member. This knowledge, coupled with a general understanding of the academic world, affords the college a rich source of information.

The criteria for membership on the advisory committee include:

A. A willingness to devote valuable time to the committee.
B. A wide range of experience.
C. Recognized leadership.
D. Career commitment.
E. An interest in Fort Hays Kansas State College.

2. Term of Membership - While Fort Hays Kansas State College is appreciative of the cooperation and contribution of all individuals who consent to serve on the SET Advisory Committee, the college realizes that members have other commitments and busy schedules. Therefore it is the policy to appoint members to the committee for one year. We expect that some individuals can and would be willing to serve additional terms. In addition, there are those who will be involved in some facet of the program which will make a continuing relationship with the committee an asset.

In consideration of the above, we expect to rotate the membership so that it will not be burdensome and so that other individuals who have expressed an interest in the program may have the opportunity to make a contribution. Even though the policy calls for one-year membership, we hope that approximately two-thirds of the committee members would be appointed to serve as experienced members. Using a staggered replacement rate of one-third per year, there will always be new members coming into the committee with experienced members providing the needed stability and leadership. When a term has expired, a new committee member will be appointed by the college.

3. Selection of Committee Members - Advisory Committee members must meet the criteria given previously. It is desirable that various professional organizations and labor and manufacturing organizations within the

area as well as faculty of the college feel free to offer nominations of potential advisory committee members. The final selection and approval of advisory committee members will be made by the college.

4. Selection of the Chairperson - The advisory committee will select from within its membership a chairperson who will preside over the meetings.

5 Duties of the Chairperson - The chief duty of the chairperson will be to preside over all SET Advisory Committee meetings. This person is expected to work closely with the college administration at all times and will be consulted when an agenda for a meeting is being prepared. Any subcommittees which are needed will be appointed by the chairperson who will represent the advisory committee when appropriate.

6. Who Represents the College - The SET coordinator at the college as well as the department chairpersons or other representatives of chemistry, English, industrial arts, mathematics, and physics will constitute the official school representatives at the meetings of the SET Advisory Committee.

7. Duties of the SET Coordinator - The SET Coordinator is present mainly to seek advice. The Coordinator in consultation with the Committee Chairperson will be responsible for the preparation of the agenda for each meeting. It is the responsibility of the chairperson and the coordinator to outline tasks to be accomplished

by the committee and to present items or problems needing action to the advisory committee for discussion and recommendation. Other duties of the Coordinator include reproduction of the minutes, notifying members of time and place of meetings, arranging for meeting rooms at the college, and preparing reports of progress.

8. Line of Communication - Copies of the minutes, including recommendations will be sent to the following:
(A) College Administration (Academic Vice President, Dean of Arts & Sciences, Dean of Instruction) (B) Department Chairpersons, (C) Members of the Advisory Committee, (D) Organizations represented by the committee members, and (E) SET national project director.

9. Number of Members of the Advisory Committee - In addition to the six college representatives it is hoped that the committee will have six occupational advisors from the industrial community. The membership should not exceed twelve persons.

10. Number of Advisory Committee Meetings - There will be no set pattern as to the number of meetings held by the advisory committee during the course of a year. The number of meetings called should depend upon the number of tasks that need to be accomplished. It may be possible to avoid calling numerous meetings by polling committee members via telephone or by mail questionnaires thereby reducing the number of times for holding an official meeting.

THE SCIENCE AND ENGINEERING TECHNICIAN CURRICULUM

1. The Objectives of the Science and Engineering Technician Curriculum.

The Science and Engineering Technician Curriculum is a two-year Associate Degree program which is designed to prepare technicians who are versatile and who may work at a variety of jobs. SET graduates will be able to acquire skills very quickly in a wide range of different jobs, and they may work in support of engineers or scientists in research and development, or test laboratories of industry, education or government. Their knowledge of modern electronic instrumentation will enable them to work in the application of electronic instrumentation and controls to many manufacturing and industrial processes. They will be familiar with instruments and apparatus used for measurement, detection, testing and control in research, development, or manufacturing. Graduates of the SET curriculum will know the basic concepts, definitions and principles of physics and chemistry and how these relate to real devices and systems in modern industrial technology. They will know the properties of a variety of different materials used in manufacturing, research, and engineering applications and methods of fabrication of these materials using modern machinery and techniques.

