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Water and Wastewater Technology; A Suggested 2-Year Post High School Curriculum.

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This curriculum guide with accompanying course outlines was developed by technical education specialists for teacher use in conducting courses of instruction for the preparation of water and wastewater technicians. The content objectives are to provide students with a background of knowledge in the diverse areas of applied sanitation which relate to water and wastewater: a foundation in microbiology and basic hydraulics, sanitary chemistry and biology, water supply and wastewater collection, water purification, wastewater treatment, and water pollution control. The material is to be used over a 2-year period of systematic instruction at the post secondary level of education. Teachers of sanitation subjects must have special competencies derived from training in technical subject matter, practice, and instructional experience. Students should be high school graduates with reasonable maturity and seriousness of purpose and whose educational backgrounds include chemistry, physics, and mathematics, including algebra and geometry. In addition to a 265-entry bibliography of text and references, information on technical education procedure, facilities, equipment and cost, and scientific and technical societies is included. (CH)

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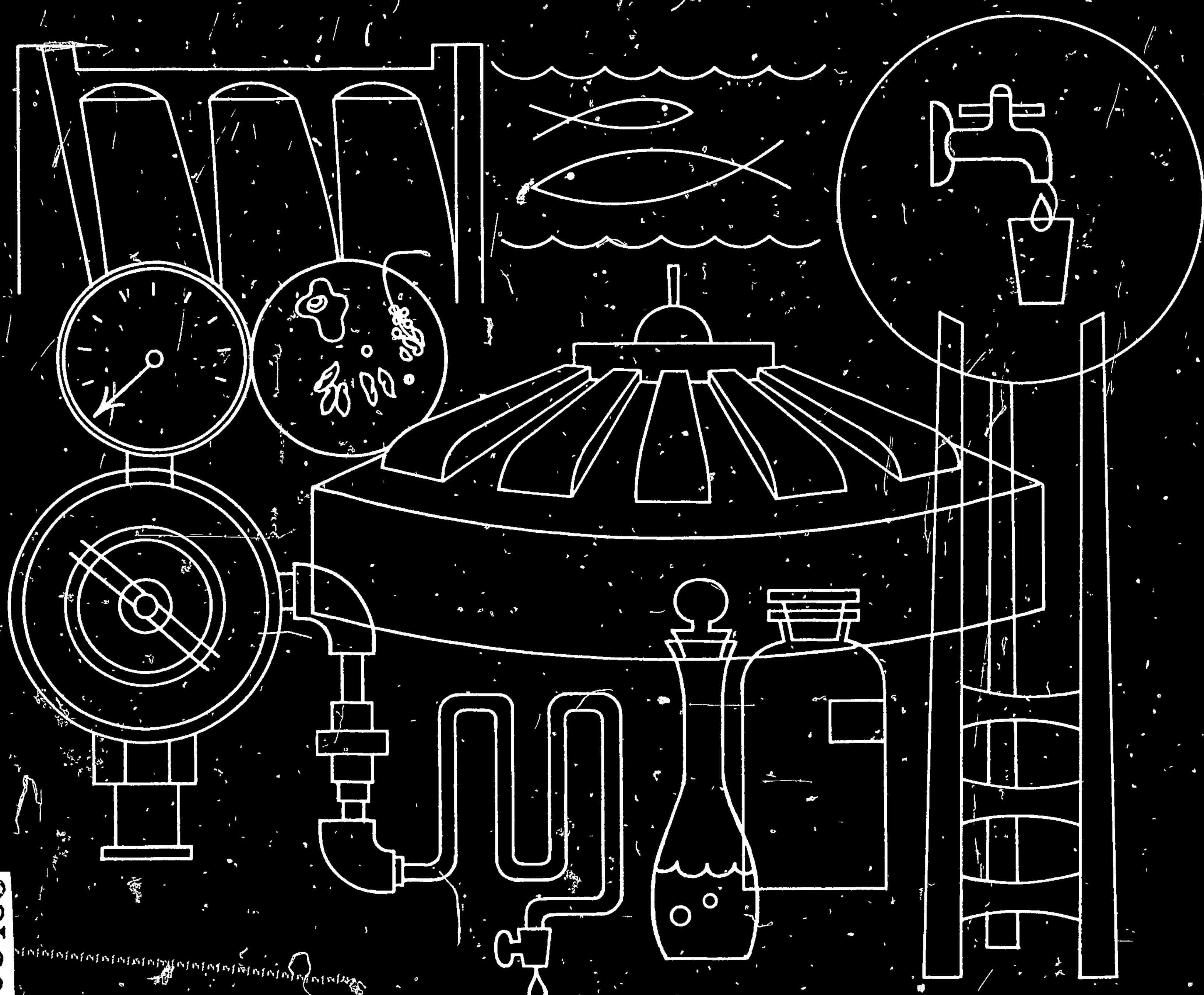
TECHNICAL EDUCATION PROGRAM SERIES NO. 11

Water and Wastewater Technology

A Suggested 2-Year Post High School Curriculum



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Technical Education Program Series No. 11 OE-80057

WATER AND WASTEWATER TECHNOLOGY

A Suggested 2-Year Post High School Curriculum

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION

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FOREWORD

THE NEED for trained personnel in the clean water field has reached an all time high, and is rapidly outstripping available training resources.

Under the stimulus of grants provided by State and Federal governments, the expenditure for construction of municipal waste treatment plants has been accelerated. Treatment plants have grown larger and more complex, requiring additional and more highly trained operating staffs. Moreover, from all indications, industry, too, will greatly expand water pollution control programs in order to meet the requirements of the Water Quality Act of 1965. Without trained personnel, even the most sophisticated waste treatment plant will fail to yield its full potential in improved water quality. It is estimated that approximately 28,000 technicians will need training in wastewater technology within the next 5 years.

The Federal Water Pollution Control Administration is the Federal agency responsible for assuring adequate amounts of clean water for this Nation, and thus has an important role in helping to provide the required manpower for the water pollution control field at Federal, State, and local levels.

In developing programs for technician education, the Federal Water Pollution Control Administration has found need of a sound, comprehensive curriculum that could be adapted to local requirements. *Water and Wastewater Technology* is a response to that need. This publication will prove to be a valuable tool in initiating technician programs at State and local levels. Such programs will need to be revised periodically to keep abreast of ever-improving water technology.

The Federal Water Pollution Control Administration is pleased to collaborate with the U.S. Department of Health, Education, and Welfare, Office of Education, to provide this suggested guide to programs in the highly critical field of wastewater technology.

JOE G. MOORE, JR., *Commissioner*
Federal Water Pollution Control Administration

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PREFACE

TO HELP vocational educators and other interested persons and agencies to plan urgently needed water and wastewater technology programs, or evaluate existing ones, this publication offers a suggested 2-year post high school curriculum and course outlines. There is also information on technical education procedure, facilities, equipment and costs, texts and references, and scientific and technical societies.

Persons who master the full-time, preparatory program can serve as assistants to engineers, scientists, and public health personnel concerned with water supply development and distribution, and with wastewater collection and treatment to abate and prevent pollution. Although the indicated level of instruction is post high school, the sequence of course work may start at any grade level if students have the prerequisite background.

This publication was developed by technical education specialists in the Division of Vocational and Technical Education, U.S. Office of Education, from materials prepared, under contract, by the Fayetteville Technical Institute, Fayetteville, N.C. In view of the publication's intended use, it should not be inferred that the suggested curriculum is completely endorsed by any one institution, agency, or person. It is a plan for a program; a plan to be modified by administrators and their advisors to meet local, State, and regional needs.

GRANT VENN
Associate Commissioner for Adult, Vocational, and Library Programs

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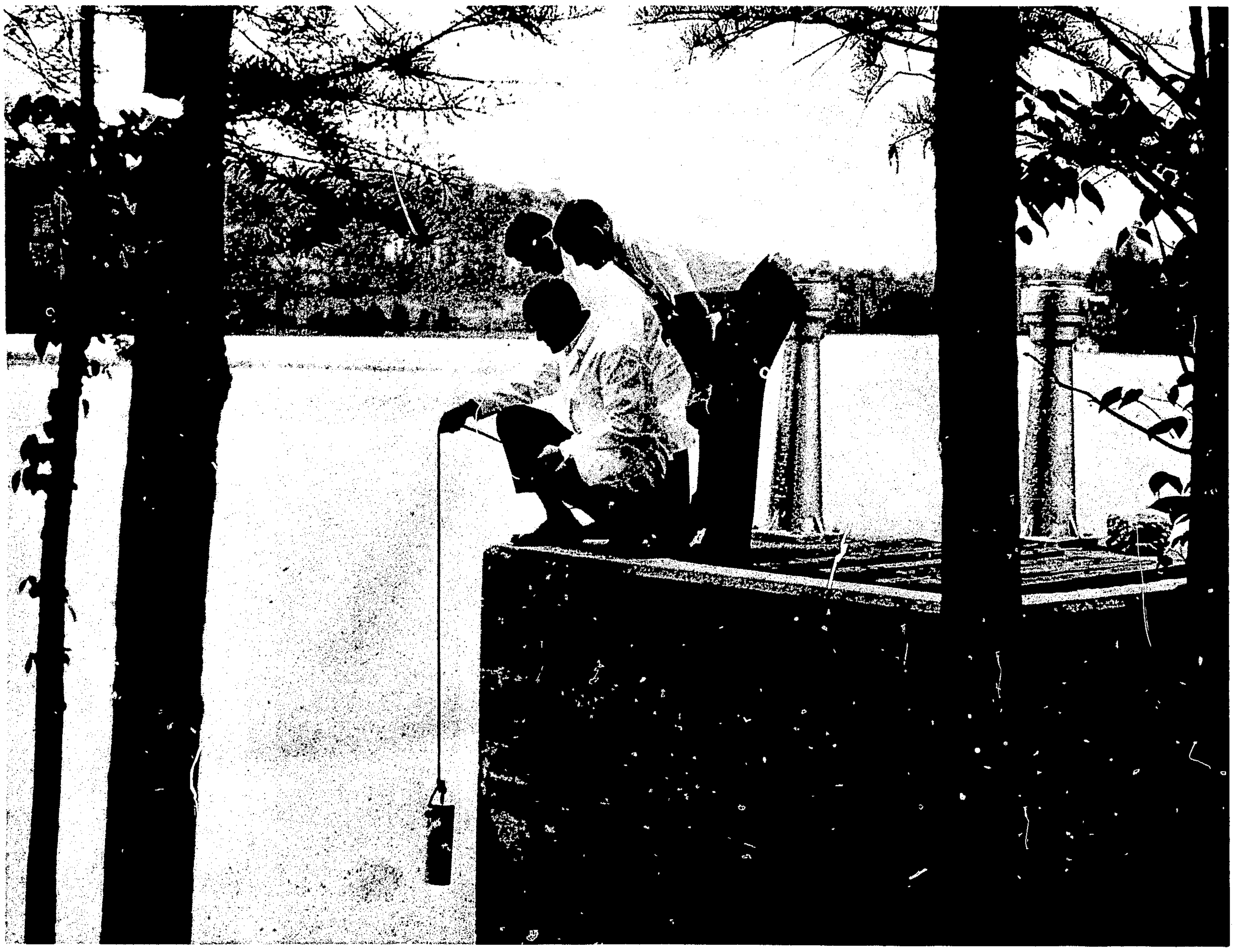
THE WATER AND WASTEWATER TECHNOLOGY PROGRAM

IN 1945, 169 billion gallons of water were used daily in the United States. In 1966 approximately 360 billion gallons were used each day, and it is estimated that 600 billion gallons per day will be used in 1980. Theoretically, with proper storage and conservation, the maximum daily supply of fresh water for the United States can be only 650 billion gallons. In practice this supply seldom can be stored in the right amounts and in the right places. At the present time, the waters of the Ohio River are reused almost twice before reaching the Mississippi; the Mahoning's waters, in Pennsylvania, are reused eight times before reaching the Ohio at Youngstown.

Small amounts of industrial wastes have destroyed aquatic life along several hundred miles of river. Many types of industrial wastes cannot even be detected by ordinary methods. *Adequate treatment methods for some pollutants have not been developed.* The present crisis in water will become worse because of the increasing water shortages in various areas, population and urban growth, and continued pollution of the Nation's waterways.

Increased research, more sophisticated and complicated systems for water purification and distribution, and more and complex sewage-handling and disposal systems point to the growing demand for highly trained personnel who can analyze,

FIGURE 1—*Water and wastewater technicians apply modern technology to conserve and develop the Nation's water resources.*



operate, and control public, private, or industrial water facilities and perform other related duties. Their work is to maintain clean, safe water in behalf of the health and well-being of our country's communities.

Mounting concern about pollution of the Nation's water resources led to the establishment of the Federal Water Pollution Control Commission Administration on May 9, 1966, and expansion of the functions of Federal, State, and local water pollution control agencies.

The impact of applied technological developments and changes in the field of water and wastewater treatment and the magnitude of the waste and trash-disposal problem have created the need for competent support personnel at the technician level. The technicians assist researchers, public health guardians, and plant operators. They may develop competency for other responsible positions in the general field of water usage and public health.

The water and wastewater technician can function as a member of the team engaged in research or pilot plant development and operation; as an operator or assistant operator of water purification or wastewater-treatment facilities; as a member of the public health team; or as an assistant in designing operational facilities.

The growing concern about the pollution of our watercourses, the complexity of various pollutants, and the mounting problems of providing properly treated waters for our daily use have caused the more frequent use of the general terms "domestic wastewater" and "industrial wastewater," instead of "sewage" and "industrial waste." This change in terminology is reflected in the revised titles of the "Standard Methods" manual:

> "Standard Methods of Water Analysis," 1899, 1912, 1917, 1920, 1923.
>
> "Standard Methods for the Examination of Water and Sewage," 1925, 1933, 1936, 1946.
>
> "Standard Methods for the Examination of Water, Sewage, and Industrial Waste," 1955.
>
> "Standard Methods for the Examination of Water and Wastewater," 11th Ed., 1960; 12th Ed., 1965. (Note that "sewage" does not occur in the latest title.)

"Sewage," "industrial waste," and "wastewater" are used interchangeably in this publication, although precise definitions are supplied at appropriate places in the various courses. The term "wastewater," in accepted usage, means used water which contains waste materials because of its use. Wastewater originating predominately from habitations is termed "domestic wastewater," and that originating from industrial operations is termed "industrial wastewater."

GENERAL CONSIDERATIONS

The objective of the total curriculum recommended in this guide is to train competent water and wastewater technicians. They must be capable of working and communicating directly with engineers, scientists, and other personnel; of performing satisfactorily for employers, and of growing into more responsible positions. In addition, graduate technicians should possess acceptable personal attitudes and be well-informed, active members of society.

A curriculum that will produce, when mastered, the type of technician described must be carefully designed. Each course must be planned to develop the student's knowledge and skill in a particular area and still be directly integrated into the whole curriculum. The sequence of courses is specially constructed so that each course in the sequence contributes toward the objective of educating competent technicians. If a close correlation of courses is not maintained, the curriculum will not provide the depth of understanding required of modern water and wastewater technicians.

The curriculum's technical content is intended to supply the student with a background of knowledge in the diverse areas of applied sanitation which relate to water and wastewater. It offers a firm foundation in microbiology and basic hydraulics during the first year. The second year builds directly on this background but introduces material from many subject areas, such as sanitary chemistry and biology, water supply and wastewater collection, water purification, wastewater treatment, and water pollution control. The methods used for analysis and control gradually become more sophisticated as the student progresses.

Graduates of this curriculum can expect to find employment in many areas of the sanitation, public health, and physical facilities operation. Each of these areas may require different abilities and variations in specialized knowledge and skills for a successful career. Most of these abilities will be developed by continued study on the job or part-time study. Listed below are some of the major areas or clusters of job opportunities for water and wastewater technicians, as described by employers:

1. *Research and Development Technician:* A technician working directly with engineers and scientists in developing new devices or processes or in doing basic research.
2. *Sales and Service Technician:* A technician representing a company and its products, dealing directly with the customer. He advises the customer, and is capable of installing and operating equipment, of trouble shooting, and of training the customer's personnel to service and maintain the equipment.
3. *Plant Operator:* A technician working as a water purification plant operator or wastewater treatment plant operator, for a municipal, industrial, or private facility.
4. *Regulatory Technician:* A technician working for a local, State, or Federal agency which has regulatory responsibilities in the field of water sanitation and public health. The technician's responsibilities would include such duties as stream monitoring and water and wastewater sampling, analysis, and control.
5. *Design and Construction Technician:* A technician working for consulting engineers or contractors, assisting with the design or construction of water distribution or treatment plants and wastewater collection systems or treatment plants.

Examples of *work titles* in various clusters of employment opportunities in the water and wastewater field are:

1. Public health engineering aide
2. Sanitarian aide
3. Water and waste treatment plant operator
4. Stream sanitation technician
5. Technical sales and service representative

Highly skilled technicians must be capable of working closely with engineers and scientists and of supervising and coordinating the efforts of skilled craftsmen and workmen.

Although many technical schools and some comprehensive high schools provide technical and related vocational education programs, technician education programs generally are designed for

2 years of intensive study at the post high school level. This type of program is concerned primarily with producing highly specialized and qualified workers who can perform many tasks which require special skills, and who are near professional in education, attitude, and competence. Therefore, the 2-year program provides a carefully structured, rigorous study of applied scientific principles and supporting mathematics. In addition, intensive laboratory-oriented instruction is coordinated with classroom study to provide application of (1) scientific principles being learned; (2) materials, apparatuses, and techniques commonly used in the technology; and (3) oral and written communication skills essential to the technician who, as an assistant or delegate, works with the engineer or scientist engaged in research, development, or production, or doing scientific or medical service work.

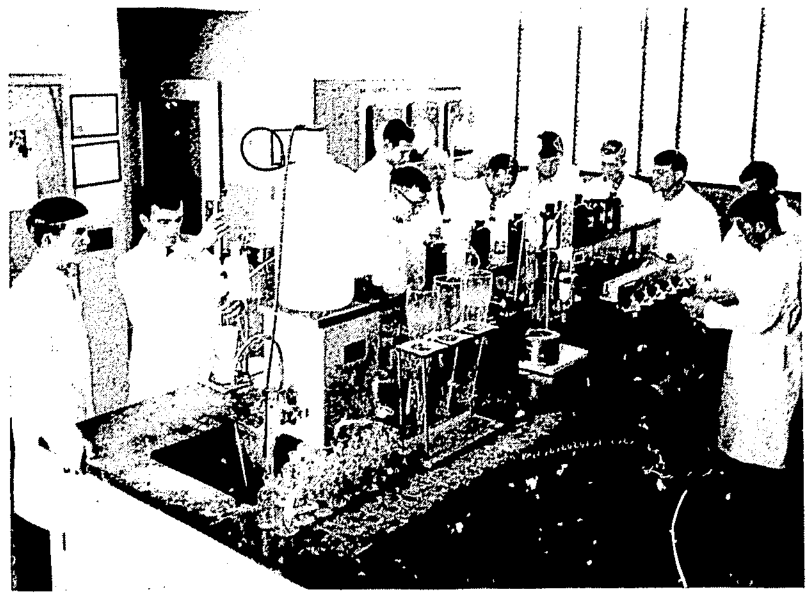


FIGURE 2—*Making precise measurements and analysis by using sophisticated scientific methods and apparatuses is part of the technician's work. These students are determining the amount of an impurity in wastewater by titration.*

Abilities and Activities Required of Technicians

The following analysis of the special scientific-technical abilities and work capabilities required of technicians in several related fields and specialized occupations will give some indication of the special nature of postsecondary, technician-education programs.