They will be able to read and interpret mechanical and electrical drawings and be able also to prepare rough but correctly detailed drawings and sketches. SET graduates will be able to organize and present technical reports clearly and systematically in written and oral form. Because Science and Engineering Technicians are broadly trained by physicists, chemists, and technical personnel in the vocational areas of the college working together to achieve the necessary interdisciplinary approach, they are particularly suited to the many positions which overlap the traditional fields of engineering and science, or fill positions which don't require the in depth training of the traditional engineering or science graduates.

2. The Curriculum at Fort Hays for the Science and Engineering Technician.

The Science and Engineering Technician Curriculum has courses in the technical specialities as well as in physics, chemistry, mathematics, English and the social sciences. The curriculum also provides a practicum where students can gain practical experience through supervised off-campus assignments in industry.

The following courses constitute the area of concentration for the Science and Engineering Technician for the Associate of Arts Degree.

Associate of Arts--Natural Science and Mathematics (Physics)

First Semester			Credits
Ind Arts	118	Metal Materials & Processes I	3
Math	363	*Intro to Computing Systems	3
Ind Arts	101	Visual Communication	3
Phys	111	*Physics I	5
+Math	110	*College Algebra	3
			17

Second Semester			
Ind Arts	114	Plastic Materials & Processes U	3
Phys	231	Electronics	3
Phys	112	Physics II	5
Engl	101	*English Composition I	3
+Math	122	Plane Trigonometry	3
			17

Third Semester			
Phys	232	Analog and Digital Electronics	2
Chem	120	*Intro to Chemistry	5
		*Technical Elective (1)	3
		*Gen. Ed. Elective (2)	3
Math	331	*Calculus Methods	3
			16

Fourth Semester			
Phys	233	Scientific & Industrial Instrumentation	2
Engl	246	*Technical & Report Writing	3

Fourth Semester Cont.			Credits
Speech	104	*Fund. of Interpersonal Communication	3
Chem	284	Selected Studies in Chemistry	3
Math	250	Elements of Statistics	3
		Applied Tech. Practicum	2
			16
		Total	66 hours

*Courses approved for General Education Credit

(1) Suggestions for the Technical Elective are:

Chem	580	*Scientific Approach for the Consumer
Ind Arts	119	Welding Materials and Processes I
Ind Arts	320	Sheet Metal
Ind Arts	330	Metal Materials and Processes II
Ind Arts	508	Liquid Resin Technology

(2) Third term General Ed. Electives:

Soc	140	*Intro to Sociology	3
His	100	*Heritage of Modern Man	3
Pol Sci	101	*American Government	3

+ Students who test out of College Algebra and Plane Trigonometry can take Pre-Calculus Mathematics (Math 130) in the first semester. These studer. will delay taking Introduction to Computing Systems (Math 363) until the second semester substituting it for Plane Trigonometry at that time. General Education

3. After Graduation.

With this degree the graduate may: (1) go to work as a technician; (2) continue at Fort Hays or transfer to another four-year college or university to work toward a four-year degree in science or engineering or technology; or (3) go to work as a technician while at the same time attending a four-year college or university to complete a four-year degree.

The Fort Hays State College SET Curriculum is designed so that students who deside to continue with a four-year program will be able to transfer most, if not all, of their course work. The SET Curriculum has a strong mathematics and science basis so that many transfer options are available for SET graduates.

Development of the Science and Engineering Technician Curriculum

The Science and Engineering Technician curriculum was developed with the support of a grant from the National Science Foundation in June of 1974. The project, under the directorship of Bill G. Aldridge, was to include the design of the curriculum and curriculum trials at several institutions of higher education across the United States. The total project consisted of one year of extensive planning and design conferences, two years of curriculum trials, and study guide preparation; and one year of evaluation and the finalization of study guides. Over 24 educators, 19 institutions of higher education, and 11 representatives from business, government and industry participated in the national project. This curriculum guide results from the four-year effort.

The basic curriculum was identified at national conferences in which representatives of business, industry and possible trial colleges participated.

First Curriculum Development Meeting, September 27-28, 1974.

1. Technician competencies were identified.
2. Ways of including on-the-job training were recommended.
3. Technical specialty courses were recommended.