Special abilities [1] required of technicians are as follows:

1. Proficiency in using the scientific method to apply the basic principles, concepts, and laws of physics and chemistry, and/or the biological sciences, to the individual's field of technology.
2. Facility with mathematics; ability to use algebra and trigonometry as tools to develop, define, or to quantify scientific phenomena or principles; and an understanding of, though not necessarily facility with, higher mathematics through analytic geometry, calculus, and differential equations, according to the requirements of the technology.
3. A thorough understanding of the materials, processes, equipment, and techniques commonly used in the technology.
4. An extensive knowledge of a field of specialization, with an understanding of the underlying physical or biological sciences and their application to the engineering, health, agricultural, or industrial processing or research activities that distinguish the technology of the field. The degree of competency and the depth of understanding should be sufficient to enable the individual to establish rapport with the scientists, doctors, managers, researchers, or engineers with whom he works, and to enable him to perform a variety of detailed scientific or technical work using general procedures or instructions but requiring individual judgment, initiative, and resourcefulness in the use of techniques, handbook information, and recorded scientific data.
5. Communication skills that include the ability to record, analyze, interpret, and transmit facts and ideas orally, graphically, and in writing with complete objectivity.

Work activities [2] required of technicians, some combinations of which any technician must be prepared to perform, are as follows:

1. Applies knowledge of science and mathematics extensively in rendering direct technical assistance to physical and/or biological scientists, or engineers or medical personnel

[1] Adapted from *Occupational Criteria and Preparatory Curriculum Patterns in Technical Education Programs*, OE-80015. U.S. Department of Health, Education, and Welfare, Office of Education (Washington: U.S. Government Printing Office, 1962).

[2] *Ibid.*

engaged in scientific research and experimentation.

2. Designs, develops, or plans modifications of new products and techniques or processes under the supervision of scientific, engineering, or medical personnel in applied research, design, and development.
3. Plans, supervises, or assists in installation; and inspects complex scientific apparatus, operation equipment, and control systems.
4. Advises regarding the operation, maintenance, and repair of complex equipment with extensive control systems.
5. Plans production as a member of the management unit responsible for efficient use of money, manpower, materials, and equipment in mass production or in routine technical services.
6. Advises, plans, and estimates costs as a field representative of a manufacturer or distributor of technical equipment and/or products, or services.
7. Assumes responsibility for performance or tests of mechanical, hydraulic, pneumatic, electrical, or electronic components or systems in the physical sciences; and/or for determinations, tests and/or analyses of substances in the physical, agricultural, biological, or medical or health-related sciences, and the preparation of appropriate technical reports covering the tests.
8. Prepares or interprets engineering drawings and sketches, or writes detailed scientific specifications or procedures for work related to the physical and/or biological sciences.
9. Selects, compiles, and uses technical information from references such as engineering standards, handbooks, biological, agricultural, or medical and health-related procedural outlines; and technical digests of research findings.
10. Analyzes and interprets information obtained from precision measuring and recording instruments and/or from special procedures and techniques, and makes evaluations upon which technical decisions are based.
11. Analyzes and diagnoses technical problems that involve independent decisions. Judgment requires, in addition to technical know-how, substantive experience in the occupational field.
12. Deals with a variety of technical problems involving many factors and variables which require an understanding of several technical fields. This versatility is a characteristic that relates to breadth of understanding applied scientific and technical principles, the antithesis of narrow specialization.

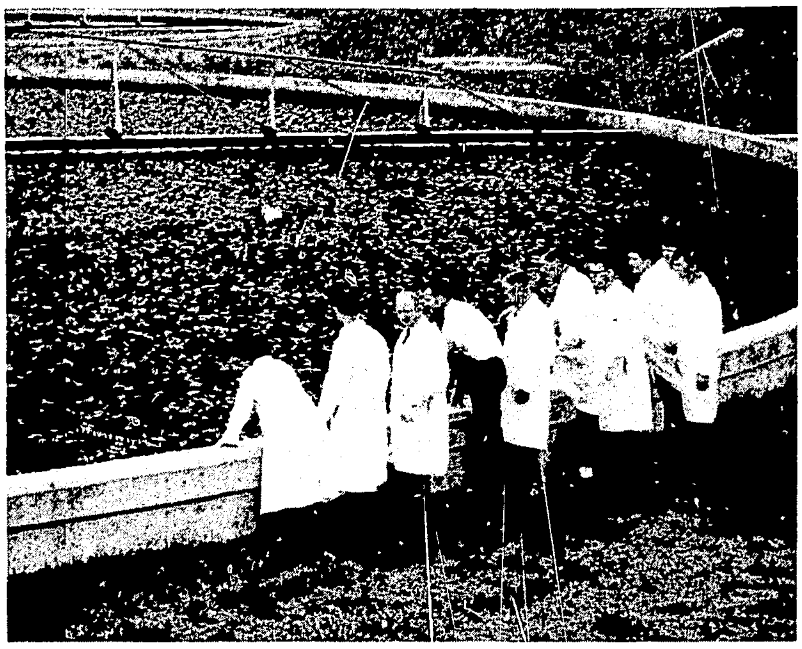


FIGURE 3—*Water and wastewater technicians must understand the mechanical operation and scientific principles of a wastewater treating unit, such as this one in a municipal wastewater treating plant.*

A 2-year curriculum must concentrate on primary or fundamental needs if it is to prepare individuals for responsible technical positions in modern industry. It must be realistic and practical in its approach. *The suggested curriculum outlined in this bulletin is designed to provide maximum technical instruction in the time that is scheduled.*

To those who are not familiar with this type of educational program, or with the goals and interests of students who elect it, a technical curriculum often seems to be inordinately rigid and restrictive. While modifications may be necessary to meet local needs or the objectives of certain institutions, the basic structure and content of this suggested curriculum should be maintained.

The specialized technical courses are laboratory-oriented. They provide application of the scientific principles concurrently being learned in physics, mathematics, chemistry, and microbiology. *For this reason, mathematics and science courses must be coordinated carefully with technical courses at all stages of the program.* This coordination is accomplished by a concurrent scheduling of these courses during the first two semesters, a curriculum principle that will be illustrated at several points. General education courses constitute a relatively small part of the total curriculum. Experience shows that students who enter a technical program do so because of the depth of specialization that the program provides, and that many students who elect this type of program will bring to it a background of general study.

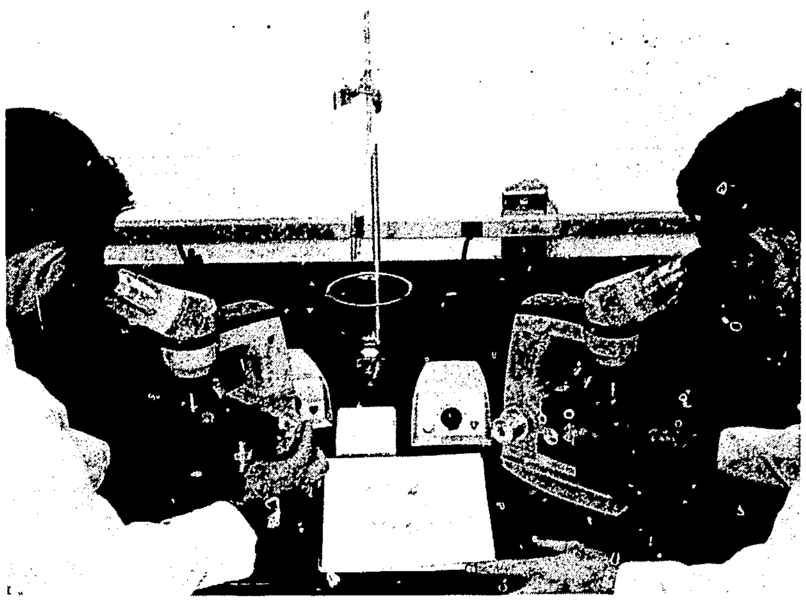


FIGURE 4—*The technician must understand microbiology and the roles played by microorganisms in water and wastewater.*

Faculty

The effectiveness of the curriculum depends largely upon the competence and the enthusiasm of the teaching staff. Teachers of sanitation subjects must have special competencies derived from training in technical subject matter, practice, and industrial experience. In addition, all members of the faculty must understand the educational philosophy, goals, and requirements that characterize this phase of technical education.

For added effectiveness, faculty members must have interests and capabilities beyond their area of specialization. All staff members should be well oriented as to the study requirements for and applications in sanitary science and engineering, so that they may use field examples or subject matter as supporting material in their teaching. For example, if the courses in water supply and wastewater collection are to be of maximum value, the teacher must be familiar with the construction problems and demands placed on technical personnel. Similarly, various scientific principles taught in physics, mathematics, and microbiology require instructors to emphasize and illustrate the application of these principles in design and in operations control.

Teachers of specialized technical subjects must have advanced technical training. Many of these teachers have been recruited from the ranks of the engineering profession. Engineering graduates who have acquired industrial experience and have continued their technical education often become excellent teachers of specialized technical subjects. Persons with this background are more likely to understand the program's objectives and instructional requirements and appreciate the importance of technical education, characteristics essential to the success of any educational program.

Technical education programs must be presented as a series of well-integrated courses if the scope and depth of training is to be adequate. Therefore, careful consideration must be given to determining when a new concept should be introduced and at what level. This may be accomplished through "team teaching," which, in this case, means the organization of a technical staff into a coordinated teaching unit. Teaching assignments are made according to each instructor's special training and talents. Concurrent courses are closely coordinated by team members so that the student's time is used profitably as he progresses to higher levels of understanding.

Team teaching can be developed and nourished only by the teaching staff. A weekly departmental staff meeting to encourage the development of team teaching is recommended, at which each instructor should check with instructors of concurrent courses to insure that course coordination is being maintained. This procedure is especially important when new courses or techniques are involved so that if optimum coordination is lacking the deterrents can be analyzed and efforts made to resolve the problems.

In addition to helping keep concurrent courses well coordinated, staff meetings provide time and opportunity for free exchange of ideas on new and effective teaching techniques, and on recently developed and successful laboratory projects. Any project which has been especially interesting and beneficial to the student should be analyzed to find out if the basic principles of presentation can be used in developing other projects. Special attention should be given to any scientific or technical journal articles that may improve the method of teaching a subject, or that present new information which should be taught.

To help keep a staff effective, faculty members should be encouraged to become active members of professional and technical societies. Through these media and the organizations' meetings, they become acquainted with the professional and technical literature and maintain a closer liaison with leaders in the field and employers of technicians. Increasingly, professional self-development is being encouraged by technical school administrators in the form of allowed time and financial assistance, enabling instructors to attend meetings of technical societies and special teacher-training institutes. Periodic or sabbatical leaves offer staff members opportunities for advanced study or a chance to update their industrial experience.

When determining teaching loads for instructors of technical specialty courses, consideration should be given to the number of student-contact hours required in the schedule. These instructors, to be fully effective, require considerably more time in their schedules to develop courses and laboratory materials than do shop instructors or teachers of general education courses. Therefore, 15 to 20 student-contact hours per week usually constitute a full teaching load for instructors of technical specialty courses, permitting teachers sufficient time to assist students and develop courses and effective laboratory experiments.

Class size must be considered because being able to give individual attention to students is recognized as a vital part of effective teaching. The maximum size of a lecture class may vary somewhat, depending on the material to be covered, the lecture room, and teaching techniques used; but for blackboard-lecturing, 20 to 30 students should be considered maximum. If little or no class discussion follows the lecture the class size may be significantly increased, especially if overhead projectors are used to present carefully prepared portions of the lecture which normally would be written on the blackboard.

Careful planning of laboratory teaching schedules is important. Laboratory sections should not be overloaded with students. Teaching cannot be effective if too many students are in the work groups or if too many different experiments are conducted simultaneously in the same laboratory. If too many students try to work on a project, most of them will not be able to participate sufficiently in doing the work and will not benefit from the experiment. An optimum group size is usually two students per laboratory setup, although some experiments can be effective for groups of three or even four. If too many laboratory experiments are conducted simultaneously, they cannot be closely coordinated with the theory lectures and laboratory instruction cannot be effective.

Technical curriculums are designed to produce supporting personnel who, when used resourcefully as assistants, increase the effectiveness of engineering teams; and the same principles may be applied to increase the effectiveness of the teaching staff. Staff assistants may be used in stock control to set out the proper equipment for laboratory classes, to keep equipment operating properly, to fabricate training aids, and to do a limited amount of routine paper grading. When these important, but time-consuming activities are performed by assistants, the teaching staff will have more time for curriculum-development activities, for preparing hand-outs to supplement lecture material, and for insuring that necessary parts and properly functioning equipment will be available when needed. Resourceful use of support personnel makes it possible to operate with a small but versatile staff which may be maintained as enrollment varies. By adjusting the size of the support personnel staff to the demands of enrollment, a school may, to a degree, avoid having too few instructors if the enrollment increases and too many instructors if the enrollment decreases. Most of the support personnel may be recruited from the student body.

Student Selection and Services

While the effectiveness of a technical education program depends greatly upon the quality of the faculty, the program's ultimate objective is to produce high-quality graduates. It is essential, therefore, that the accepted students have certain capabilities because instructors will tend to compromise the course work to allow for the students' inadequacies, with the probable result that the program will lack the depth and scope needed to achieve its objective.

Students chosen for this program should have similar backgrounds and capabilities and should evidence a reasonable degree of maturity and seriousness of purpose. Wide ranges of ability among students can create an inefficient teaching situation and thereby prevent the required progression of the program. The amount of material to be presented and the principles to be mastered require that students not only be well prepared in formal course material, but that they also have the ambition and determination to master a difficult program and develop their capabilities to the limit.

The technical curriculum is designed for high school graduates who have particular abilities and interests. In general, students entering the program should have completed 2 years of high school mathematics, including algebra and geometry, and 1 year of chemistry. Some knowledge of physics is advantageous, but chemistry is considered necessary.

The ability levels of students who meet these general requirements, and of those who do not, will vary greatly. If a student enters a program without adequate preparation he usually fails; if a class, or majority of a class, begins without the requisite preparation, the program cannot produce highly capable technicians and the program will fail. If an applicant has not had the necessary mathematics, science, or language skills, he should expect to be required to take remedial work which, if possible, should be offered at the school where he plans to enter a technical program.[3]

Effective guidance and counseling services are essential. The student should be aided in selecting educational and occupational objectives consistent with his interests and aptitudes. Whenever possible, institutions offering technical education programs should select and use standardized or special tests to assist in student selection, placement, and guidance. A student should be advised to change or reconsider his educational objectives if it becomes apparent that he is more suited to another program, either by his lack of interest or his lack of ability to complete the curriculum satisfactorily.

[3] See publication *Pretechnical Post High School Programs, A Suggested Guide*, OE–80049. U.S. Department of Health, Education, and Welfare, Office of Education (Washington: U.S. Government Printing Office, 1967).

The new student should become familiar with campus facilities as soon as possible, particularly the library and its facilities and the rules and procedures controlling the use of the library. If possible, organized field trips to nearby plants should be arranged early in the program to give new students an opportunity to see sanitation technicians on the job. These tours may provide motivation, and perhaps point out why certain required subjects are important.

A departmental student organization may be formed to help bring together people with similar interests and its meetings should provide exercise for the students in arranging their own technical programs. Speakers from industry or selected films may be used to stimulate interest at meetings. Student organizations may assist with and participate in department activities, such as "career days" and "open house" events.

Students should be given information concerning student membership in technical societies and encouraged to join. Student chapters of professional societies offer an opportunity for the student to receive professional journals on a regular basis at nominal cost. After graduation, the technician may find society membership and regular reading of journal articles helpful in keeping his technical knowledge current.

Students should be encouraged to get certification or operators licenses as quickly as possible. Although preparation for a certificate or license is not part of the curriculum, most of the students in the technical programs should have no great difficulty in qualifying. As graduation approaches, students should be made aware that technicians may be certified and that certification may be one of the criteria for employment.[4]

Academic achievement of students should be recognized. Many institutions grant an associate degree as tangible evidence of achievement and graduation. One function of a departmental student club could be the presentation of an annual award to an outstanding graduate. Industrial organizations might offer to contribute to an annual scholarship award.

Graduates of technical programs should receive

[4] Information concerning the certification of engineering technicians may be obtained from: Institute for the Certification of Engineering Technicians, 2020 K Street, NW., Washington, D.C. 20006; the certification of wastewater treatment plant operators, from the Water Pollution Control Federation, 3900 Wisconsin Avenue, Washington, D.C. 20016.

all the aid possible from the placement personnel in finding suitable employment. Placement personnel should be aware of the needs of industry for water and wastewater technicians and should acquaint prospective employers with the qualifications of graduates. The placement function is an extremely valuable service to the student, to the institution, and to employers. In the final analysis, the placement of graduates is an important responsibility which is directly or indirectly the concern of the department head of the instructor who teaches the technical specialty. An excellent placement record is important in getting new enrollees. In addition, the school should conduct periodic followup studies of its graduates to determine their progress and evaluate their training. In many instances, this information can point to ways for improving the curriculum or teaching techniques.

Textbooks, References, and Visual Aids

Textbooks, references, and visual aids for teaching any technology must be reviewed constantly and supplemented in light of (1) the rapid developments of new knowledge in the field, and (2) the results of research in *methods* of teaching and developing basic concepts in the physical sciences and mathematics. This is especially true in the field of sanitation and public health. The impact of the newly developed areas of theoretical and applied scientific knowledge is demanding new textbooks and references, up-to-date information from scientific and technical journals, and new visual aids material.

New textbooks reflect recent methods of teaching scientific principles and their application as fast as the current research becomes applicable. Recent extensive research into the methods of teaching mathematics and physics certainly will affect teaching materials and methods. It is therefore mandatory that instructors review texts, references, and visual aid materials as they become available and *adopt* them when they are an improvement over those suggested here or those being used.

The suggested texts and references listed in this guide have been carefully selected. There is a lack of good texts at the technician level in the water and wastewater field, but from the books listed herein department heads and teachers should be able to select suitable texts. However, it should not be assumed that other pertinent, but unlisted, books are not suitable—no doubt many are excellent.

Before undertaking a program in water and wastewater technology or any course in the curriculum, the department head or instructor is urged to become familiar with the texts and references listed in this guide and with other available literature. He will then be able to select the text and references that can best serve his particular needs and help him make an intelligible, high-level technical presentation to the students.

Visual aids can be of great help in many teaching programs, and the ones suggested in this guide have been selected from an extensive list and represent those considered most suitable at the time the curriculum was prepared. Many are not listed because the variety and extent of the materials would make an all-inclusive listing prohibitive. From among those listed and others that are available and pertinent, an instructor may select visual aids which meet his teaching objectives. These aids should *always* be viewed and studied prior to using them in a teaching program.

Laboratory Equipment and Facilities

Laboratory facilities and equipment used for water and wastewater technology programs must meet high standards of quality since achievement of objectives and the strength of the programs depend on valid laboratory experience—basic in nature, broad in variety, and intensive in practical application. Well-equipped laboratories, with up-to-date sufficient facilities to enable all students to participate in laboratory work are required for technical courses. The training program should include experiences that show the nature and application of a wide variety of standard tests and functional systems and how they are used in the technological field.

In establishing laboratories, variety and quality of equipment and facilities are more important than quantity. Laboratory equipment and facilities will account for a major part of the program's cost, but are essential if the training objectives are to be met.