Second Project Meeting, November 15-16, 1974.

1. Subject area distribution was determined for each trial college.
2. High school counselors were identified.
3. Potential employers were identified.
4. A general technician curriculum was proposed by each participating college.

Third Project Meeting, April 11-13, 1975.

1. Publicity and recruitment techniques were planned.
2. Study guides were planned.
3. Course descriptions were reviewed.
4. The curriculum was named--Science and Engineering Technology.

The college participants in these planning conferences were the following individuals.

Bussian, Alfred, Community College of Denver, Red Rocks Campus, Golden, CO
Davidson, Daniel, Pima College, Tucson, AZ
Davies, E. J., Metropolitan State College, Denver, CO
Dixon, Peggy, Montgomery College, Takoma Park, MD
Gosselin, Charles, Penn Valley Community College, Kansas City, MO
Heath, Elbert, Penn Valley Community College, Kansas City, MO
Holmes, Lonnie, Metropolitan State College, Denver, CO
King, Floyd, Richland College, Dallas, TX

Knowles, Jim, Mountain View College, Dallas, TX
Klos, Walter, Oregon Institute of Technology, Klamath Falls, OR
Kurtz, Earl, Oregon Institute of Technology, Klamath Falls, OR
Miller, Daniel, Forest Park Community College, St. Louis, MO
Murray, Robert, Meramec Community College, St. Louis, MO
Preston, Norman, Penn Valley Community College, Kansas City, MO
Schrautemeier, Bernard, Meramec Community College, St. Louis, MO
Sukle, Daniel, Community College of Denver-North Campus, Denver, CO
Wilson, Henry, Delaware Technical and Community College, Newark, DE

The Advisory Committee participants in the planning conferences were the following:

Avtgis, Alexander--Wentworth Institute, Boston, MA
Bickel, William--University of Arizona, Tucson, AZ
Chapman, Kenneth--American Chemical Society, Washington, D.C.
Fath, Jack--Eastern Standards Laboratory Division, Washington Navy Yard, Washington, D.C.
Grant, John--Stanford University, Palo Alto, CA
Haberstroh, Robert--College of the Virgin Islands, St. Croix, Virgin Islands
Jackson, T.A.--Florida A & M University, Tallahassee, FL
McWane, John--Massachusetts Institute of Technology, Cambridge, MA
Melonakis, Mathew--Adolph Coors Co., Golden, CO
Meyer, Richard--McDonnell Douglas Corp., St. Louis, MO
Nemecek, Joseph--Trans World Airlines, Kansas City, MO
Rogowski, Lavern--Ball Brothers Research Corp., Boulder, CO
Skilton, Ronald--General Electric Co., San Francisco, CA
Smith, James--Texas Instruments, Dallas, TX
Walton, William--Education Development Center, Newton, MA
Wolf, Clarence--McDonnell Douglas Corp., St. Louis, MO
Wolf, Lawrence J.--Wentworth Institute, Boston, MA
Wolff, Norman--VACTEC, Inc., St. Louis, MO
Woolf, Kenneth--Delaware County Community College, Media, PA

The following colleges evaluated the SET curriculum for adoption:

Community College of Alleghney County, South Campus, West Mifflin, PA
Community College of Denver, North Campus, Denver, CO
Community College of Denver, Red Rocks Campus, Denver, CO
Delaware Technical and Community College, Newark, DE
Durham Technical Institute, Durham, NC
Florissant Valley Community College, St. Louis, MO
Forest Park Community College, St. Louis, MO
Fort Hays Kansas State College, Hays, KS
Hudson Valley Community College, Troy, NY
Meramec Community College, St. Louis, MO
Metropolitan State College, Denver, CO
Modesto Community College, Modesto, CA
Montgomery College, Rockville, MD
Mountain View College, Dallas, TX
Muskegan Community College, Muskegan, MI

Penn Valley Community College, Kansas City, MO
Pima College, Tucson, AZ
Richland College, Dallas, TX

The colleges which conducted some curriculum trials are listed below.