Equipment must be of good quality if laboratory work is to provide valid experiences for the student. Inferior equipment may not show the principles being studied or may not be sensitive enough to supply reliable or precise data. Such equipment may require unreasonable amounts of time and expense for repairs or adjustment. Although the initial cost of high-quality equipment is usually greater than that of low-quality equipment, the difference is justified by making it possible to conduct laboratory experiments that give precise results.

In the selection of laboratory equipment, the need for each item should be well established. Expensive apparatus may not always be required since many significant experiments can be built around relatively inexpensive components. In fact, the principles are often more evident because these components present only the essentials. The number of units purchased, the areas of interest, the emphasis required by the particular industry and the ingenuity of the instructor(s) in adapting equipment to teaching needs will play a major part in governing the selection and cost of laboratory equipment. Throughout the program, the greatest emphasis should be on the principles which serve as the basis for so many different sanitation and public health problems.

A recommended approach to developing laboratory work and equipping water and wastewater science laboratories is to determine what experiments are needed for each course, then design these experiments as far as possible using standard components and equipment which are representative of apparatus currently being used in the industry or in related government agencies. This approach requires more time and effort on the part of the staff, but there is compensation in that the experimental equipment usually accomplishes the best teaching because it has been assembled to demonstrate some principle or to make a specific experimental determination with clarity and precision. Laboratory equipment and facilities are discussed in more detail in the sections entitled "Laboratory and Physical Facilities" and "Laboratory Equipment and Costs."

FIGURE 5—*Sufficiently equipped and up-to-date laboratories, such as the one shown, are required so that each student can have extensive experience in the use of scientific equipment. These students are practicing a technique in bacteriology.*

Scientific and Technical Societies

Scientific and technical societies[5] are important sources for instructional materials and other opportunities that can benefit both staff and students. These societies, in their publications and at meetings, provide continual exposure to the most recent developments in the science and related technologies and probably serve as the best means for helping persons keep up-to-date in a particular phase of science. They present data in a manner that provides a "popularizing" and informative bridge between the creative theoretical scientist and the applied sciences; practitioners, including the technicians. Usually these societies are the first to announce and describe significant discoveries and research in the field.

Teachers in technical programs should be encouraged to become active members of scientific and technical societies in order to keep abreast of new developments in the technology and to become acquainted with the people in the community who are most actively interested in the field. Some educational institutions pay all or part of the cost of membership in selected societies, and all or part of the cost of attendance at local or national society meetings as a means of encouraging staff activity in such societies.

Early in their study program students should be made aware of the literature and services of the scientific, technical, and engineering societies related to the field of water and wastewater technology. Student-affiliate memberships are offered

[5] See publication *Scientific and Technical Societies Pertinent to the Education of Technicians*, OE-80037. U.S. Department of Health, Education, and Welfare, Office of Education (Washington: U.S. Government Printing Office, 1966).

by some of these societies, and students should be encouraged to become members.

The American Water Works Association, 2 Park Avenue, New York, N.Y. 10016, and the Water Pollution Control Federation, 3900 Wisconsin Avenue, Washington, D.C. 20016, are two societies which serve the scientist, engineer, technician, administrator, teacher, student, and others in the field of water, wastewater, water pollution, and in public health. Both organizations have monthly publications as well as manuals and bulletins covering special topics.

Some other scientific and technical societies with publications and services which may be of interest to teachers and students in water and wastewater programs are:

Air Pollution Control Federation
American Industrial Hygiene Association
American Meteorological Society
American Academy of Environmental Engineers
Institute of Environmental Sciences
Institute of Sanitation Management
National Association of Sanitarians
National Rivers and Harbors Congress

These societies and their publications, as of 1965, are described briefly in Appendix A.

Advisory Committees and Services

Almost all successful technical education programs are assisted and benefited by advisory committees and special consultants. Most institutions have an advisory committee or committees to assist the administrators in planning and implementing programs to meet the objectives of the institution and the needs of those served. In addition, each specific technology program or other specialized occupational objective has a special curriculum advisory committee made up of representatives of employers, civic leaders, and representatives of public employment services, scientific or technical societies and associations in the field, and of specialists from the school's staff.

A curriculum advisory committee usually is appointed by the chief administrator or the dean of the institution when it becomes evident that a particular technology program should be considered, and perhaps offered by the institution. The advisory committee then assists in making a survey of employment requirements; employment opportunities; available student population; curriculum, faculty, laboratory facilities and equipment; and the cost of the program. These committees often provide the added support that school administrators need for requesting appropriations, raising public funds, and for obtaining State or Federal support for the program.

Sometimes results of studies made by the curriculum advisory committee demonstrate that a proposed program is not needed. But when they show that a program should be offered, the committee's support and assistance in planning and initiating the program is invaluable. When the program's graduates begin seeking employment, the committee assists in placing them in jobs and in evaluating their performance. These evaluations often lead to minor modifications in the program.

Committee members usually are appointed for a year to prevent the duties from becoming a burden to any one member and to give other qualified and interested people an opportunity to serve. The average committee usually consists of 12 members, but this number may vary from 6 to 20. Those selected to serve are busy people and meetings should be called only when there are problems or tasks that demand committee action. In most instances, the committee chairman is either the head of the institution or the department head. The members serve without pay, participating as interested citizens and providing invaluable assistance whether serving formally or informally. The continuous support provided by an advisory committee has proved to be a source of strength for the program and the most reliable means for maintaining a successful, high-quality, and up-to-date program.

As stated in the "Preface," this guide is to be used for program planning and development in post high school institutions. Modifications in the program are expected in order to make it suitable to local needs and/or various school situations. The assistance given by an advisory committee and special consultants, using a guide such as this and modifying it to meet local needs, has been found effective in initiating needed programs and developing them quickly to a high level of excellence. The courses have often been modified by school administrators and advisory committees to serve the needs of employed adults who need to update or upgrade their skills and technical capability.

THE CURRICULUM

Curriculum Outline

	Hours Per Week Class	Laboratory	Outside Study	Total
First Semester				
Introduction to Water and Wastewater Technology and Related Fields	3	3	6	12
Mathematics I (Technical)	5	0	10	15
Physics I (Heat and Mechanics)	3	3	6	12
General Drafting	0	8	0	8
Communication Skills	3	0	6	9
	14	14	28	56
Second Semester				
Mathematics II (Technical)	4	0	8	12
Technical Reporting	2	0	4	6
Basic Hydraulics for Water and Wastewater	3	4	6	13
Microbiology for Water and Wastewater	2	6	4	12
Physics II (Electricity and Light)	3	4	6	13
	14	14	28	56
Third Semester				
Sanitary Chemistry and Microbiology I	2	6	4	12
Water Supply and Wastewater Control	2	4	4	10
Water Purification	3	3	6	12
Surveying	2	6	4	12
General and Industrial Economics	3	0	6	9
	12	19	24	55
Fourth Semester				
Sanitary Chemistry and Microbiology II	2	6	4	12
Wastewater Treatment	2	4	4	10
Instrumentation and Controls	3	2	6	11
Contracts, Specifications, Codes, and Estimates and Costs	3	4	6	13
Industrial Organizations, Institutions, and Government	3	0	6	9
	13	16	26	55

Brief Description of Courses

First Semester

Introduction to Water and Wastewater Technology and Related Fields

A study of methods of disease transmission, hygienic excreta disposal, municipal and industrial wastewater collection and treatment, characteristics of water, water treatment, protection of ground water, insect and rodent control, solid waste collection and disposal, milk and food sanitation, swimming pool sanitation, and industrial hygiene.

Mathematics I (Technical)

A course in algebra, analytic geometry, and introductory trigonometry, with particular stress on slopes and rates of change and the determination of maxima and minima conditions.

Physics I (Heat and Mechanics)

A study of the basic principles of mechanics and heat, with the emphasis in both laboratory and lecture on the scientific method. Laboratory-oriented to provide application of principles learned in the mathematics course, including use of the slide rule for computation of data.

General Drafting

A beginning course for students who have had little or no previous experience in drafting. The principal objectives are to provide an elementary understanding of: orthographic projection; isometric and oblique sketching; detail and assembly working drawings; principles and applications of descriptive geometry to drawings; plan, profile, and topographic drawing; how to use handbooks and other resource materials. Interpretation of industrial sketches and prints is introduced.

Communication Skills

A program designed to increase competence in reading, writing, and talking, and understanding oral instructions.

Second Semester

Mathematics II (Technical)

A continuation of mathematics I which completes the study of necessary principles of analytic geometry and concludes with introductory phases of calculus required for optimum performance in hydraulics and process control.

Technical Reporting

A study of effective ways of presenting information, with emphasis on the use of graphs, drawings, sketches, and outlines for various types of oral presentations and written reports.

Basic Hydraulics for Water and Wastewater Technology

A basic study of closed conduit and open channel flow, including stream flow, subterranean flow, runoff, pump characteristics, and wave action.

Microbiology for Water and Wastewater Technology

A basic course in microbiology with emphasis on microorganisms, and on the laboratory procedures for identifying and differentiating organisms peculiar to water and wastewater treatment, and related public health and stream sanitation problems.

Physics II (Electricity and Light)

A study of the basic principles of electricity, electrical circuitry, motors, and light, emphasizing the concepts of physics and laboratory-oriented to provide application of principles.

Third Semester

Sanitary Chemistry and Microbiology I

Theory and laboratory techniques for all control tests of water purification including: bacteriology, color, turbidity, *pH*, alkalinity, hardness, coagulations, chlorides, fluorides, iron, manganese, detergents, bactericides, and nitrates. It includes basic "in-plant studies at nearby plants."

Water Supply and Wastewater Control

A course designed to familiarize the student with the elementary engineering aspects of water supply and distribution; and of wastewater collection, removal, and disposal.

Water Purification

A study of basic principles of water purification including: aeration sedimentation, rapid sand filtration, chlorination, treatment chemicals, taste and odor control, bacteriological control, mineral control, design criteria, maintenance programs, and operational problems. New processes and recent developments are studied. Criteria, rules, regulations, forms, and records associated with the field are considered.

Surveying

A study of the elementary theory and practice of plane surveying including taping, differential and profile leveling, cross sections, earthwork computations; and transit, stadia, and transit-tape surveys.

General and Industrial Economics

A study of the principles of general and industrial economics; an analysis of the factors involved and the importance of cost control in an industrial or municipal enterprise.

Fourth Semester

Sanitary Chemistry and Microbiology II

A study of the theory and laboratory techniques for the determination of solids, dissolved oxygen, oxygen consumed, relative stability, bacteria, biochemical oxygen demand, organic nitrogen, volatile acids, and toxic metals in liquid media. The course includes stream studies and in-plant studies.

Wastewater Treatment

This course is designed to familiarize the student with the elementary engineering aspects of design, operation, process control, and maintenance of wastewater treatment plants and facilities.

Instrumentation and Controls

An elementary study of hydraulic, pneumatic, mechanical, electrical and electronic control systems and components. It includes a basic description, analysis, and explanation of operation of instrumental controls for water and wastewater plants. Typical performance characteristics, accuracy, and applications of instruments are studied.

Contracts, Specifications, Codes, and Estimates and Costs

A course designed to teach the methods and procedures of consummating an engineering contract with code and cost limitations.

Industrial Organizations, Institutions, and Government

A study of the roles played by labor and management in the development of American industry. Analysis is made of forces affecting labor supply, employment, and industrial relations in a democratic system of government.

Curriculum Content and Relationships

Functional competence in a broad field such as water and wastewater technology has at least three components around which the curriculum must be designed:

1. The training should prepare the graduate to be a productive employee in an entry-level job.
2. The broad technical training, together with a reasonable amount of experience, should enable the graduate to advance to positions of increasing responsibility.
3. The foundations provided by the training must be broad enough so that the graduate can do further study within his field.

A 2-year technology program has certain unique requirements that influence the content and organization of the curriculum. Some requirements are imposed because of occupational functions that graduates are expected to perform; some result from the emphasis of industry on particular areas of sanitation; some may be incidental to the need for content that will maximize the effectiveness of teachers with special competencies. Other requirements result from the limited time available to produce a competent technician in such a diverse field. This water and wastewater technology curriculum guide reflects three basic requirements: functional utility, units of instruction in specialized technical subjects, and the teaching of principles by application.

The sequence of courses in a 2-year technical curriculum is as important as course content if the limited time is to be used effectively. In general, subject matter is carefully coordinated into groups of concurrent courses which are arranged to blend smoothly into each subsequent group. This is in sharp contrast to the arrangement of the professional curriculum in which basic and somewhat unrelated courses usually make up the first part of the study program and specialization is deferred to subsequent terms.

The relationship between laboratory time and class lecture, or theoretical study time, is of great importance in a technical education curriculum. The necessary theory, skills, techniques, understanding of principles and applications, and knowledge of equipment could be taught in the laboratory without separate and organized lecture classes.

The converse is *not* true. Laboratory experience, skills, and the know-how and capability, which are the characteristic attributes of technicians, can be acquired only in *separate and coordinated laboratory classes*. However, related ideas, concepts, and factual information can be taught in "theory" classes by judiciously using demonstrations and visual aids, selected texts and references, and requiring students to do regular and systematic outside study. Usually group teaching makes more efficient use of the instructor's time in a classroom than in a laboratory and tends to place emphasis on developing the student's skills in obtaining knowledge from texts and references. Thus there must be a special relationship between the amount of the technical specialty taught in the "theory" classes and that taught in the laboratory.

This curriculum provides a large proportion of time for laboratory study of the basic sciences and related mathematics and relatively less time in the technical specialty during the first two semesters. This is done because introductory and elementary laboratory skills and knowledge of apparatus, tools, processes, materials, techniques, and good laboratory practice can (and should) be learned early. The elementary laboratory work can get underway without much underlying theory. As the underlying theory is developed and understood, it can be incorporated as rapidly as possible into the laboratory work which then becomes a significant experience for increasing the depth of subjects being taught.

Since many basic laboratory skills and enough basic theory have been learned in the first year, relatively less laboratory time is required to illustrate basic principles in second year courses. During the second year, more technical specialty courses are studied and the total hours of laboratory time are greater than in the first year. Experience has shown that the relative number of semester hours required for science or technical specialty laboratory work, compared to class theory hours, should not be reduced. A reduction of laboratory work usually causes the student to lose interest and fail, or to abandon the course; or produces a graduate who is deficient in the essential laboratory capabilities and unemployable at the technician level.

In technical curriculums, the introduction of specialized technical course work in the first semester is mandatory. To defer this introduction, even for one term, limits the effectiveness of the curriculum. Several advantages are derived from an early introduction of the technical specialty:

1. The student interested specifically in water and wastewater technology is motivated when training starts immediately in his specialty. When the first semester consists entirely of general subjects—mathematics, English, social studies—technical students often lose interest.
2. The student achieves greater depth of understanding in specialized subjects in the later stages of the 2-year program.
3. The student gains needed experience when he sees immediate application of the principles studied in mathematics, physics, and microbiology.

Safety and careful workmanship must be emphasized throughout the course of study. The technician's work often involves potential dangers that can be avoided with an understanding of equipment and observance of normal safety practices. In addition to preventing loss of life or limb, or injury to the body, careful workmanship is necessary to protect delicate apparatus and expensive test equipment. Safety must be a constant preoccupation and

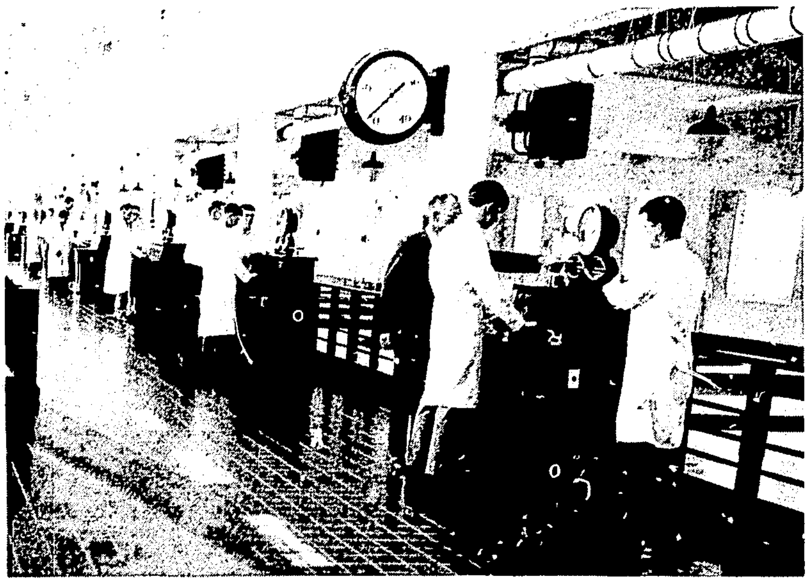


FIGURE 6—*Student technicians gain understanding and valuable experience by visiting municipal water plants, especially if allowed to participate in the operation as shown here.*

continual emphasis must be given to safety practices.

Honesty and integrity must be stressed in the training of any technician. His observations must be reported accurately and any modification in data should be fully explained in his record. False reporting should be dealt with instantly by the instructor. The original data recorded by an employed technician may become evidence in a court of law and are therefore of great importance.

Throughout the course of study the student is trained in the scientific method of observation, and to record his observations in laboratory reports. During the fourth semester he records his observations in a laboratory log book. The laboratory log book is a bound, journal-type notebook with "numbered" pages in which the student must keep a permanent record of each laboratory experiment, including the objective thereof; all pertinent drawings, equipment lists, observed and computed data; date of experiment and name of observer. This procedure approximates the type of journal recording required of most employed technicians. The required maintenance of a laboratory log is recommended during the final semester of the program and should constitute a complete chronological record of a student's technical course work for that semester.

Introduction to Water and Wastewater Technology and Related Fields, a first-semester course, provides the student with a broad overview of the field. Field trips to water and wastewater treatment plants and those taken with local public health personnel help stimulate the student's interest, because he can observe water and wastewater technicians on the job. This introductory course to the technology also helps the student understand why the other basic courses in the first-semester study plan are necessary.

Microbiology for Water and Wastewater Technology and *Basic Hydraulics for Water and Wastewater Technology,* second-semester courses, continue the technical specialty by providing intensive laboratory study of processes and techniques to develop skills to the degree needed for the laboratory analyses required in the second year.

Mathematics II (Technical) concludes the sequence of selected topics in algebra, trigonometry, analytic geometry, and calculus which comprise the two courses in mathematics. The inclusion of calculus is not intended to make the student proficient in all aspects of the calculus, but rather to help him understand how to use calculus as a basic tool in problem analysis and in communicating with engineers. The student's background in calculus should be broad enough to allow him to follow, though not necessarily reproduce, the development of equations. Examples might include the differentiation

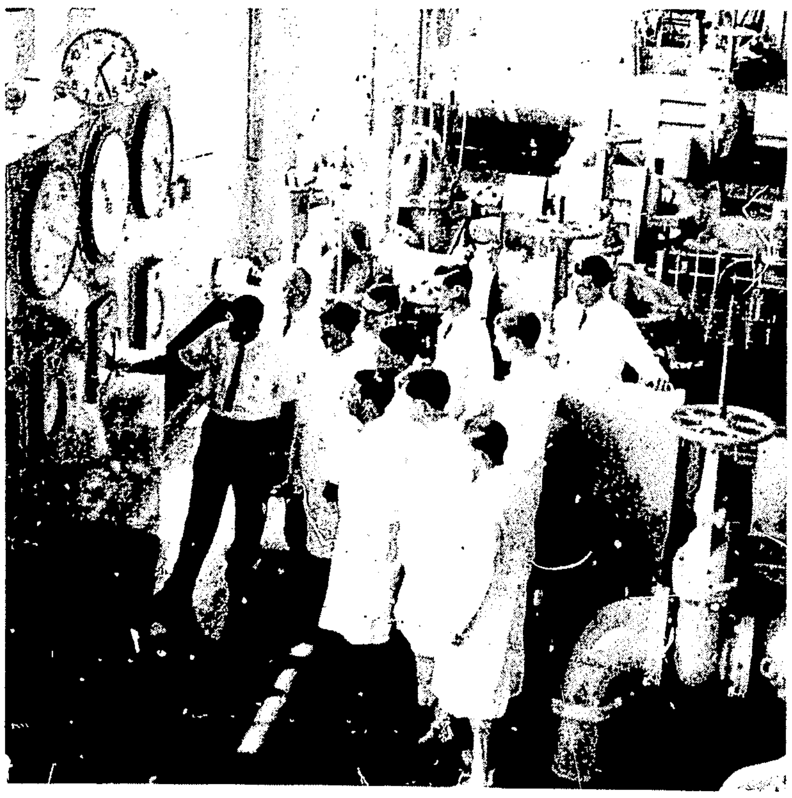


FIGURE 7—*Hydraulics, fluid flow, pumping, and fluid distribution and control are essential scientific studies for water and wastewater technicians. Here student technicians receive instruction on water distribution demand from flow- and liquid-level recording charts of a municipal water system.*

of elementary functions to determine the instantaneous velocities and accelerations in physics, and the use of calculus in the analysis of transient conditions and control systems.

Physics II (Electricity and Light) gives the student an essential understanding of the electrical principles in circuitry and equipment, and a basic knowledge of the principles of light required for the spectroscopic and photoelectric analyses made in the second year. The 14 hours of laboratory work in the sciences and technical courses provide for practical demonstration and application of the principles learned or being learned.

The third semester's study is based on the student's accumulated knowledge of physics, mechanics, electricity, microbiology, and hydraulics. In *Sanitary Chemistry and Microbiology I,* the student spends more time in the laboratory learning and using refined techniques which are necessary for performing all analyses to determine the suitability of water sources for various purposes. *Water Supply and Wastewater Control* enables the student to use his knowledge of hydraulics in the study of water distribution systems and wastewater sewer collection systems. In the *Water Purification* course, the student becomes familiar with the elementary engineering aspects of design operation, and the maintenance of water purification plants. A course in *Surveying* is added to give the student a working knowledge of the principles of plane surveying which is useful in understanding plant layout and system design.

The fourth semester provides further depth of comprehension and practice in application of principles, techniques, skills, and concepts previously learned. *Wastewater Treatment* is a study of the elementary engineering aspects of design, operation, and maintenance of wastewater treatment plants. *Sanitary Chemistry and Microbiology II* continues to develop the student's knowledge and skills in making laboratory analyses of wastewater. *Instrumentation and Controls* applies principles previously learned to the operation of a modern water and wastewater sewer complex. A class and laboratory course in *Contracts, Specifications, Codes, and Estimates and Costs* gives the students further understanding of the complex problem of designing and building modern facilities. A complete quantity take-off and detailed cost estimate is made of a modern water or wastewater treatment plant.

General and Industrial Economics, and *Industrial Organizations, Institutions, and Government* are designed to broaden the student's concept and perspective of the society in which he lives and will be employed. These courses include broad economic and industrial concepts, and sufficient emphasis on corporate or municipal organizational structure and economics to enable the student to comprehend the terminology and recognize the motives, methods, objectives, and administrative procedures of employers.

Close correlation of concurrent courses has not been stressed as strongly in the third- and fourth-semester courses as it was in the first- and second-semester courses because of the diversity of study. There are necessary areas of overlap in course content throughout the second year. In the regularly scheduled planning sessions involving teachers of concurrent second-year courses, the most effective material may be prepared for each course. This minimizes duplication and loss of time.

Communication Skills emphasizes the mechanics of reading, writing, listening, speaking, and reporting early in the curriculum (first semester). In the second semester, these skills are reinforced in *Technical Reporting.* Instructors in technical courses should set high standards for student work in reporting, with emphasis on clarity, conciseness, and neatness. Freedom to report on technical subjects of their own choice may add reality and extra motivation for technology students. In the final phases of the 2-year program, the student's reporting should approach the standards required by employers. During this time, instructors should encourage a show of individual style and initiative in reporting by allowing as much freedom as possible without violating the school's established standards. Not all reports should require an unusual length of time for preparation. The judicious use of reporting, both informal and formal, provides training that is realistic to employment situations and the length of time students take in preparing formal reports can be adjusted to require a reasonable portion of their time.

The course outlines are concise and comprehensive and are intended as guides rather than as specific plans of instruction to be covered in an inflexible order. They represent a judgment on the relative importance of each instructional unit, especially where time estimates are shown for the divisions

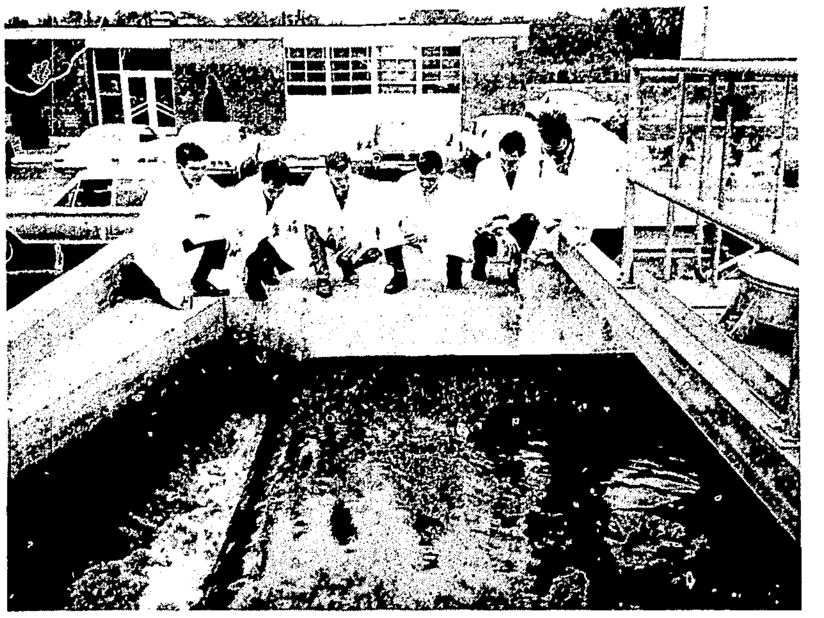


FIGURE 8—*Field trips help student technicians to comprehend design and construction features of units, such as this rapid sand filter at a local water plant.*

within each course. It is expected that the principles outlined in these courses will be supplemented with industrial applications whenever relevant. Field trips add greatly to the effectiveness of the instruction if they are carefully planned in advance so that the processes observed are understood and relate to the subject material being studied at the time of the trip.

Outside study is a significant part of the student's total program. In this curriculum, *2 hours of outside study time have been suggested for each hour of scheduled class time.* A typical weekly work schedule for a student in the first semester of this curriculum would be: class attendance, 14 hours; laboratory, 14 hours; outside study 28 hours—totaling 56 hours per week. This is a full schedule, but not an excessive one for this type of program.

It should be noted that no examinations have been scheduled in the outlines. It is clearly intended that time be made available for examinations. Therefore, a 17-week semester is assumed, and the outlines are designed to cover a full 16 weeks. The primary objectives of examinations would be to evaluate the student's knowledge and to require him to make a periodic comprehensive review of the subject. The results of these examinations may also point out weaknesses in teaching techniques or in the subject matter.

If opportunities for summer employment exist in the water and wastewater field, employment should be arranged for the student between the second and third semester. Employers at local municipal and industrial water purification and wastewater treatment plants often cooperate with administrators of student summer-employment programs because of the need for relief operators during the vacation season. Where this is done, a close check with the employer may enable extra credit to be given to the student for such work.

Suggested Continuing Study

A 2-year program must concentrate on providing the necessary science, mathematics, and related knowledge and skills in the technical specialty if it is to produce graduates who can qualify for employment.

This type of program cannot cover in depth all of the subjects which are pertinent to the technology; other important related subjects may be introduced. In addition, the graduate may obtain work in a new area of the industry for which little or no related subject matter had been developed during his training period.

The program is not designed to produce an individual who is proficient in all of the duties he might be asked to perform. Proficiency in highly specialized work will come with practice and experience. It is impossible to forecast the exact requirements of the duties assigned to any individual, and it is almost impossible to predict accurately the direction or rate of change in various technologies. Employers generally recognize that the recent graduate engineers may require a year or more to obtain the specific training needed and to become fully aware of their responsibilities and role in an organization. Similarly, employers must allow newly graduated water and wastewater technicians a 3- to 6-month orientation period to give them time to become familiar with the special procedures and problems related to the job. Furthermore, productive graduate technicians will continue to study throughout their careers in order to develop their capabilities to the maximum.

For these reasons, continuing study is necessary for graduates of technology programs. They can, however, keep abreast of technical developments by reading current literature related to the technology, by attending meetings of scientific and technical societies, and by studying on the job. These methods of study tend to build on the organized technological base of the 2-year curriculum. Continuing inschool study of supplementary courses is the most efficient and practical way for the postsecondary graduate to acquire additional knowledge and skill that can broaden his initial education. Formal study offers the advantages of systematic arrangement of subject matter, disciplined and competent teaching, and class discussion. In addition, the courses studied may be scheduled for Saturday or after the technician's work hours.

Rapid advances in the water and wastewater field and in closely related technologies will require graduates to update their training. Some suggested areas or subjects for continued study in water and wastewater technology include:

- Air Pollution Control

  Most of the processes and the analytical techniques learned in water and wastewater technology are similar to those used in air pollution control.

  Some additional specialized study might qualify the water and wastewater technican to serve as an assistant to a specialist in air pollution control.

- Microbiology as applied to dairy or food processing
- Hydrology
- Chemical Process Control
- Instrumentation
- Mechanical Drawing and Drafting

ERIC

COURSE OUTLINES

The intent of the course outlines is to suggest content which might be taught and provide practical and attainable coverage of the field. The material presented has been reviewed by instructors in water and wastewater technician education programs and by representatives of employers who require the services of skilled water and wastewater technicians.

Some modification of content is expected to meet the need defined by local advisory committees and to use effectively the special interests and capabilities of the teaching staff in any particular institution. But the implied level, quality, and completeness of the program should not be compromised.

At the end of each course outline is a list of texts and references. Each list should be analyzed for its content and pertinency, and any available new or more suitable texts and references should be substituted. The information needed to cover a particular course in technician education curriculums, particularly the technical specialty courses, is seldom available in one textbook; hence, several are listed. The lists could be augmented considerably with current materials from manufacturers, trade journals, technical societies, and suppliers of apparatus and services.

Suggested visual aids are listed for many courses. Each visual aid should be used when pertinent and when its use can be more effective than any other teaching method. *Excessive use of films to replace well-prepared lectures and demonstrations is to be avoided.* Some of the suggested outside study time may be used for screening films instead of the scheduled class-lecture time. All visual aids should be examined by the instructor before they are shown. In addition to a brief description of the film and the name and address of the distributor, information is provided as to the size, time required for showing, and whether black and white or color, and sound or filmstrip.

Undoubtedly, the experienced instructor will use charts, slides, models, samples, and specimens to illustrate the special technical aspects of the subject. These aids are usually accumulated by the experienced instructor as a result of previous laboratory or lecture preparations, but should be updated when new developments occur.

The laboratory sessions suggested in the curriculum outline and in the course descriptions are not necessarily intended as single sessions, but rather as total hours of laboratory sessions per week which are to be scheduled in reasonable and effective increments. For example, a 6-hour laboratory course might be scheduled as three 2-hour sessions or two 3-hour sessions per week, or other divisions of laboratory time that seem appropriate may be arranged.

Technical Courses

INTRODUCTION TO WATER AND WASTEWATER TECHNOLOGY AND RELATED FIELDS

Hours Per Week

Class, 3; Laboratory, 2

Course Description

An introductory study of the fundamental principles of environmental control, water and wastewater, and sanitation normally employed in the field of public health for protecting the health and well being of people. Methods of disease transmittal are studied. Emphasis is placed on the physical, chemical, or biological means of prevention or minimizing the threat of pathogens and nuisance organisms as this relates to water resources and water pollution control. Important areas covered are water treatment, water pollution control, waste disposal, insect and rodent control, solid waste collection, solid waste disposal, food sanitation, swimming pool sanitation, industrial hygiene, air pollution control, and radiological protection. Field inspection trips and visual aids are used extensively as methods of instruction.

Major Divisions

	Hours Class	Hours Laboratory
I. Disease Transmittal	8	2
II. Hygienic Excreta Disposal	8	6
III. Sources, Protection, and Treatment of Water	8	6
IV. Insect and Rodent Control	4	0
V. Solid Wastes, Collection, and Disposal	4	4
VI. Food Sanitation	4	4
VII. Swimming Pool Sanitation	4	4
VIII. Industrial Hygiene	4	2
IX. Radiological Sanitation	4	4
Total	48	32

I. Disease Transmittal
- A. Units of Instruction
  - 1. Air
    - a. Colds
    - b. Tuberculosis
    - c. Influenza
  - 2. Food, water, and solids
    - a. Typhoid
    - b. Paratyphoid
    - c. Dysentery
    - d. Cholera
  - 3. Insects and animals
    - a. Malaria
    - b. Yellow fever
    - c. Plague
    - d. Brucellosis
    - e. Bovine tuberculosis
    - f. Anthrax
    - g. Psittacosis
    - h. Trichinosis
- B. Laboratory Projects
  - 1. Visit laboratory section of local health department.
  - 2. Prepare report of health services rendered county citizens.

II. Hygienic Excreta Disposal
- A. Units of Instruction
  - 1. Purpose
  - 2. Basic principles
    - a. Isolation
    - b. Natural decay
  - 3. Decay cycles
    - a. Nitrogen
    - b. Carbon
    - c. Sulfur
  - 4. Excreta disposal without water carriage
    - a. Pit privy
    - b. Septic privy
    - c. Chemical toilet
    - d. Box and can privy
  - 5. Excreta disposal with water carriage
    - a. Cesspool
    - b. Septic tank
    - c. Soil-absorption fields
  - 6. Municipal sewage disposal
    - a. Dilution
    - b. Preliminary treatment
    - c. Sedimentation
    - d. Filtration

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e. Aeration
f. Oxidation ponds
g. Disinfection
h. Sludge disposal
i. Irrigation

B. Laboratory Projects
1. Observe design features of household septic tank under construction.
2. Prepare a flow sheet for the municipal wastewater plant complete with rate, time, and type of treatment process.
3. Prepare a preliminary design of a wastewater treatment facility for a motel.

III. Sourses, Protection, and Treatment of Water

A. Units of Instruction
1. Desired qualities
a. Biologically safe
b. Clear and colorless
c. Odorless and tasteless
d. Free from toxic substance
e. Relatively soft
f. Noncorrosive
2. Sources
a. Wells
b. Reservoirs
c. Rivers
d. Oceans
3. Protection
a. Well construction and location
b. Watershed management
c. Pollution abatement
4. Water treatment
a. Storage and plain sedimentation
b. Aeration
c. Sand filter
d. Coagulation
e. Sedimentation
f. Chlorination
g. Softening
h. Stabilization
i. Fluoridation
j. Corrosion control
k. Algae control
l. Taste and odor control
m. Demineralization

B. Laboratory Projects
1. Prepare a flow sheet for the municipal water treatment plant complete with rate, time, name of various treatment processes.
2. Observe steps in the well-drilling procedure and sterilization process, before placing in service.
3. Observe construction of private water system and municipal water system, and prepare a report on the principal differences in sizes and materials.

IV. Insect and Rodent Control

A. Units of Instruction
1. Basic principles
a. Ecology of vector
b. Epidemiology of diseases
c. Control measures
2. Specific insects
a. Mosquitoes
b. Flies
3. Rodents
a. Ecology
b. Transmittable diseases
c. Economic loss
d. Rodent surveys
4. Rodent control
a. Proper sanitation
b. Poisoning
c. Trapping
d. Fumigation
e. Ectoparasite control
f. Rat proofing
g. Port regulations

V. Solid Wastes, Collection, and Disposal

A. Units of Instruction
1. Solid wastes
a. Garbage
b. Rubbish
c. Ashes
d. Dead animals
e. Street sweepings
f. Industrial wastes
2. Collection
a. Frequency
b. Equipment
c. Records
d. Costs
3. Disposal
a. Dumping
b. Hog feeding
c. Incineration
d. Sanitary landfill
e. Composting

f. Reduction
g. Grinding

B. Laboratory Projects
1. Inspect, with the local sanitarian, a private solid waste collection and disposal system.
2. Visit the local municipal solid waste disposal site and prepare a report on area required and the cost.

VI. Food Sanitation

A. Units of Instruction
1. Factors affecting health
a. Animal parasites
b. Bacteria
c. Bacterial toxins
d. Preservatives
e. Poisonous foods (toadstools, for example)
2. Food infectants and intoxicants
a. *Staphylococcus*
b. Botulinus (*Clostridium botulinum*)
c. *Clostridium welchii*
d. Salmonellosis (*Salmonella*)
e. Spray residues
3. Control methods used by restaurants
a. Health certificates
b. Sterilization of utensils
c. Refrigeration
d. Building and equipment inspection
4. Control methods used by U.S. Government
a. Meat inspection
b. Poultry inspection
c. Approving shellfish waters
d. Milk inspection

B. Laboratory Projects
1. Inspect, with local sanitarian, a milk producing and bottling plant.
2. Observe Federal meat inspector examining animals at a local poultry plant or abatoir.
3. Observe local sanitarian inspecting a food serving establishment.

VII. Swimming Pool Sanitation

A. Units of Instruction
1. Infections and diseases associated with swimming pools.
a. Intestinal diseases
b. Eye, ear, nose, and throat infections
c. Skin diseases
2. Water sanitation standards for swimming pools.
a. Chlorine
b. Alkalinity
c. Clearness
d. Bacterial quality
3. Methods of purification
a. Pressure sand filter
b. Diatomaceous earth filter
c. Fill and draw procedure
d. Disinfection
e. Vacuum system
4. Provisions for safety
a. Life guards
b. First aid supplies
c. Safety buoys
d. Regulations

B. Laboratory Projects
1. Perform chlorine and alkalinity determinations for the municipal swimming pool.
2. Observe an operator working the pressure filters.
3. Calculate filtration and turnover rate from data on recirculation pump.

VIII. Industrial Hygiene

A. Units of Instruction
1. Industrial hazards
a. Temperature extremes
b. Dust, fumes, and gases
c. Poisons
d. Illuminations
e. Radiation
f. Accidents
g. Bacterial infections
2. Specific toxic compounds
a. Gases: CO_2, HCN, H_2S, SO_2, NH_3, C_{12}
b. Vapors: benzol (C_6H_6), CC_{14}, trichlorethylene, gasoline, alcohol
c. Fumes of molten metals, Pb, Zn, Hg, Mn, Cd
d. Dusts: silica, asbestos, coal
3. Methods of control
a. Ventilation
b. Isolation
c. Dust collectors
d. Protective clothing

B. Laboratory Projects
1. Visit local atmospheric sampling station for information on equipment and operation.
2. Describe analyses of air samples.