Community College of Allegheny County, South Campus, West Mifflin, PA
Pearley Cunningham, Curriculum Coordinator
Community College of Denver, North Campus, Denver, CO
Daniel Sukle, Curriculum Coordinator
Community College of Denver, Red Rocks Campus, Denver, CO
Alfred Bussian, Curriculum Coordinator
Florissant Valley Community College, St. Louis, MO
Bill G. Aldridge and Donald R. Mowery, Curriculum Coordinators
Fort Hays Kansas State College, Hays, KS
Roger A. Pruitt, Curriculum Coordinator
Metropolitan State College, Denver, CO
E. J. Davies, Curriculum Coordinator
Modesto Community College, Modesto, CA
John Mudie and Leroy Holmes, Curriculum Coordinators
Montgomery College, Takoma Park, MD
Peggy Dixon, Curriculum Coordinator
Penn Valley Community College, Kansas City, MO
Norman Preston, Curriculum Coordinator
Pima College, Tucson, AZ
Daniel Davidson, Curriculum Coordinator
Richland College, Dallas, TX
Floyd King, Curriculum Coordinator

The colleges which have implemented the Science and Engineering Technician Curriculum as approved independent curricula are:
Community College of Allegheny County, South Campus, West Mifflin, PA
Pearley Cunningham, Curriculum Coordinator
Durham Technical Institute, Durham, NC
John Zunes, Curriculum Coordinator
Fort Hays Kansas State College, Hays, KS
Roger A. Pruitt, Curriculum Coordinator
Florissant Valley Community College, St. Louis, MO
Donald R. Mowery, Curriculum Coordinator

Three colleges which are offering the SET curriculum under the framework of a technician curriculum previously existing at those institutions:
Modesto Community College, Modesto, CA
John Mudie and Leroy Holmes

Montgomery College, Rockville, MD
Peggy Dixon

Pima College, Tucson, AZ
Daniel Davidson

APPENDIX IV

ALGEBRAIC AND TRIGONOMETRIC EQUATIONS WITH APPLICATIONS

I. Linear Equations in Two Unknowns
- Definition of Function--Function Notation
- Linear Equations in Two Unknowns
- The Rectangular Coordinate System
- Graph of a Linear Function in Two Unknowns
- Distance Between Two Points in the Plane
- Slope of a line
- Equations of a Line
- Direct Variation (Data Analysis)

II. Trigonometric Equations and Vectors
- Angles and Their Measure
- Conversion From One Angular Measure to Another
- The Trigonometric Functions
- Solving Right Triangles
- Applications of Radian Measure
- Vectors--Geometric Interpretation
- Vectors as Ordered Pairs
- Computer and Calculator Applications

III. Systems of Linear Equations
- Two Linear Equations in Two Unknowns
- Solution of a System by Graphing
- Solving a System by Elimination--Addition or Substitution Method
- Solving a System Using Determinants--Cramer's Rule
- Three Linear Equations in Three Unknowns
- Solving a System--Elimination Method--Cramer's Rule
- Computer and Calculator Applications

IV. Quadratic Equations
- Quadratic Functions in One Unknown
- Roots and Zeros
- Finding Zeros of a Quadratic Function

V. Complex Numbers--Imaginary Roots of Quadratic Equations
- Complex Numbers
- Operations Involving Complex Numbers
- Imaginary Solutions of Quadratic Equations

VI. Equations Containing Fractions
- Rational Expresssions
- Operations Involving Rational Expressions
- Solving Equations Containing Fractions

VII. Exponential and Logarithmic Equations
- Exponential Form--Laws of Exponents
- Zero, Negative, and Fractional Exponents
- The Exponential Function $y = b^x$
- Logarithms--Properties of Logarithms
- Application of Logarithms--Solving Exponential Equations
- The Logarithmic Function

ANALOG AND DIGITAL ELECTRONICS

I. Diodes

- Definition
- Power Diodes
- Electro-optical Devices
- Thyristors
- Zener Diodes
- Varactor Diodes

II. Transistors

- Introduction
- Bipolar Transistors
- Field Effect Transistors

III. Regulated Power Supplies

IV. Oscillators

- Introduction
- Wein Bridge Oscillator
- Crystal Oscillator
- Multivibrators
- Waveform Generators

V. Filter Circuits

- Low-Pass Filters
- High-Pass Filters
- Band-Pass Filters
- Integrators and Differentiators

VI. Digital Concepts

- Introduction
- Switching Circuits
- Combinational Logic
- Truth Tables

VII. Digital Electronic Circuits

- Logic Gate Symbols
- Timing Diagrams
- Integrated Circuits

VIII. Combinational Logic

- Truth Tables
- Circuit Synthesis and Analysis
- Boolean Algebra

IX. Binary Arithmetic

- Binary Numbers
- Complemented Numbers

CHEMICAL SCIENCE AND TECHNOLOGY I

I. Chemical Laboratory Safety and Practices

On the Prevention of Explosions, Fires and Great Bodily Harm
Chemistry Laboratory Glassware, Hardware, and Beware
Burners, Ovens, and Other Hot Things
Pressure, Pressure Everywhere
The Laboratory Notebook Versus the Paper Towel

II. Atomic Structure

Atoms, Elements and Atomic Weights
The Mole Concept
The Periodic Table

III. Inorganic Chemistry

Electronegativity
Electron-Dot Structures
Naming Inorganic Compounds

IV. Nuclear Chemistry

Fission and Fusion
Types of Radiation
Rate of Radioactive Decay

V. Organic Chemistry

Aliphatic Hydrocarbons
Aromatic Hydrocarbons
Functional Groups

CHEMICAL SCIENCE AND TECHNOLOGY II

I. Solutions and Concentrations

Concentration Expressions
pH

II. Chemical Equations

Balancing Chemical Equations
Stoichiometry
Theoretical and Actual Yields
Limiting Reagent

III. Electrochemistry

The Galvanic Cell
The Corrosion of Iron and Steel
Galvanic Corrosion
Applied Electrochemistry
Corrosion Control and Prevention

IV. Gas Laws

Gas Pressure
The Ideal Gas Law

V. Organic Materials

Chemistry of Plastics
Selection of Plastics
Elastomers
Adhesives

COMPUTER AND CALCULATOR TECHNIQUES

I. Hand-held Electronic Calculators

History and Principles
Four Function Calculators
Scientific Calculators
Calculator Errors
Estimation
Significant Figures
Problems for the Expert

II. Programmable Electronic Calculators

Introduction
Registers
Instructions Found Only on Programmable Calculators
Programming
From Algorithms to Finished Programs

III. Computers

Introduction
Batch Processing
The Interactive Terminal
Programming Language
BASIC Language

DIFFERENTIAL AND INTEGRAL CALCULUS

I. Instantaneous Rate of Change

Limit--Limit Notation
Instantaneous Rate of Change

II. The Derivative

The Derivative of a Function
Differentiation Formulas
Higher Order Derivatives--Implicit Differentiation

III. Applications of the Derivative

Tangent and Normal Lines
Related Rates
Applications Involving Maximum or Minimum Function Values

IV. Antidifferentiation--The Indefinite Integral

Using Differentials to Approximate Errors
Antidifferentiation

V. The Definite Integral

Finding Areas by Integration--The Definite Integral
Approximating the Definite Integral--Trapezoidal Rule

ELECTRONIC COMPONENTS, TRANSDUCERS, AND BASIC CIRCUITS

I. Basic Electrical Quantities

II. Test Instruments

III. Resistors and Resistance Circuits
    DC and AC Characteristics
    Series and Parallel Circuits
    Voltage Dividers
    Kirchoff's Laws

IV. Operational Amplifier
    The Op-Amp
    Inverting Amplifier
    Non-Inverting Amplifier
    AC Characteristics

V. Bridge Circuits
    DC Bridge
    AC Bridge

VI. Temperature Transducers
    Resistance Thermometer
    Thermistors
    Thermocouples
    Applications

VII. Power Amplifier
    Transistor Basics
    Power Amplifier

VIII. Recorders
    Chart Recorders
    X-Y Recorders

IX. Strain Gauge

X. Light Transducers
    Photoemissive Tubes
    Photovoltaic Cells
    Photoconductive Cells

XI. Sound Transducers
    Crystal Microphone
    Loudspeaker

XII. Linear Variable Differential Transformer

XIII. Differential Amplifier

FUNCTIONS, ANALYTIC GEOMETRY, PROBABILITY AND STATISTICS

I. Variation
   Direct Variation
   Inverse Variation
   Joint Variation

II. Polynomial Equations of Higher Degree
   Polynomial Functions in One Variable
   Roots and Zeros
   The Graph of a Polynomial Function
   The Remainder Theorem and Synthetic Division
   The Factor Theorem
   Roots of Higher Degree Polynomial Equations
   Irrational Roots of Polynomial Equations