IX. Radiological Sanitation

A. Units of Instruction

1. Radioactivity terms
   a. Alpha radiations
   b. Beta radiations
   c. Gamma radiations
   d. Energy released
   e. Half-life
   f. Ionization
2. Units of radiation and radioactivity
   a. Curie: 3.7×10^{10} dis./sec.
   b. Millicurie: 1/1000 curie
   c. Microcurie: 1/1,000,000 curie
   d. Roentgen: Dis. to produce 1 esu/cm^2 of air (gamma only)
   e. Roentgen equivalent of man; alpha and beta equivalent of Roentgen
3. Effects of radiation
   a. Cancer
   b. Mutations
   c. Blood changes
   d. Death
   e. Shortened life span
4. Safety measures
   a. Checking exposure
   b. Shielding
   c. Burying radioactive wastes

B. Laboratory Projects

1. Demonstrate survey type radiological instruments.
2. Demonstrate radiation from a radioactive substance.

Texts and References

AMERICAN PUBLIC HEALTH ASSOCIATION. *Control of Communicable Diseases in Man.*

AMERICAN PUBLIC HEALTH ASSOCIATION. *Standard Methods for the Examination of Water and Wastewater.*

AMERICAN SOCIETY OF CIVIL ENGINEERS. *Sanitary Landfill.*

BABBITT. *Water Supply Engineering.*

EHLERS *and* STEEL. *Municipal and Rural Sanitation.*

FAIR *and* GEYER. *Elements of Water Supply and Wastewater Disposal.*

LOGAN, OPPERMANN, *and* TUCKER. *Environmental Engineering and Metropolitan Planning.*

PRATT. *Mosquitoes of Public Health Importance.*

———. *Milk Sanitation Administration.*

ROLLINS. *Federal and State Regulations on Pesticides.*

SALVATO. *Environmental Sanitation.*

U.S. PUBLIC HEALTH SERVICE. *Manual of Septic Tank Practice.*

Visual Aids

Communicable Disease Center, Atlanta, Ga. 30333.

Biology and Control of Domestic Mosquitoes. (M–357) 16 mm., 13 min., sound, color.

Community Fly Control Operations. (4–094) 16 mm., 12 min., sound, color.

Construction of a Typical Household System. (M–50c) 16 mm., 14 min., sound, black and white.

Engineering Your Health. (M–15–567) 16 mm., 13½ min., sound, color.

Epidemiology of Staphylococcal Infection. (F–363) 36 mm. filmstrip, 112 frames, 14 min., sound, color.

Insects of Importance to Public Health in the U.S. (9–034) 35 mm. filmstrip, 37 double frames, sound, black and white.

Introduction to Backsiphonage and Cross Connections. (F–171) 35 mm. filmstrip, 75 frames, 11 min., sound, color.

Introduction to Swimming Pool Sanitation. (M–402) 16 mm., 23½ min., sound, color.

Life with Radiation. (M–15–567 16 mm., 58 min., sound, color.

Municipal Sewage Treatment Processes. (M–6) 16 mm., 13 min., sound, black and white.

Refuse Disposal by Sanitary Landfill. (M–228) 16 mm., 13 min., sound, color.

Outbreak of Salmonella Infection. (M–148 a) 16 mm., 14 min., sound, color.

Dow Chemical Co., Midland, Mich. 48640.

Air, Water and Industry. 16 mm., 22 min., sound, color.

Water Pollution Control Federation, 3900 Wisconsin Avenue, Washington, D.C. 20016.

Wastewater Treatment Plant Operator Training Course One (with visual aids). 107 2" x 2" color slides.

Wastewater Treatment Plant Operator Training Course Two (with visual aids). 166 2" x 2" color slides.

BASIC HYDRAULICS FOR WATER AND WASTEWATER TECHNOLOGY

Hours Per Week

Class, 3; Laboratory, 4

Course Description

A course to provide the student with an understanding of practical hydraulic design as it applies to the collection, treatment, and distri-

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bution of water and the collection and treatment of domestic and industrial wastewater.

The physical phenomena of hydraulics are studied first, followed by the application of fundamental laws in useful formulae by employing empirical coefficients. Problems studied include pressure on submerged areas, flow in open conduit, flow in a closed conduit, fluid measurement, pipe fitting characteristics, pump characteristics, pump horsepower, and overall pump performance.

Major Divisions

	Hours Class	Hours Laboratory
I. Component Pressures Against Submerged Surfaces	6	8
II. Buoyancy and Flotation	3	6
III. Visual Presentation of Data	2	8
IV. Orifices and Restrictive Devices	9	8
V. Flow of Water over Weirs	9	10
VI. Flow of Water in Closed Conduits	10	12
VII. Flow of Water in Open Channels	3	0
VIII. Pump Design, Selection, and Characteristics	6	12
Total	48	64

I. Component Pressure Against Submerged Surfaces

A. Units of Instruction
1. Terminology
   a. Hydrostatics
   b. Liquid
   c. Head
   d. Atmospheric pressure
2. Measurement of pressure
   a. Gage
   b. Water column
   c. Absolute pressure
   d. U-tube gages
3. Total liquid pressures
   a. Plane area
   b. Components of plane areas
   c. Components of curved areas
   d. Vertical liquid pressure
   e. Hoop tension formula
   f. Pressure centers

B. Laboratory Projects
1. Demonstrate the limitation and correct use of bourdon gages, bellows gages, and manometers.
2. Demonstrate vertical liquid pressure, as in a standpipe.

II. Buoyancy and Flotation

A. Units of Instruction
1. Buoyancy
   a. Archimedes' principle
   b. Specific gravity
   c. Hydrometer principle
2. Flotation
   a. Righting and upsetting moments
   b. Unusual shapes
   c. Stability

B. Laboratory Projects
1. Demonstrate buoyancy principle.
2. Calculate specific gravity of solution by comparison of flotation effect.

III. Visual Presentation of Data

A. Units of Instruction
1. Types of graph paper
2. Proper scaling of paper
3. Points and lines—their meaning
4. Bar graphs
5. Nomographs
6. Schematic diagrams
7. Multiview sketches
8. Graphical interpretation

B. Laboratory Projects
1. Plot and interpret the following types of graphs.
   a. Rectilinear
   b. Polar
   c. Log-log
   d. Trilinear
2. Solve typical flow problems by the use of a nomograph.
3. Make a schematic water treatment process flow diagram, labeling all elements.

4. Construct free-hand sketches of sectional views of a piece of laboratory equipment and show significant dimensions.
5. Make a perspective drawing of a typical treatment process.

IV. Orifices and Restrictive Devices

A. Units of Instruction
1. State of flow
a. Steady
b. Unsteady
c. Uniform
d. Nonuniform
e. Continuity equation
2. Head of concept
a. Potential
b. Pressure
c. Velocity
3. Orifice formuli development
4. Type of orifices
a. Square edge
b. Rounded entry
c. Short pipe
d. Reentrant orifice
e. Flaring
5. Bernoulli's theorem
a. Jet
b. Converging nozzle
c. Venturi meter
d. Kennison nozzle
e. Dall flow tube
f. Pitot tube

B. Laboratory Projects
1. Measure flow by venturi meter, orifice meter, and check volumetrically.
2. Compare loss of head through venturi meters and orifice meters.

V. The Flow of Water over Weirs

A. Units of Instruction
1. Weir terminology
a. Head
b. Nappe
c. Crest
d. Shape
2. Development of general weir formula
3. Special weir conditions
a. Thickness of weir
b. End contractions
c. Approach velocity
4. Types of weirs
a. Triangular
b. Cipoletti
c. Rectangular
d. Dams
e. Submerged
f. Parshall flume
g. Sutro (proportional flow)

B. Laboratory Projects
1. Measure flow by triangular weir, rectangular weir, sutro weir, and check volumetrically.
2. Compare head on weirs by manometers, hook gages and staff gages for accuracy.

VI. Flow of Water in Closed Conduits

A. Units of Instruction
1. Terminology
a. Pipe
b. Closed conduit
c. Uniform flow
2. Development of pipe flow formula
a. Wetted perimeter
b. Hydraulic radius
c. Hydraulic slope
d. Imperical coefficients
3. Empirical formulae
a. Chezy
b. Hazen and Williams
4. Head loss in fittings
a. Theory
b. Curves
c. Tees
d. Enlargements
e. Contractions
f. Valves
g. Hydrants
h. Meters

B. Laboratory Projects
1. Determine head loss in pipe fittings.
2. Demonstrate carrying capacity of pipe at varying depths.
3. Verify Chezy formula for open channel flow.

VII. Flow of Water in Open Channels

A. Units of Instruction
1. Empirical formulae
a. Extension of Chezy formula
b. Kutter's formula

c. Manning formula
d. Bazin formula
2. Turbulent flow
a. Viscosity
b. Length
c. Velocity
d. Roughness
3. Laminar flow

VIII. Pump Design, Selection, and Characteristics

A. Units of Instruction
1. Types
a. Centrifugal
b. Vane
c. Piston
d. Diaphragm
e. Pneumatic
2. Construction
a. Dry-wet pit
b. End-side suction
c. Split-solid case
d. Single-multi stage
e. Manual self-priming
f. Horizontal-vertical installation
3. Selection
a. Flow
b. Head
c. Suction
d. Head variation
e. Job conditions
f. Material to transfer
4. Characteristics
a. Speed
b. Discharge
c. Head
d. Efficiency

B. Laboratory Projects
1. Develop pump characteristics curves for a centrifugal pump.
2. Disassemble two types of pumping units to show construction features.
3. Test and calculate efficiency of a positive displacement pump.

Texts and References

COX and GERMANO. *Fluid Mechanics.*
DAUGHERTY and INGERSOLL. *Fluid Mechanics.*
DODGE and THOMPSON. *Fluid Mechanics.*
HYDRAULIC INSTITUTE. *Pipe Friction Manual.*
KING and BRATER. *Handbook of Hydraulics.*
MCCLAIN. *Fluid Flow in Pipes.*
ROBINSON. *Basic Fluid Mechanics.*
RUSSELL. *Hydraulics.*
VENNARD. *Elementary Fluid Mechanics.*

Visual Aids

Portland Cement Association, 33 W. Grand Avenue, Chicago, Ill. 60610.

Flow in a Circular Culvert. (FWr–6) 16 mm., 20 min., sound, color.

Shell Oil Co., 149 Northern Boulevard, Flushing, N.Y. 11354. *Harnessing Liquids.* 16 mm., 12 min., sound, black and white.

MICROBIOLOGY FOR WATER AND WASTEWATER TECHNOLOGY

Hours Per Week

Class, 2; Laboratory, 6

Course Description

A course to acquaint the technician with the fundamentals of microbiology pertinent to water and wastewater treatment. The nature and behavior of micro-organisms are basic to the entire operation of waste treatment plants, and must be thoroughly understood before adequate design and operation can be comprehended. The subject matter, presented in a natural sequence, includes the life processes of organisms, the sanitary significance of each organism, the specific disease caused by each organism, and the observation and control of organisms. Specific laboratory procedures are given for algae and bottom fauna.

Major Divisions

	Hours Class	Laboratory
I. Scope and Service	2	0
II. The Nature of Life	2	6
III. The Living Cell	2	6
IV. The Life Processes of the Cell	2	0
V. Observations of Microorganisms	4	8
VI. Bacteria	2	12
VII. Fungi	2	8
VIII. Algae	4	10
IX. Protozoa	2	8
X. Microbic Infections	2	0
XI. Microorganism Control	2	8
XII. Higher Animals	2	8
XIII. Plankton Enumeration in Water	2	12
XIV. Bottom-Fauna Samples	2	10
Total	32	96

I. Scope and Service

A. Units of Instruction
1. The scientific method
a. Observation
b. Hypotheses
c. Experiments
d. Deductions
e. Principle
f. Comparison
2. Classification
3. Biology in service of man
a. Agriculture
b. Forestry
c. Fisheries
d. Medicine
e. Public health
f. Society

II. The Nature of Life

A. Units of Instruction
1. Characteristics of living matter
a. Protoplasm
b. Cellular structure
(1) Animal
(2) Plant
c. Energy
(1) Anabolism
(2) Catabolism
d. Irritability
e. Growth
f. Reproduction
(1) Asexual
(2) Sexual
g. Adaption to environment
h. Evolution
2. Introduction to classification
a. Kingdom
b. Phylum
c. Subphylum
d. Class
e. Order
f. Family
g. Genus
h. Species

B. Laboratory Projects
1. Observe and study proper care and use of microscope.
2. Examine a specific organism to illustrate all features of a microscope.

III. The Living Cell

A. Units of Instruction
1. Sizes, shapes, and types
2. Parts of animal cell
a. Membrane
b. Nucleus
c. Nucleolus
d. Nuclear membrane
e. Cytoplasm
f. Mitochondrium
3. Parts of plant cell
a. Vacuole
b. Plasma membrane
c. Nucleus
d. Chloroplast
e. Cytoplasm
4. Cell reproduction
a. Mitosis
(1) Prophase
(2) Interphase
(3) Metaphase
(4) Anaphase
(5) Telophase
(6) Daughter cells
b. Meiosis
5. Chromosomes

B. Laboratory Projects
1. Study prepared slides for specific parts of plant cells.
2. Study prepared slides for specific parts of animal cells.

IV. The Life Processes of the Cell

A. Units of Instruction
1. Photosynthesis
a. Carbon dioxide
b. Sunlight
c. Water
d. Chlorophyll
e. Other elements
2. Oxygen production
3. Cell metabolism
a. Aerobic
b. Anaerobic
4. Interdependence of plants and animals

V. Observation of Microorganisms

A. Units of Instruction
1. Microscope
a. Eye piece
b. Objective
c. Stage
d. Diaphragm
e. Other parts
2. Slide stains—bacteria
a. Gram stain
b. Alcian blue stain
3. Hanging-drop slide
4. Sample concentration
a. Sedgwick-Rafter funnel
b. Centrifuge

B. Laboratory Projects
1. Prepare a gram stain of known culture.
2. Prepare an acid-fast stain of a known culture.
3. Prepare a flagella stain of a known culture.
4. Identify unknown culture.

VI. Bacteria

A. Units of Instruction
1. Definition
2. Forms

B. Laboratory Projects
1. Prepare bacterial cultivation media.
2. Adjust acidity of culture media.
3. Determine plate count on nutrient agar.
4. Determine M.P.N. (most probable number) on lactose broth.
5. Determine count on membrane filter.
6. Prepare pure culture on nutrient agar.

VII. Fungi

A. Units of Instruction
1. General
a. Sanitary significance
(1) Low moisture
(2) Low *p*H
(3) Dark places
b. Food sources
(1) Parasites
(2) Saprophytes
2. Major divisions
a. Myxomycetes—slime fungi
b. Phycomycetes—algae fungi
c. Ascomycetes—sac fungi
d. Basidiomycetes—rusts, smuts, and mushrooms
e. Imperfect fungi
3. Characteristics
a. Aerobic
b. Reproduction
c. True branching
4. Microscopic identification
a. Hanging-drop slide
b. Dried
c. Stained
d. Branching
e. Solid media

B. Laboratory Projects
1. Prepare a pure fungi culture.
2. Classify the protist by morphological details.

VIII. Algae

A. Units of Instruction
1. Definition
2. Classification
a. Chlorophyta—green
b. Euglenophyta—motile green
c. Chrysophyta—golden yellow
d. Pyrophyta—motile brown, golden
e. Cyanophyta—blue-green
3. Identification
a. Physical characteristics
b. Hanging-drop slide
c. Sedgwick-Rafter funnel

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d. Membrane filter
e. Magnification
f. Pure cultures

4. Sanitary significance
   a. Taste
   b. Odor
   c. Filter clogging
   d. Oxygen production

B. Laboratory Projects
1. Prepare a hanging drop slide of known algae.
2. Classify an unknown algae by the hanging-drop slide method.

IX. Protozoa

A. Units of Instruction
1. General
   a. Sanitary significance
      (1) Liquid food
      (2) Solid food
      (3) Bacterial food
   b. Extent of occurrence and distribution
2. Identification
   a. Physical characteristics
   b. Magnifications
   c. Solution
   d. Motility
3. Major classes
   a. Sarcodina
   b. Mastigophora
   c. Sporozoa
   d. Ciliata
4. Species of interest
   a. Amoeba
   b. Endamoeba
   c. Euglena
   d. Volvox
   e. Trichomonas
   f. Plasmodium
   g. Paramecium
   h. Vorticella
   i. Trichodina
   j. Hydra

B. Laboratory Projects
1. Examine prepared known slides of protozoa which have sanitary significance.
2. Prepare wet sample of activated sludge and identify all protozoa.

X. Microbic Infections

A. Units of Instruction
1. Skin
   a. Carbuncle
   b. Smallpox
   c. Shingles
   d. Fever blisters
   e. Warts
2. Mouth and throat
   a. Scarlet fever
   b. Vincent's angina
   c. Diphtheria
3. Intestinal tract
   a. Typhoid fever
   b. Dysentery
   c. Cholera
   d. Hepatitis

XI. Microorganism Control

A. Units of Instruction
1. Physical controls
   a. Temperature
   b. Moisture
   c. Osmosis
   d. Radiation
2. Chemical controls
   a. Phenols
   b. Alcohols
   c. Halogens
   d. Quaternary ammonium compounds
   e. Acids and alkalies
   f. Hydrogen peroxide
3. Antibiotic and chemotherapeutic controls
   a. Sulfonamides
   b. Penicillin
   c. Streptomycin

B. Laboratory Projects
1. Demonstrate effect of osmosis on microorganisms.
2. Determine heat tolerance of microorganisms.
3. Compare effect of chemical agents on microorganisms.

XII. Higher Animals

A. Units of Instruction
1. Rotifera
   a. Metabolism
   b. Motility
   c. Indicators

2. Crustacea
   a. Physiology
   b. Metabolism
   c. Species of interest
      (1) Daphnia
      (2) Cyclops
3. Worms and larvae
   a. Metabolism
   b. Sanitary significance
   c. Species of interest
      (1) Tubifex
      (2) Chironomidae

B. Laboratory Projects
   1. Observe and sketch a known worm specimen.
   2. Isolate and identify rotifera in a water sample.
   3. Study morphological feature of crustacea.

XIII. Plankton Enumeration in Water

A. Units of Instruction
   1. Collection
      a. Bottles
      b. Plankton net
      c. Depth samples
   2. Concentration of sample
      a. Centrifuge
      b. Sedgwick-Rafter funnel
      c. Settling
      d. Filter paper
      e. Cloth disc
   3. Examination
      a. Microscope
      b. Counting cells
      c. Micrometers
   4. Calculation of results
      a. Cubic standard unit
      b. Drop-sedimentation method

B. Laboratory Projects
   1. Prepare a standard algae count by use of the Sedgwick-Rafter funnel.
   2. Check results of Sedgwick-Rafter funnel by use of the membrane filter.

XIV. Bottom-Fauna Samples

A. Units of Instruction
   1. Collection
      a. Ekman dredge
      b. Petersen dredge
      c. Hess sampler
      d. U.S.P.H. samples
   2. Concentration
      a. Screen
      b. Decant
      c. Storage
   3. Examination
      a. Microorganisms
      b. Macroorganisms
   4. Calculation
      a. Organisms per square yard
      b. Organisms per square mile

B. Laboratory Projects
   1. Sample bottom deposits of flowing and still streams for organisms.
   2. Compare the type of organisms found in flowing and still streams.
   3. Identify several organisms and check their sanitary significance.