III. Analytic Geometry
   Linear Equation in Two Unknowns--The Line
   Distance Between Two Points and Slope of a Line
   Equations of a Line
   The Circle
   The Parabola
   The Ellipse
   The Hyperbola

IV. Graphs of the Trigonometric Functions
   Graphs of $y = a \cdot \sin b\theta$ and $y = a \cdot \cos b\theta$
   Graphs of $y = a \cdot \sin (b\theta + c)$ and $y = a \cdot \cos (b\theta + c)$
   Graphs of $y = \tan \theta$, $y = \cot \theta$, $y = \sec \theta$, $y = \csc \theta$

V. Counting and Probability
   Counting: The Multiplication Principle
   Counting: The Addition Principle
   The Multiplication and Addition Principles Together
   Pwrmutations and Combinations
   Mathematical Probability
   Empirical Probability

VI. Statistics--Curve Fitting
   Tabulation of Data
   Mean, Median, Mode
   Standard Deviation
   Curve Fitting--Linear Empirical Equation

ELECTRONIC INSTRUMENTATION

I. Instrumentation Systems

- Introduction
- Classification of Instruments
- Basic Building Blocks
- The Total Instrument/Instrumented System

II. Basic Laboratory Instruments

- Function (Signal) Generator
- Frequency Meter/Interval Timer
- The Voltmeter
- Ammeter
- Oscilloscopes
- Measurement of Passive Components

III. Other Sensing and Measuring Instruments

- Integrated Circuits as the Basic Instrument Building Block
- A Look at the Basic Instrument
- Processors
- Input
- Output

IV. Power Supplies

- Introduction
- Voltage and Current Generator Theory
- Voltage Regulated Power Supply
- Other Power Supplies
- DC-AC and DC-DC Conversion
- Despiking, Filtering and System Considerations
- Surge Suppression
- Environmental Factors

V. Instrumentation

- Coupling Requirements
- Instrumentation Systems
- Noise in Measurement Systems

MATERIALS AND FABRICATION METHODS I

I. Measurements
   - Metric Units (SI) and English Units
   - Measuring Instruments
     - Length--Vernier Calipers, Scales and Tapes
       - Dial Indicators
     - Angle Measurement
     - Speeds and Feed Rate
   - Layout, Radius, and Hole Gauges

II. Electrical Fabrication
   - Symbols and Schematics
   - Components
   - Wiring Types and Identification
   - Soldering
   - Circuit Fabrication
   - Instrumentation Wiring

III. Hand Tools
   - Safety
   - Vises and Gripping Tools
   - Material Removing Tool
   - Punches and Chisels and Impact Tools
   - Drills and Reamers
   - Threads and Fasteners

IV. Power Hand Tools
   - Safety
   - Hand-held Drill Motors
   - Saber and Power Saws
   - Staplers and Power Riveting
   - Routers
   - Sanders and Grinders
   - Impact Tools

V. Power Bench Tools
   - Safety
   - Drill Press
   - Grinder
   - Band Saw
   - Table Saws

VI. Metal Fabrication
   - Safety
   - Shearing and Punching
   - Braking and Rolling
   - Spot Welding and Soldering
   - Fasteners
   - Bonding and Cementing

MATERIALS AND FABRICATION METHODS II

I. Welding, Soldering and Brazing
   - Introduction
   - Arc Welding
   - Gas Welding
   - Brazing
   - Oxygen-Acetylene Torch Cutting
   - Silver Soldering

II. Plastics Fabrication
   - Types, Properties and Identification
   - Safety
   - Machining, Fasterners, Bonding, Forming and Molding

III. Tubing and Piping Fabrication
   - Introduction
   - Symbols and Schematics
   - Components
   - Tubing Systems
   - Soldering and Bonding of Copper, Steel and Plastic Pipe Tubing Systems
   - Gaskets and Seals

IV. Materials' Properties and Testing
   - Material Properties and Tests
   - Selection and Ordering of Materials

V. Heat Treating
   - Introduction
   - Hardness Testing
   - Strain Hardening and Annealing
   - Alloying and Crystal Structure
   - Quench Hardening of Ferrous Metals