Texts and References

BURDON. *Textbook of Microbiology.*
MCKINNEY. *Microbiology for Sanitary Engineers.*
PELCZAR *and* REID. *Microbiology.*
WYSS, WILLIAMS, *and* GARDNER. *Elementary Microbiology.*

Visual Aids

Communicable Disease Center, Atlanta, Ga. 30333.

Basic Biology of Bacteria. (5–174) filmstrip, 56 frames, 7 min., color.

Identifying Pathogens. (5–174) filmstrip, 64 frames, 9 min., color.

Sterling Movies, Inc., 43 West 61st Street, New York, N.Y. 10023.

Life with Molds. 16 mm., film, 21 min., sound, color.

U.S. Atomic Energy Commission, Division of Public Information, Washington, D.C. 20545.

Riddle of Photosynthesis. 16 mm., 12½ min., sound, color.

SANITARY CHEMISTRY AND MICROBIOLOGY I

Hours Per Week

Class, 2; Laboratory, 6

Course Description

A systematic study of laboratory procedures as applied to water analyses and purification. The course is designed to provide the student with an understanding of both the theory and laboratory techniques required to perform all analyses to determine the sanitary characteristics of water from a particular source, its suitability for various uses, and to determine the processes required for its purification. Areas of study include: bacteriology, color, turbidity, hydrogen-ion concentration, alkalinity, hardness, coagulation, chlorides, fluorides, iron, manganese, nitrites and nitrates, detergents, and bactericides. Test results should be correlated with specific plant design and/or process control problems for waters in the immediate area.

Major Divisions

	Hours	
	Class	*Laboratory*
I. Introduction	4	8
II. Turbidity	2	4
III. Color	1	4
IV. Hydrogen-ion Concentration: *p*H	2	6
V. Alkalinity	2	6
VI. Coagulation	4	14
VII. Hardness	2	4
VIII. Chlorides	2	4
IX. Fluorides	2	8
X. Iron and Manganese	3	8
XI. Bacteriology	4	14
XII. Detergents	2	8
XIII. Nitrogen	2	8
Total	32	96

I. Introduction

A. Units of Instruction
1. Chemical measurements
   a. Importance of measurements
   b. "Standard methods"
   c. Parts per million
   d. Milligrams per liter
2. Standard solutions
   a. Normality
   b. Standardization
   c. Acid solutions
   d. Base solutions
3. Bacteria
   a. Occurrence
   b. Types, pathogenic and nonpathogenic
   c. Significance in water and wastewater

B. Laboratory Projects
1. Orient the students in the care and use of the analytical balance.
2. Prepare a normal solution.
3. Prepare a molar solution.
4. Prepare specific laboratory reagents to be used in subsequent laboratory projects.

II. Turbidity

A. Units of Instruction
1. Constituents
   a. Organic
   b. Inorganic
2. Significance
   a. Aesthetic
   b. Filterability
   c. Disinfection
3. Methods of determination
   a. Jackson candle turbidimeter
   b. Bottle standards
   c. Color discs
4. Expression and application of results
   a. Standard
   b. Chemical coagulation
   c. Plant evaluation

B. Laboratory Projects
1. Determine turbidity by Jackson candle turbidimeter, and color discs of raw, settled and tap water.
2. Determine turbidity of raw water, using prepared standards.

III. Color

A. Units of Instruction
1. Sources
   a. Swamps
   b. Iron
   c. Dyes
2. Significance
   a. Aesthetic
   b. Staining
   c. Treatment difficulties
3. Methods of determination
   a. Standard color solutions
   b. Color discs

4. Expression and application of results
    a. Platinum cobalt standards
    b. Designing new facilities

B. Laboratory Projects
  1. Determine color of raw, settled, and tap water, using prepared standards.
  2. Determine color of raw water, using color discs.

IV. Hydrogen-ion Concentration: *p*H

A. Units of Instruction
  1. Theory
    a. Ionization constant
    b. H-ions
    c. OH-ions
  2. Measurement
    a. Unit of measurement
    b. Colorimetric
    c. Electrometric
  3. Significance
    a. Control biological processes
    b. Control chemical processes
    c. Simplicity of test

B. Laboratory Projects
  1. Determine hydrogen-ion concentration in raw, settled, and tap water by the colorimetric method.
  2. Determine hydrogen-ion concentration in rain water by the electrometric method.

V. Alkalinity

A. Units of Instruction
  1. General
    a. Sources
    b. Hydroxides
    c. Carbonates
    d. Bicarbonates
  2. Methods of determination
    a. Titration
    b. Phenolphthalein
    c. Methyl orange
    d. Electronic titration
  3. Expression and application of results
    a. Hydroxide
    b. Carbonate
    c. Bicarbonate
    d. Total
    e. Chemical coagulation
    f. Softening
    g. Corrosion control
    h. Buffer capacity
    i. Industrial wastes

B. Laboratory Projects
  1. Determine components of alkalinity, using raw, settled, and tap water as indicator solutions.
  2. Demonstrate alkalinity of water, using methyl orange as an indicator.

VI. Coagulation

A. Units of Instruction
  1. Purposes
    a. Turbidity
    b. Color
    c. Bacteria
    d. Algae
    e. Taste and odor
  2. Coagulants used
    a. Alum
    b. Ferric chloride
    c. Ferric sulphate
  3. Stoichiometric equation
    a. Alum
    b. Sodium aluminate
    c. Ferrous sulphate
    d. Ferric chloride
  4. Coagulation control
    a. Jar test
    b. Hydrogen-ion concentration
    c. Alkalinity
    d. Settling rate
  5. Coagulant aids
    a. Activated silica
    b. Polyelectrolytes

B. Laboratory Projects
  1. Perform the standard jar test on two or more sources of raw water with two or more coagulants.
  2. Visit local water plant and compare results of laboratory coagulant test with operating results.
  3. Determine effect of coagulant aids on the standard jar test.
  4. Perform a cost analysis of coagulation based on chemical performance in a standard jar test.

VII. Hardness

A. Units of Instruction
  1. General

a. Definition
b. Occurrence
c. Sanitary significance
2. Causes and sources of hardness
a. Calcium
b. Magnesium
c. Strontium
d. Iron
e. Manganese
3. Methods of determination
a. Soap
b. E.D.T.A. (ethylenediamine tetraacetic acid)
4. Types of hardness
a. Carbonate
b. Noncarbonate

B. Laboratory Projects
1. Determine hardness of two sources of water by soap method.
2. Determine hardness of two sources of water by E.D.T.A. titration.

VIII. Chlorides

A. Units of Instruction
1. General
a. Occurrence
b. Sanitary significance
2. Methods of determination
a. Mohr
b. Mercuric nitrate
3. Application of results
a. As a tracer
b. Selecting source of water supply
c. As a regulatory measure

B. Laboratory Projects
1. Determine chlorides in two sources of water by the Mohr and the mercuric nitrate methods.
2. Demonstrate chlorides in water, using silver nitrate.

IX. Fluorides

A. Units of Instruction
1. General
a. Occurrence
b. Sanitary significance
c. Proper amount
2. Types used in water supplies
a. Sodium fluoride
b. Calcium fluoride
c. Hydrofluoric acid
d. Sodium silicofluoride
e. Hydrofluosilicic acid
3. Methods of determination
a. Scott-Sanchis
b. Megregian-Maier
4. Application of results
a. Control proper dosage
b. Evaluate removal techniques

B. Laboratory Projects
1. Prepare colorimetric standards for the determination of fluorides.
2. Determine fluorides by Megregian-Maier method.
3. Determine fluorides by Scott-Sanchis method.
4. Check results of fluoride test with spectrophotometer.

X. Iron and Manganese

A. Units of Instruction
1. General
a. Occurrence
b. Sources
c. Sanitary significance
2. Iron determination
a. Orthophenanthroline
b. Tripyridine
3. Manganese determination
a. Persulfate
b. Periodate
4. Application of results
a. Selecting water sources
b. Tracing corrosion products

B. Laboratory Projects
1. Determine iron concentration in two sources by the phenanthroline and tripyridine methods.
2. Determine manganese concentration in two sources by the persulfate and periodate methods.
3. Check results of previous laboratory sessions on iron and manganese by spectrophotometer.

XI. Bacteriology

A. Units of Instruction
1. General
a. Definition

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b. Size
c. Reproduction
d. Shape
e. Occurrence
f. Types
g. Identification

2. Water bacteria: coliforms
3. Total counts
   a. Media
   b. Dilutions
   c. Incubation
   d. Counting
   e. Interpretation
4. Presumptive coliform test
   a. Media
   b. Dilutions
   c. Incubation
   d. Reading
   e. Interpretation
5. Confirmed coliform test
   a. Media
   b. Dilution
   c. Incubation
   d. Reading
   e. Interpretation
6. Coliform density

B. Laboratory Projects
   1. Familiarize the student with the special glassware, dilution principles, and reading equipment used in bacteriology.
   2. Prepare lactose broth, nutrient agar, and other special bacteriological media.
   3. Perform a standard-plate count.
   4. Perform a multiple-tube fermentation test.
   5. Perform a membrane-filter test.

XII. Detergents (Surfactants)

A. Units of Instruction
   1. General
      a. Definition
      b. Soaps
      c. Synthetics
         (1) Anionic
         (2) Nonanionic
         (3) Cationic
   2. Treatability
      a. Soaps
      b. Synthetics
   3. Methods of determination
      a. Methylene blue
      b. Infrared
   4. Sanitary significance
      a. Frothing
      b. Coagulation
      c. Aesthetics downstream
      d. Public health aspect

B. Laboratory Projects
   1. Determine detergents by methylene-blue method.
   2. Determine detergents by spectrophotometer.

XIII. Nitrogen

A. Units of Instruction
   1. General
      a. Life processes
      b. Nitrogen cycle
   2. Sanitary significance
      a. Indicator
      b. Infants' diseases
      c. Control biological process
   3. Methods of analyses
      a. Nesslerization
      b. Distillation
      c. Phenoldisulfonic acid
   4. Application of results
      a. Chlorine needed
      b. Sludge value
      c. Controlling aerobic treatment
      d. Stream control studies

B. Laboratory Projects
   1. Determine nitrogen by nesslerization in two samples of water from different sources.
   2. Determine nitrogen by distillation in two samples of water from different sources.

Texts and References

AMERICAN PUBLIC HEALTH ASSOCIATION. *Standard Methods for the Examination of Water and Wastewater.*

BABBITT, DOLAND, *and* CLEASBY. *Water Supply Engineering.*

HARDENBERGH *and* RODIE. *Water Supply and Waste Disposal.*

HIRSCH. *Manual for Water Plant Operators.*

MUGELE *and* WISEMAN. *Water Treatment.*

NORDELL. *Water Treatment for Industrial and Other Uses.*

PRESCOTT, WINSLOW, *and* MCGRADY. *Water Bacteriology.*

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE, OFFICE OF EDUCATION. *Chemical Technology, a Suggested 2-Year Post High School Curriculum* (OE-80031).

Visual Aids

Atlas Chemical Industries, Public Relations Department, Wilmington, Del. 19899.

Chemistry of Water. 16 mm., 14 min., sound, black and white.

Communicable Disease Center, Atlanta, Ga. 30333.

Basic Biology of Bacteria. (5–174) 35 mm., filmstrip, 56 filmstrip, 74 frames, 8 min., sound, color.

Sampling and Testing Drinking Water. (5–140) 35 mm., filmstrip, 74 frames, 8 min., sound, color.

Membrane Filter. (F–386) 35 mm., filmstrip, 80 frames, 12 min., sound, color.

SANITARY CHEMISTRY AND MICROBIOLOGY II

Hours Per Week

Class, 2; Laboratory, 6

Course Description

A systematic study of laboratory procedures as applied to wastewater treatment and disposal. The course is designed to develop understanding of the theory and adequate laboratory techniques needed to evaluate wastewater treatment methods, operational practices, and the effect of wastewater on a water source. Emphasis is on solids, dissolved oxygen and chemical oxygen demand, relative stability, biochemical oxygen demand, wastewater bacteriology, nitrogen, volatile acids, grease, toxic metals, radiological detection, and stream studies. Test results should be correlated with specific design and/or operational problems of wastewater disposal plants and streams in the immediate area.

Major Divisions

	Hours: Class	Hours: Laboratory
I. Solids	2	8
II. Dissolved Oxygen	2	6
III. Chemical Oxygen Demand	2	3
IV. Relative Stability	2	3
V. Biochemical Oxygen Demand (B.O.D.)	4	12
VI. Wastewater Bacteriology	4	9
VII. Nitrogen	2	6
VIII. Volatile Acids	2	6
IX. Grease	2	6
X. Toxic Metals	4	12
XI. Radiological Detection	2	9
XII. Stream Studies	4	16
Total	32	96

I. Solids

A. Units of Instruction

1. General
   a. Definition
   b. Significance
   c. Sampling
   d. Test errors
2. Total solids
   a. Suspended
   b. Dissolved
   c. Volatile
   d. Fixed
3. Solids analyses
   a. Evaporation
   b. Burn
   c. Filter
   d. Settle
4. Application of results
   a. Sizing units
   b. Sizing blowers
   c. Locating infiltration
   d. Determining efficiency

B. Laboratory Projects

1. Determine the total volatile and fixed residue of a wastewater sample.
2. Determine the volatile and fixed suspended residue of a wastewater sample.
3. Determine the dissolved matter of a wastewater sample.
4. Determine the settleable matter of a wastewater sample.

II. Dissolved Oxygen

A. Units of Instruction

1. Significance
   a. Aerobic bacteria

b. Fish life
c. Corrosion

2. Sampling
a. Specific depth
b. Closed container
c. Displaced liquid

3. Tests
a. Winkler
b. Rideal Stewart
c. Alkali-hypochlorite
d. Field-test method

4. Application of results
a. Determining air needed
b. Degree of pollution
c. Measure stream regeneration
d. Evaluating plant operation

B. Laboratory Projects
1. Determine dissolved oxygen by Winkler method of effluent of all processes of municipal waste plant.
2. Check dissolved oxygen determination for interfering substances by the Rideal-Stewart and alkali-hypochlorite modification.
3. Check all determinations by use of electrometric dissolved oxygen probe.

III. Chemical Oxygen Demand

A. Units of Instruction
1. Theory
a. Potassium permanganate oxidizes carbonaceous material
b. Ferrous ammonium sulfate

2. Tests
a. Sample size
b. KMm04
c. H2S04
d. Temperature
e. Ferrous amonium sulfate
f. Titrate

3. Application of results
a. Comparative evaluation
b. Necessary where toxic chemical prevent biochemical oxygen demand
c. Quick idea of pollution load

B. Laboratory Projects
1. Determine chemical oxygen demand of two sources of wastewater.
2. Determine chemical oxygen demand of untreated domestic wastewater.

IV. Relative Stability

A. Units of Instruction
1. Theory
a. Definition
b. Methylene blue
c. Percent oxygen demand

2. Tests
a. Sample
b. Methylene blue
c. Incubate
d. Calculations

3. Applications of results
a. Small plants because easy to run
b. Not definite results
c. Testing being replaced by dissolved oxygen

B. Laboratory Projects
1. Determine the relative stability of several waste treatment plant effluents and compare results.
2. Determine the relative stability of untreated domestic wastewater.

V. Biochemical Oxygen Demand (B.O.D.)

A. Units of Instruction
1. General
a. Definition
b. Types of demand
c. Stabilization time
d. Sampling

2. Tests
a. Dilution technique
b. Dilution water
c. Seeding
d. Pretreatment
e. Incubation
f. Filtration
g. Seed correction
h. 40–70 percent depletion
i. Calculations

3. Application of results
a. Degree of pollution
b. Plant evaluation
c. Sizing of treatment units
d. As a regulatory charge

B. Laboratory Projects
1. Prepare B.O.D. dilution water.
2. Set up appropriate dilution on effluent of all processes of local waste treatment plant.
3. Standardize thiosulfate.

4. Titrate samples with thiosulfate and calculate B.O.D.

VI. Wastewater Bacteriology

A. Units of Instruction
   1. Purpose
      a. Degree of pollution
      b. Tracer
   2. Types of tests
      a. Plate count
      b. Lactose broth
      c. Membrane filter
      d. Selective media
   3. Interpretation of results
      a. Most probable number (M.P.N.)
      b. Total count
      c. Coliform colonies
      d. Dilutions
   4. Application of results
      a. Utilization of a particular water supply
      b. Determining pollution
      c. Differentiating types of bacteria
      d. Evaluate by standards

B. Laboratory Projects
   1. Prepare dilutions of sample to cover wide range of bacterial counts.
   2. Determine the M.P.N. of a wastewater sample by the lactose broth fermentation tube method.
   3. Prepare a standard plate count on a wastewater sample.
   4. Determine by appropriate tests the reduction of coliform bacteria through the municipal waste treatment plant.

VII. Nitrogen

A. Units of Instruction
   1. General
      a. Occurrence
      b. Index of pollution
      c. Water treatment significance
      d. Nitrogen cycle
   2. Ammonia nitrogen
      a. Distillation
      b. Nesslerization
   3. Nitrate nitrogen
      a. Phenoldisulfonic acid
      b. Brucine
   4. Nitrite nitrogen
   5. Organic nitrogen
   6. Application of nitrogen
      a. Determining chlorine demand
      b. Sewage sludge value
      c. Sewage treatment control
      d. Fertilizing value of natural waters

B. Laboratory Projects
   1. Determine ammonia nitrogen by distillation and nesslerization in raw wastewater sample.
   2. Determine nitrate nitrogen by brucine and phenoldisulfonic methods in raw wastewater sample.
   3. Determine nitrite nitrogen in raw wastewater sample by means of a spectrophotometer.

VIII. Volatile Acids

A. Units of Instruction
   1. General
      a. Anaerobic
      b. How formed
      c. Associated organisms
   2. Test methods
      a. Steam distillation
      b. Direct distillation
   3. Application of test results

B. Laboratory Projects
   1. Determine volatile acids in a digestor sample by the direct distillation method.
   2. Repeat #1, using the steam distillation method.

IX. Grease

A. Units of Instruction
   1. General
      a. Grease characteristics
      b. Detrimental effects
      c. Organic substance included
   2. Test methods
      a. Soxhlet
      b. Semiwet
   3. Application of test results
      a. Regulatory purposes
      b. Treatment evaluation
      c. Industrial process evaluation: waste
      d. Sludge content for fertilizer
      e. Filterability of sludge

B. Laboratory Projects
   1. Determine grease content of domestic

wastewater and an industrial water waste by the Soxhlet and semiwet methods.

2. Determine grease content of river or marsh water.

X. Toxic Metals

A. Units of Instruction

1. General
   a. Characteristics
   b. Sources
2. Preliminary treatment
   a. Acid indigestion
   b. Filtration
3. Test methods
   a. Cadmium-dithizone
   b. Chromium-diphenylcarbazide
   c. Copper-neocuproine
   d. Iron-phenanthroline
   e. Lead-dithizone
   f. Manganese-periodate
   g. Nickel-chloroform
   h. Zinc-dithizone
4. Application of test results
   a. Regulatory control
   b. Effect on biological treatment
   c. Effect on fish life
   d. Effect on humans
   e. Recovery of materials

B. Laboratory Projects

1. Determine total chromium in a metal plating waste sample.
2. Determine nickel concentration in a metal plating waste sample.
3. Determine zinc concentration in a metal plating waste sample.