VI. Finishes
   - Types and Identification
   - Application
   - Surface Preparation
   - Paints, Lacquers, Varnishes and Primers
   - Identification and Uses of Plating

ORGANIZATION AND EXPRESSION IN WRITING

I. Reading Efficiently
   Scanning
   Skimming
   Reading for Comprehension
   Reading Specialized Material

II. Use of the Library and Its Resources
   Kinds of Resources Available
   Organization of Library Facilities and Resources

III. Principles of Organization
   Planning
   Writing the Thesis Statement
   Choosing the Organizational Pattern

IV. Writing the Summary
   Basic Types of Summaries
   Writing the Summary

V. Writing and Reading Definitions
   Definition and Examples
   Writing the Definition
   Reading Definitions

VI. Explaining a Process
   Definition
   Method of Writing the Process Paper

VII. Classification
   Definition and Examples
   Writing the Classification Paper
   The Outline

VIII. Comparison and Contrast
   Definition of Comparison and Contrast
   Writing the Comparison/Contrast Paper

IX. Diction
   Definition
   General Principles and Examples

X. The Paragraph
   Definitions and Examples

XI. Coherence
   Definition

PHYSICS OF ELECTROMAGNETIC OPTICAL AND SOLID STATE SYSTEMS

I. Electromagnetism
   - DC Circuits
   - Electrostatics
   - Magnetism I (Magnetic Induction Field)
   - Magnetism II (Magnetic Forces)
   - Basic Measuring Instruments
   - Electromagnetic Induction; Self and Mutual Inductance
   - AC Circuits

II. Optics
   - Electromagnetic Waves
   - Basic Geometrical Optics
   - Optical Instruments
   - Physical Optics
   - Photometry
   - Quantum Optics

III. Solid-State and Nuclear Physics
   - Atomic Structure and Solid State Physics
   - Nuclear Physics

PHYSICS OF MECHANICAL GASEOUS AND FLUID SYSTEMS

I. Basic Concepts
- Length and Time
- Mass and Weight
- Measurement and Error; Accuracy; Precison
- Basic Electrical Concepts

II. Translational Motion
- Distance
- Speed and Velocity
- Acceleration
- Linear Momentus and Its Conservation
- Newton's Laws of Motion: Gravitation
- Work; Energy; Power

III. Rotational Motion
- Centripetal Force
- Rotational Angle, Velocity, Acceleration
- Torque and Static Equilibrium
- Moment of Inertia; Rotational Energy

IV. Temperature and Heat
- Temperature Scales and Measurements
- Specific Heat
- Transfer of Heat

V. Properties of Gases and Liquids
- Density, Specific Gravity, Archimedes Principle
- Phase Changes
- Pressure and Its Measurement
- Gas Laws
- Hydrodynamics

VI. Sound and Wave Motion
- Basic Wave Properties
- Superposition, Standing Waves, and Harmonics
- Sound Power, Intensity, and Decibels

SCIENCE AND ENGINEERING GRAPHICS

I. Introductory Topics
   Lettering
   Use of Equipment

II. Geometrical Construction
   Basic Applied Geometry

III. Sketching and Shape Description
   Sketching Materials and [illegible] Technique
   Isometric Sketching

IV. Multiview Projection
   Theory of Projection
   Instrument Drawing

V. Auxiliary Views
   Primary Auxiliary Views

VI. Sectional Views
   Cutting Planes, Section Lining, Full and Half Sections
   Other Types of Sectioned Views

VII. Basic Dimensioning
   Means for Specifying Dimensions
   Standard Methods of Dimensioning [illegible]
   Special Dimensioning Notes and Symbols
   Tolerancing

VIII. Electrical and Electronic Drafting
   Block Diagrams
   Connection Diagrams [illegible]
   Schematic Diagrams
   Logic Diagrams, Integrated Circuits, Printed Circuits

IX. Welding Drawing
   Processes, Joints, and Symbols

X. Pipe Drawing
   Joints, Fittings, and Valves
   Single-Line and Double-Line Drawing

XI. Charts and Graphs
   Rectangular Line Charts
   [illegible] Logarithmic [illegible]