XI. Radiological Detection

A. Units of Instruction

1. General
   a. Nature of problem
   b. Sources
   c. Terminology
   d. Decay system
2. Ionization
   a. Definition
   b. Effect
   c. Measurement
   d. Protection
3. Sample collection
   a. Glassware
   b. Preservation
4. Counting instruments
   a. End window ionization chamber
   b. Internal proportional counter
5. Expression of results
   a. Picocuries per liter
   b. Nanocurie
   c. Microcurie
   d. Millicurie
6. Alpha and beta radioactivity
   a. Suspended
   b. Dissolved
7. Strontium
8. Application of results
   a. Tracing isotopes
   b. Determining potability
   c. Safety precaution in reactors

B. Laboratory Projects

1. Familiarize the student with the equipment, using samples with known radiological counts.
2. Prepare samples for counting.
3. Determine total alpha and gross beta activity.
4. Determine strontium-90 content in raw and treated water in a local treatment plant.

XII. Stream Studies

A. Units of Instruction

1. Purposes
   a. Determine degree of pollution
   b. Determine recovery of stream
2. Sampling devices
   a. Dissolved gases
   b. Microscopic organisms
   c. Chemical
3. Concentration of microscopic organisms
   a. Sling filter
   b. Cotton disc
   c. Sedgwick-Rafter funnel
   d. Centrifuge
4. Oxygen balance
   a. Pollution effect
   b. Reaeration
   c. Plant sources of oxygen

5. Application of study data
    a. Determine degree of pollution allowable
    b. Determine required flow from reservoirs
    c. Determine safety of water for recreation and harvesting of shell fish

B. Laboratory Projects
1. Determine flow of streams by velocity meters and cross sectional area.
2. Run plankton counts on stream above pollution entrance, and several places below.
3. Check bottom fauna above point of pollution and in several places below.
4. Determine dissolved oxygen and B.O.D. above point of pollution and in several places below.

Texts and References

AMERICAN PUBLIC HEALTH ASSOCIATION. *Standard Methods for the Examination of Water and Wastewaster.*

BABBITT. *Sewage and Sewage Treatment.*

HAWKES. *The Ecology of Wastewater Treatment.*

RICH. *Unit Processing of Sanitary Engineering.*

SAWYER. *Chemistry for Sanitary Engineers.*

WATER POLLUTION CONTROL FEDERATION. *Operation of Wastewater Treatment Plants.*

WATER SUPPLY AND WASTEWATER CONTROL

Hours Per Week

Class, 2; Laboratory, 4

Course Description

A course designed to familiarize the technician with the engineering aspects of water supply, water distribution, wastewater collection, and wastewater treatment and disposal. Areas of instruction in water supply and distribution include: sources, quantity required, effect of storage on quality, storage capacity, water transmission, watershed protection, quality evaluation, stream sampling procedures, and distribution design. Studies in wastewater include: physical conditions, quantity anticipated, collection system design, collection system maintenance, wastewater lift stations, biological life associated with water pollution control, and the effect of liquid wastes on streams and lakes. Sufficient instructional material should be provided so that the wastewater part of the course will relate to a more comprehensive study in the fourth semester.

Major Divisions

	Hours Class	Hours Laboratory
I. Water Sources	2	0
II. Water Demand	2	0
III. Water Storage	3	8
IV. Storage Effect on Water	2	0
V. Raw Water Transmission	2	10
VI. Watershed Protection	2	0
VII. Water Quality Evaluation	2	0
VIII. Water Distribution Design	4	14
IX. Wastewaters	2	0
X. Wastewater Collection	4	16
XI. Wastewater Treatment	4	8
XII. Effect of Liquid Wastes on Streams and Lakes	3	8
Total	32	64

I. Water Sources

A. Units of Instruction
1. Rain water supplies
    a. Area required; roof
    b. Storage required; cisterns
2. Surface water supplies
    a. Ponds and lakes
    b. Rivers
        (1) Continuous draft
        (2) Flood water storage
        (3) Impounding reservoir
3. Ground water supplies
    a. Springs
    b. Shallow wells
    c. Deep wells

d. Artesian wells
e. Infiltration galleries
f. Filter crib and flooded areas

B. Laboratory Projects (none)

II. Water Demand

A. Units of Instruction
1. Domestic
a. Metered
b. Nonmetered
2. Industrial
3. Fire demand
a. Duration
b. Population
4. Demand factors
a. Living standard
b. Climate
c. Quality
d. Size of city

B. Laboratory Projects (none)

III. Water Storage

A. Units of Instruction
1. Rainfall
a. Amount
b. Measurement and records
c. Distribution
2. Storage losses
a. Evaporation
b. Infiltration
c. Transpiration
3. Rainfall-runoff relationship
a. Loss coefficient
b. Intensity
c. Area
4. Mass curve
a. Stream yield
b. Demand

B. Laboratory Projects
1. Predict population growth of typical city by graphical projection showing arithmetical, geometric, and incremental increase, and the population census ratio.
2. Determine yield of watershed by rainfall-runoff relationship.
Determine raw water storage requirement for a typical supply by means of mass diagram, dryest month, and empirical data.

IV. Storage Effect on Water

A. Units of Instruction
1. Sedimentation
2. Bacterial decay
3. Organic matter decomposition
4. Controlling factors
a. Shape
b. Size
c. Depth
d. Temperature
e. Organic content
f. Wind action

B. Laboratory Projects (none)

V. Raw Water Transmission

A. Units of Instruction
1. Methods
a. Open channel
b. Closed conduit
2. Proper intake design
a. Variable depth
b. Proper values
c. Debris screen
d. Ice protection

B. Laboratory Projects
1. Select and detail transmission line and appurtenances for a specific flow and topographic condition.
2. Draw and detail a raw water intake structure for a specific flow and impoundment condition.

VI. Watershed Protection

A. Units of Instruction
1. Wastewater Pollution
a. Domestic
b. Industrial
2. Recreation
3. Erosion

B. Laboratory Projects (none)

VII. Water Quality Evaluation

A. Units of Instruction
1. Potability
a. Bacteria
b. Taste
c. Odor

2. Chemical
   a. Calcium
   b. Magnesium
   c. Iron
   d. Manganese
   e. Sulphur
   f. Carbon dioxide
   g. Methane
3. Physical
   a. Hardness
   b. Corrosiveness
   c. Color
4. Manufactured pollutants
   a. Phenols
   b. Metal wastes
   c. Acids
5. Natural pollutants
   a. Fluorides
   b. Phosphates
   c. Manganese
   d. Iron

B. Laboratory Projects (none)

VIII. Water Distribution Design

A. Units of Instruction
1. Component parts
   a. Pipes
   b. Valves
   c. Hydrants
   d. Storage
2. System layout
   a. Belt
   b. Grid
   c. Tree
3. Quantity considerations
   a. Area demand
   b. Plant location
   c. Expected growth
4. General rules
   a. Pipe sizes
   b. Hydrants
   c. Interconnections
   d. Velocities
5. Planning methods
   a. Pressure contours
   b. Fire flows
   c. Pitometer studies
6. Elevated storage
   a. Constant head
   b. Unequal demand
   c. Fire protection
   d. Plant malfunction

B. Laboratory Projects
1. Select proper pipe size for principal distribution mains, with elevated storage located at various points in a typical city.
2. Construct a pressure contour map of a section of a typical city.
3. Select and detail water distribution system of a typical subdivision to comply with N.B.F.U. requirements.

IX. Wastewaters

A. Units of Instruction
1. Composition
   a. Sources
   b. Physical
   c. Chemical
   d. Biological
2. Quantity
   a. Population prediction
   b. Flow per capita
   c. Flow pattern
   d. Infiltration
   e. Industrial

B. Laboratory Projects (none)

X. Wastewater Collection

A. Units of Instruction
1. Transportation
   a. Gravity flow
   b. Pressure mains
   c. Appurtenances
2. Collection system design
   a. Population
   b. Flow formuli
   c. Nomographs
   d. Map construction
   e. Profiles
   f. Construction materials
   g. Construction procedures
3. Maintenance of collection system
   a. Inspection
   b. Measuring
   c. Cleaning
   d. Flushing
   e. Repairs

f. Taps
g. Explosions

B. Laboratory Projects
1. Diagram a wastewater collection system for a subdivision, complete with profile and details.
2. Visit a sanitary sewer construction project to observe materials, equipment, and methods used.
3. Draw in detail a liquid waste lift station for a specific flow.

XI. Wastewater Treatment

A. Units of Instruction
1. Necessity of treatment
a. Protect health
b. Preserve aesthetic environment
c. Preserve recreational areas
2. Disposal without treatment
a. Dilution
b. Irrigations
c. Lagoons
3. Primary treatment
a. Screens
b. Natural sedimentation
c. Sludge disposal
4. Secondary treatment
a. Conditioning
b. Biological process
c. Sludge disposal
5. Disinfection and deodorization
a. Chlorine
b. Lime
c. Hydrogen sulfide
d. Organic compound

B. Laboratory Projects
1. Visit selected installations in the locality for innovations in basic processes.
2. Prepare a report describing and comparing the main features of each installation visited.

XII. Effect of Liquid Wastes on Streams and Lakes

A. Units of Instruction
1. Zones of pollution
a. Degradation
b. Decomposition
c. Recovery
2. Methods of recovery
a. Wind action
b. Biological organisms
c. Shallow versus deep water
d. Indices of self-purification
3. Biological life of pollution
a. Worms
b. Fungi
c. Protozoa
d. Resistant forms of fish
4. Bottom deposits
a. Oxygen demand
b. Oxygen penetration
c. Rising problems
5. Industrial wastes
a. Oxygen consuming wastes
b. Colored wastes
c. Toxic wastes
d. Obstructing wastes
e. Acid wastes

B. Laboratory Projects
1. Observe streams above and below discharge points for visible effect of pollution.
2. Check effluent from a wastewater lagoon for comparison with municipal waste treatment plant.

Texts and References

FAIR and GEYER. *Elements of Water Supply and Wastewater Disposal.*

HARDENBERGH and RODIE. *Water Supply and Waste Disposal.*

WATER POLLUTION CONTROL FEDERATION. *Design and Construction of Sanitary and Storm Sewers.*

Visual Aids

Can-Lex Industries, Inc., Film Library, Cannelton Sewer Pipe Division, Cannelton, Ind. 77520.

The Gamble. 16 mm., 16 min., sound, color.
From the Earth and Back Again. 16 mm., 25 min., sound, color.

Here's How with Clay Pipe. 16 mm., 22 min., sound, color.
Sewers—Guardian of Community Health. 16 mm., 26 min., sound, color.

Cast Iron Pipe Research Association, 3440 Prudential Plaza, Chicago, Ill. 60601.

The Manufacture of Cast Iron Pressure Pipe. 16 mm., 28 min., sound, color.

Installation of Cast Iron Pipe. 16 mm., 18 min., sound, color.

City of Long Beach, Sewer Division, 1601 San Francisco Avenue, Long Beach, Calif. 90813.

A Day with the Long Beach Sewer Maintenance Department. 16 mm., 14 min., sound, color.

Johns-Manville Sales Corporation, Celite Division, 22 East 40th Street, New York, N.Y. 10016.

Pipelines to Health. 16 mm., 23 min., sound, color.

WATER PURIFICATION

Hours Per Week

Class, 3; Laboratory, 3

Course Description

This course familiarizes the technician with the elementary engineering aspects of the design, operation, and maintenance of water purification plants. Specific topics cover design parameters for all processes, materials used and their purposes, types of miscellaneous equipment and their operation, maintenance of plant and equipment, and typical solutions to specific operational problems. Subject matter includes aeration, sedimentation, slow sand filtration, rapid sand filtration, chlorination, mineral control, maintenance programs, health regulations, and plant records. A critical evaluation of the design and operation of a local plant completes the course.

Major Divisions

	Hours Class	Hours Laboratory
I. Aeration	2	4
II. Sedimentation	6	4
III. Filtration	8	8
IV. Chlorination	4	4
V. Coagulation	8	8
VI. Bacteriological Control	4	4
VII. Softening	4	4
VIII. Clear-Well Storage	4	6
IX. Public Health Standards	2	0
X. Maintenance Organization	2	2
XI. Preventive Maintenance	2	0
XII. Pumps and Prime Movers	2	4
Total	48	48

I. Aeration

A. Units of Instruction
1. Objectives
   a. Taste and odor
   b. Dissolved gases
   c. *p*H alteration
   d. Demineralization
   e. Disinfection
2. Types of aerators
   a. Perforated pipe
   b. Diffusers
   c. Air lift pump
   d. Mechanical
   e. Gravity
3. Theory
   a. Partial pressure
   b. Solubility
4. Aerator design problems
   a. Hydraulic
   b. Ventilation
   c. Aesthetic
5. Operational problems
   a. Pipe corrosion
   b. Jet clogging
   c. Flow distribution
   d. Collection devices

B. Laboratory Projects
1. Diagram a local installation.
2. Calculate hydraulic head loss through a typical aerator.
3. Determine aerator pipe sizes for a specific design flow.

II. Sedimentation

A. Units of Instruction
1. Theory
   a. Viscosity
   b. Particle size and shape
   c. Concentration
   d. Stokes' law
   e. Hazens' theory
2. Types of sedimentation basins
   a. Longitudinal
   b. Radial
   c. Counterflow

3. Design parameters
   a. Time-volume
   b. Length to width
   c. Depth
   d. Surface area
4. Operational problems
   a. Dead spaces
   b. Short circuiting
   c. Wind action
   d. Cleaning

B. Laboratory Projects
1. Measure and calculate detention time of a sedimentation basin.
2. Using dyes, determine flow time and pattern of a sedimentation basin.

III. Filtration

A. Units of Instruction
1. Theory
   a. Physical
   b. Chemical
   c. Biological
   d. Biochemical
2. Types of filtration
   a. Slow
   b. Rapid
3. Design parameters
   a. Flow
   b. Depth
   c. Backwash
   d. Head loss
   e. Sand specification
   f. Underdrains
   g. Wash-water troughs
   h. Rate controllers
   i. Surface washes
   j. Sampling devices
4. Operational problems
   a. Mud ball
   b. Cracking and clogging of filter
   c. Air lock
   d. Stoppage caused by algae
   e. Iron and manganese deposition
   f. Carbon coating
   g. Loss of sand
   h. Gravel displacement

B. Laboratory Projects
1. Describe the design parameters of an existing rapid sand filter.
2. Prepare a detail diagram of the construction features of a rapid sand filter.
3. Calibrate rate controller by means of hook gage and stop watch.
4. Calibrate loss of head gages by means of piezometer tubes.

IV. Chlorination

A. Units of Instruction
1. Purposes
   a. Kill bacteria
   b. Taste and odor
   c. Oxidize iron and manganese
   d. Oxidize organic matter
2. Point of application
   a. Chlorination
   b. Prechlorination
   c. Postchlorination
   d. Rechlorination
3. Chlorination practice
   a. Chlorine-ammonia
   b. Free residual
   c. Breakpoint
   d. Superchlorination
   e. Dechlorination
4. Methods of application
   a. Liquid
   b. Gas
   c. Chlorine compound
   d. Commercial apparatus
5. Determination of dosages
   a. Chlorine demand
   b. Residuals at plant
   c. Residuals at end of distribution
6. Operational problems
   a. Solution feed lines
   b. Freezing
   c. Chlorine hydrate
   d. Diffusion
   e. Toxicity

B. Laboratory Projects
1. Trace the chlorine feeding system of a local installation.
2. Prepare a cost analysis of the various chlorine compounds available.
3. Check gravimetric feed rate against visual meter for 24-hour run.

V. Coagulation

A. Units of Instruction

1. General
   a. Definition
   b. Purposes
2. Theory of coagulation
   a. Colloids
   b. Ionic charge
   c. Absorption
   d. *p*H and buffer action
   e. Temperature
3. Chemical reactions
   a. Alum
   b. Sodium aluminate
   c. Ferric chloride
   d. Lime
   e. Coagulant aids
4. Mixing and flocculation
   a. Effect of coagulation
   b. Devices for mixing and flocculation
   c. Handbook design parameters
   d. New source investigation
   e. Jar test
5. Operational problems
   a. Handling of bulk chemicals
   b. Types of feeders
   c. Calibration of feeders
   d. Care of feeders
   e. Chemical specifications
   f. Solution feeders
   g. Sizing machines
   h. Chemical dosage calculations
   i. Safety precautions

B. Laboratory Projects

1. Observe and sketch the operational principle of two types of dry chemical feed machines.
2. Measure, calculate, and draw the mixing basin of a local plant.
3. Measure, calculate, and draw the coagulating basin of a local plant.
4. Design a coagulating basin for a specific flow-rate complete with agitators.

VI. Bacteriological Control

A. Units of Instruction

1. Chemicals used
   a. Chlorine
   b. Sodium hypochlorite
   c. Alum
   d. Ozone
   e. Lime
   f. Copper sulphate
2. Laboratory samples
   a. Hand
   b. Pressure
   c. Sample points
   d. Frequency
3. Operational problems
   a. Machine malfunction
   b. Surface contamination
   c. Cross connection
   d. Distribution contamination
   e. New line sterilization
   f. Algae

B. Laboratory Projects

1. Calculate the quantity of chlorine required to sterilize a new main installation.
2. Diagram in detail a vacuum release valve installation.

VII. Softening

A. Units of instruction

1. General
   a. Soap saving
   b. Scale prevention
   c. Economics
2. Substances causing hardness
   a. Calcium salts
   b. Magnesium salts
   c. Iron salts
   d. Aluminum salts
3. Lime-soda process
   a. Chemicals
   b. Reactions
   c. Laboratory control
   d. Limitation
   e. Split treatment
4. Zeolite process
   a. Chemicals
   b. Reactions
   c. Cost considerations
5. Operational problems
   a. Sludge disposal
   b. Excess chemicals in effluent
   c. Split treatment
   d. Condition of water

B. Laboratory Projects (none)

VIII. Clear-Well Storage

A. Units of Instruction

1. Function
   a. Operate filters at constant rate
   b. Failures of treatment system
2. Types
   a. Ground *vs.* elevated
   b. Open *vs.* covered
   c. Natural *vs.* artificial
3. Quantity requirements
   a. Based on filter capacity
   b. Based on population
   c. Based on fire flow
4. Operational problems
   a. Larvae infestation
   b. Bactericidal retention
   c. Cleaning
   d. Flow-level control
   e. Migratory birds

B. Laboratory Projects

1. Observe several types of clear-well storage reservoirs.
2. Calculate the hydraulic head loss in clear-well storage.

IX. Public Health Standards

A. Units of Instruction

1. Terminology
   a. Artificial treatment
   b. Sanitary defects
   c. Health hazard
   d. Coliform bacteria
2. Bacterial quality
   a. Sampling
   b. Test limits
   c. Exceptions
3. Physical limits
   a. Turbidity
   b. Color
4. Chemical limits
   a. Phenols
   b. Sulfates
   c. Arsenic
   d. Metals

X. Maintenance Organization

A. Units of Instruction

1. Functions
2. Essentials of program
   a. Organization
   b. Responsibilities
   c. Capabilities
   d. Secondary skill
3. Work execution
   a. Repair order
   b. Backlog control
   c. Job analysis
   d. Forecasting
   e. Parts inventory
   f. Tools
   g. Planning
4. Training
   a. Supervisory
   b. Wage roll
   c. Engineering functions
5. Preventive maintenance
   a. Standard tasks
   b. Inspection and overhaul
6. Maintenance improvement
   a. Engineering analysis
   b. Job practices
   c. Emergency investigations
7. Corrective maintenance
   a. Equipment history
   b. Engineering records
   c. Engineering analysis
   d. Design
   e. Materials
8. Cost control
   a. Direct, indirect, general
   b. Budgets
   c. Charts

B. Laboratory Projects

1. Observe the maintenance organizations of the local water treatment plant as to work orders, follow-up, and records.
2. Study the cost control for maintenance in a water treatment plant.

XI. Preventive Maintenance

A. Units of Instruction

1. Corrosion
   a. Definition
   b. Control objectives
   c. Corrosion mechanism
   d. Types of corrosion
   e. Reduction methods
2. Protective coating
   a. Purpose

b. Pretreatment for metal finishes
c. Electroplating
d. Hot dipping
e. Diffusion
f. Metal spraying
g. Paint coatings
h. Application methods
i. Testing

3. Lubrication
a. Functions
b. Properties of lubricants
c. Greases
d. Oils

B. Laboratory Projects (none)

XII. Pumps and Prime Movers

A. Units of Instruction

1. Principle causes of pump malfunction
a. Wear
b. Clogging
c. Corrosion
d. Priming
e. Packing

2. Indications of Trouble
a. Decreased pumping
b. Noise
c. Vibration
d. Heat
e. Excessive current
f. Electrical switch trips out
g. Pulls air in through packing

3. Routine maintenance of pumps
a. Oil or grease check
b. Packing check
c. Wearing rings
d. Bearings
e. Alignment
f. Vibration

4. Routine maintenance of motors
a. Oil and grease check
b. Current check
c. Brush check
d. Armature clearance
e. Armature and winding cleanliness

B. Laboratory Projects

1. Disassemble a centrifugal pump—identifying all parts.
2. Measure wearing rings to determine clearance.
3. Renew packing and check priming procedure.

Texts and References

BABBITT, DOLAND, *and* CLEASBY. *Water Supply Engineering.*

FAIR *and* GEYER. *Elements of Water Supply and Wastewater Disposal.*

HARDENBERGH *and* RODIE. *Water Supply and Waste Disposal.*

STANIAR. *Plant Engineering Handbook.*

TIPEI. *Theory of Lubrication.*

SCHREIR. *Corrosion.*

Visual Aids

The Carborundum Co., Niagara Falls, N.Y. 14302.

Porous Underdrains. 16 mm., film, 15 min., sound, black and white.

Modern Talking Picture Service, Washington, D.C. 20006.

Pure Water and Public Health. 16 mm., 28 min., sound, color.

U.S. Public Health Service, Communicable Disease Center, Atlanta, Ga. 30333.

Functioning of Gas Feed Chlorinators Part II: Volume Metering Chlorinators. (F–146b) 42 frames, 10 min., sound, color.

A Drop in the Bucket (Fluoride). M 1 S–318, 16 mm., 13 min., sound, color.

WASTEWATER TREATMENT

Hours Per Week

Class, 3; Laboratory, 3

Course Description

This course offers the elementary engineering aspects of the design, operation, and maintenance of wastewater treatment plants and includes specific topics on: design parameters for all processes; materials used and their purposes; type and operation of miscellaneous equipment; maintenance of plant and equipment and typical solutions to specific operational problems. Units of instruction cover: methods of wastewater treatment, hydraulics layout of treatment plant, selection of treatment method, industrial wastewater treatment, maintenance programs, health regulations, and pertinent reports. A critical evaluation of a local wastewater treatment plant completes the course.

Major Divisions

	Hours Class	Hours Laboratory
I. Methods of Treatment	6	9
II. Treatment Selection	6	12
III. The Treatment Plant	14	12
IV. Industrial Wastewaters	12	6
V. Rules, Regulations, and Forms	4	3
VI. Preventive Maintenance	2	3
VII. Sewer Cleaning	2	3
VIII. Safety	2	0
Total	48	48

I. Methods of Treatment

A. Units of Instruction

1. Review of basic treatment processes
   a. Preliminary
   b. Primary
   c. Biological
   d. Chemical
   e. Complete
   f. Disinfection
2. Innovations in processes
   a. Neutralization
   b. Roughing filters
   c. Guggenheim process
   d. Kraus process
   e. Extended aeration
   f. Stabilization ponds
   g. Stage aeration
   h. Two stage digestion
   i. Pearth gas recirculation
   j. Bioflocculation
   k. Subsurface irrigation
   l. Cavitation
   m. Hay's process
   n. Aero clarifier
   o. Other proprietary treating devices

B. Laboratory Projects

1. Prepare flow diagrams for several types of treatment processes that can be found in the locality.
2. Prepare reports on various manufacturer's proprietary treating devices, indicating the process and expected efficiency.

II. Treatment Selection

A. Units of Instruction

1. Objectives of treatment
   a. Protect health
   b. Avoid nuisance
   c. Protect aquatic life
   d. Protect recreational areas
2. Use of septic tank and nitrification field
   a. Home wastes
   b. Wastes from small institutions
   c. Areas without water courses
   d. Attainment of high degree of treatment
   e. Controlled biological activity assumed
   f. Control of odors by treatment
   g. Porosity of soil
   h. Maintenance of system
3. Use of septic tank and sand filter
   a. Wastes from medium-sized institutions
   b. Assured biological activity
   c. Utility of remote filtering unit
   d. Areas with dense, nonporous soil
   e. Routine maintenance available
   f. Attainment of high degree of treatment
   g. Effect of limited water course
   h. Suitable for temperate climates
4. Anaerobic lagoons
   a. Organic industrial wastes
   b. Odor problems minimized
   c. Minimum maintenance requirements
   d. Secondary treatment in aerobic lagoons
   e. Relative low cost
   f. Suitable for seasonal operation
   g. Suitable for remote locations
   h. Sludge handling eliminated
5. Aerobic lagoons
   a. Economic considerations
   b. Suitable for remote locations
   c. Availability of required areas
   d. Low maintenance requirements
   e. Suitable for temperate climates
   f. Biological activity assured
   g. Sludge handling eliminated
6. Extended aeration
   a. Multiple home wastes
   b. Institutional and industrial wastes
   c. Minimum maintenance requirements
   d. Sludge handling eliminated
   e. Minimum water course requirements
   f. Odors eliminated

g. Locate adjacent to inhabited buildings
h. Power requirements
i. Problems of location in remote areas

7. Complete municipal system
   a. Flow exceeds 50,000 gallons/day
   b. Adequate operating personnel
   c. Reasonable water course for dilution
   d. Located in remote area if possible
   e. Anticipating growth

B. Laboratory Projects

1. Make a diagram of a septic tank showing details of the entire system. Write a report describing the function of the system; its advantages and limitations in detail.
2. Write a report describing either an anaerobic or an aerobic lagoon. Diagram the system and present a detailed analysis of its operation and limitations.
3. Make a field trip to a municipal wastewater treatment plant. Make a diagram of the complete system, and write a report describing its operation in detail.

III. The Treatment Plant

A. Units of Instruction

1. Physical facilities
   a. General appearance
   b. Sewage flow
   c. Screens
   d. Sedimentation
   e. Intermediate treatment
   f. Secondary settling
   g. Sludge digestion
   h. Sludge disposal
2. Hydraulic layout of plant
   a. Pipe sizes
      (1) Flow
      (2) Head loss
   b. Recirculation
   c. Pump study
      (1) Flow
      (2) Head
      (3) Horsepower
   d. Special features
      (1) Sludge lines
      (2) Sludge gas storage
      (3) Sludge heating
      (4) Dried sludge removal
3. Laboratory efficiency check
   a. B.O.D.: raw, settled, filtered, final
   b. Solids: raw, settled, filtered, final
   c. Oxygen consumed: raw, settled, filtered, final
   d. Nitrogen: raw, settled, filtered, final

B. Laboratory Projects

1. Calculate the hydraulic head loss in a local plant.
2. Determine pump size and horsepower for recirculation pump in a local plant.
3. Study a standardized check-list used at a specific plant in the locality.
4. Assign specific operation and problems for students to solve by investigation of the local municipal waste treatment plant.

IV. Industrial Wastewaters

A. Units of Instruction

1. Nature of wastes
   a. Inorganic
   b. Organic
   c. Mixed
2. Waste effects
   a. Stream
   b. Aquatic life
   c. Economy
3. Characteristics and methods of treatment
   a. Textile
   b. Food processing
   c. Metal plating wastes
   d. Laundry
   e. Soap and detergent
   f. Insecticides
   g. Radioactive wastes
   h. Paper and pulp
   i. Acid mine drainage

B. Laboratory Projects

1. Plan a treatment process for specific industrial wastes and flow based on latest literature.
2. Observe and identify the principles and methods used in an industrial wastewater treatment process in a local plant.

V. Rules, Regulations, and Forms

A. Units of Instruction

1. Purposes
   a. Protect utility and operator

b. Record accomplishments
c. Efficiency index
d. Guide and reminder
e. Future planning and construction guide

2. Types of records
a. Daily log
b. Equipment repair and maintenance
c. Operating costs
d. Operating records
e. Laboratory results
f. Complaints

3. Monthly forms required by the Water Pollution Control Agency
a. Laboratory
b. Operational

4. Contents of annual report to governing board
a. Performance
b. Major changes
c. Personnel changes
d. Comments
e. Recommendations

B. Laboratory Projects

1. Review the operating records of the local wastewater treatment plant for information on efficiency, costs, and operational problems.
2. Prepare a sample monthly report, using data from the operating records reviewed in item #1.

VI. Preventive Maintenance

A. Units of Instruction

1. Purposes
a. Costs
b. Performance
c. Equipment manufacturer's recommendations

2. Lubrication
a. Function
b. Properties of lubricants
c. Greases

3. Protective coatings
a. Purposes
b. Specific applications

4. Electrical equipment
a. Effects of moisture
b. Voltage
c. Contact points
d. Overload protection
e. Armature clearance
f. Adequate rating
g. Bearing wear

5. Plant structure
a. General appearance
b. Structural protection
c. Aesthetic considerations
d. Gas regulating devices

6. Plant equipment
a. Screening devices
b. Chain drives
c. Sand beds
d. Grinders
e. Valves
f. Auxiliary power units
g. Safety equipment

B. Laboratory Projects

1. Disassemble a piston type pump and identify all parts.
2. Investigate types and effectiveness of protective coatings used in a local wastewater treatment plant.

VII. Sewer Cleaning

A. Units of Instruction

1. Work involved
a. Inspection
b. Measurement
c. Flushing
d. Mechanical augering
e. Repairs
f. Connections

2. Causes of trouble
a. Structural failures
b. Sand
c. Grease
d. Roots
e. Overloading

3. Necessary equipment
a. Pumps
b. Mechanical augers
c. Fire hoses
d. Hand tools
e. Protective clothing and accessories
f. First aid kits

B. Laboratory Projects

1. Visit location of a sewer-cleaning opera-

tion to familiarize the students with hand and mechanical augers.

2. Compare cost of using hand and mechanical augers.

VIII. Safety

A. Units of Instruction

1. Occupational hazards in wastewater works
   a. Infections
   b. Physical injury—falling
   c. Drowning
   d. Asphyxiation
   e. Electrocution
   f. Explosions
   g. Gas—poisonous, explosive
2. Accident prevention
   a. Plant design
      (1) Safety guards for machinery
      (2) Stairway railings
      (3) Basin railings
   b. Lighting
   c. Fire-proof chemical storage
   d. Safe access to equipment
   e. Explosion and moisture proof electrical equipment
3. Safety program
   a. Rules
   b. Warning signs
   c. Equipment
   d. Color schemes
   e. Records
   f. Incentives

B. Laboratory Projects (none)

Texts and References

ELMORE and YARBOROUGH. *Checklist for Design of Sewage Treatment Plants.*

FAIR and GEYER. *Elements of Water Supply and Wastewater Disposal.*

HARDENBERGH and RODIE. *Water Supply and Waste Disposal.*

HAWKES. *The Ecology of Waste Water Treatment.*

NEMEROW. *Theories and Practices of Industrial Waste Treatment.*

WATER POLLUTION CONTROL FEDERATION. *Sewage Treatment Plant Design.*

———. *Sewer Maintenance.*

———. *Safety in Wastewater Works.*

Visual Aids

Communicable Disease Center, Atlanta, Ga. 30333.

Activated Sludge Plant. (5-160) 75 frames, 8 min., sound, color.

Chemical Precipitation Treatment Plant. (5-158) 63 frames, 7 min., sound, color.

Primary Treatment Plants. (5-138) 47 frames, 7 min., sound, color.

Trickling Filter Plants. (5-159) 94 frames, 9 min., sound, color.

INSTRUMENTATION AND CONTROLS

Hours Per Week

Class, 3; Laboratory, 2

Course Description

This course provides the basic fundamentals of instrumentation. The application, maintenance, and calibration of specific instruments essential to water purification and wastewater treatment systems are emphasized. Instruction covers mechanical, electrical, hydraulic, and pneumatic sensing equipment; and indicating, recording, and control equipment. Study of typical performance characteristics, limitations, accuracy, and utilization of specific instruments in the various industrial processes complete this instruction.

Major Divisions

	Hours Class	Hours Laboratory
I. Pressure	5	2
II. Recorders	5	4
III. Flow	6	4
IV. Liquid Level	5	2
V. Temperature	2	2
VI. Humidity	2	2
VII. Control	5	4
VIII. Control Valves	2	2
IX. Transmitters	5	2
X. Blind Controllers	2	2
XI. Miniature Recorders	4	2
XII. Graphic Panels	5	4
Total	48	32

I. Pressure

A. Units of Instruction

1. Nature of pressure
   a. Unit area
   b. Unit weight
   c. Psi.; psf.; inches of H_2O; inches of mercury (Hg)
2. Manometers
   a. U-tube
   b. Differential
   c. Density
   d. Reservoir
   e. Vacuum
3. Gage calibration
4. Bourdon tube gages
   a. Materials
   b. Linkage
   c. Adjustment
   d. Fixed links
   e. Checking
   f. Varieties
   g. Siphons
   h. Snubbers
   i. Maintenance
5. Diaphragm pressure element
   a. Spring
   b. Stock
   c. Calibration
   d. Bellows element
6. Vacuum and compound gages
   a. Inches of mercury
   b. Psi (pounds per square inch)
   c. Absolute
   d. Gage principle
   e. Absolute pressure gages
   f. Vacuum and pressure gages
7. Electrical pressure measurements
   a. Heat conductance
   b. Ionization of a gas
   c. Strain gage
   d. Inductance
   e. Magnetic

B. Laboratory Projects

1. Compare and calibrate the following pressure gages against known standards; then, make a series of pressure measurements.
   a. Manometer
   b. Bellows
   c. Bell gage
   d. Bourdon tube
2. Demonstrate the use of resistance-change strain gages for a series of comparative pressure tests.
3. Demonstrate the use of the Pirani thermocouple vacuum for a series of comparative pressure tests.

II. Recorders

A. Units of Instruction

1. Components
   a. Case
   b. Measuring device
   c. Writing pen
   d. Timing mechanism
   e. Charts
   f. Linkage
2. Adjustments
   a. Microscrew
   b. Turnbuckle
   c. Slip-joint
   d. Split-hub
   e. Coarse adjustment
   f. Fine adjustment

Laboratory Projects

1. Study components of recorders and calibrate, utilizing pneumatic pressure and electrical signal for transmission of signal from primary device.
2. Change a chart and adjust the writing pen on a recorder.

III. Flow

A. Units of Instruction

1. Primary elements
   a. Orifice plates
   b. Venturi tubes
   c. Dall tubes
   d. Flow nozzles
   e. Pitot tubes
2. Secondary elements
   a. Manometer types
   b. Mercury cylinders
3. Installation of flow meters
   a. Radius types
   b. Flange types
   c. Sealed pots
4. Flow calibration
   a. Flow-time
   b. Weight-time
   c. Error calculations

5. Electrical flow measurements
   a. Magnetic flowmeter
   b. Turbine type
   c. Strain gage
   d. Inductance
   e. Differential transformer

B. Laboratory Projects
1. Compare the flow ratio of venturi meters, orifice plates, and various weir plates over a wide range of flow against a calibrated tank.
2. Determine discharge coefficient of venturi meters, orifice plates, and various weir plates over a wide range of flow rates.

IV. Liquid Level

A. Units of Instruction
1. Primary elements
   a. Direct link
   b. Metallic tape or chain
   c. Bubble tube
   d. Diaphragm box
   e. Differential pressure
   f. Bourdon gage
2. Secondary elements
   a. Bellows
   b. Bourdon tube
   c. Mercury cylinder
3. Application
   a. Reservoir level
   b. Closed-system level
   c. Remote-level readings
4. Electrical liquid-level measurement
   a. Probe-type
   b. Capacitance
   c. Radiation

B. Laboratory Projects
1. Plot pressure as a function of depth by means of a diaphragm box.
2. Plot pressure as a function of depth by means of back-pressure bubbler system.
3. Compare the liquid pressure observed by mechanical means with the capacitance level gage.

V. Temperature

A. Units of Instruction
1. Scales
   a. Fahrenheit
   b. Centigrade
2. Types of thermal units
   a. Liquid-filled
   b. Vapor-filled
   c. Gas-filled
3. Installation
   a. Angle
   b. Submerge
   c. Liquid-elevation correction
   d. Calibration
4. Electrical temperature measurement
   a. Resistance
   b. Capacitance
   c. Thermocouples

B. Laboratory Projects
1. Measure the temperature of different fluids with gas-filled and liquid-filled thermometers.
2. Demonstrate the use of several types of thermocouples by using them to make temperature measurements.

VI. Humidity

A. Units of Instruction
1. Absolute humidity
   a. Grain per pound of air
   b. Temperature effect
2. Relative humidity measurement
   a. Psychrometers
   b. Hygrometers
   c. Construction
   d. Calibration
3. Dew point
   a. Temperature
   b. Moisture appearance
   c. Testing device

B. Laboratory Projects
1. Determine the relative humidity of the classroom by use of the dry- and wet-bulb hygrometer, and compare humidity measurement with that determined by the resistance-type hygrometer.
2. Demonstrate dew point by cooling the warm moist air in a bell jar.

VII. Control

A. Units of Instruction
1. Process control
   a. Batch
   b. Continuous
   c. Automatic

d. Medium
e. Variables
2. On-off control
a. Measuring element
b. Indicating element
c. Pneumatic signals
d. Set point knob
e. Characteristics
3. Proportional control
a. Output proportional
b. Characteristics
c. Stabilizing action
d. Lead and lag
e. Reset
f. Rate of derivative
4. Full controllers
a. Proportional-rate-reset
b. Characteristics
5. Special control elements
a. Program control
b. Remote set
c. Relation and ratio
6. Controller auxiliaries
a. Transfer switches
b. Regulators
c. Filters
7. Adjustment
a. Proportional band
b. Reset
c. Rate
d. Sinusoidal upset
e. Step (upset)
f. Ramp (upset)

B. Laboratory Projects
1. Determine rate of response of a pneumatic system when violently upset.
2. Determine the rate of response of an electrical system and compare with that of a pneumatic system.

VIII. Control Valves

A. Units of Instruction
1. Manual
a. Pinch
b. Cook
c. Butterfly
d. Gate
e. Globe
2. Air valves
a. Diaphragm
b. Piston
c. Direct
d. Reverse
e. Range
f. Three-way
3. Valve positioners
a. Lever
b. Piston
c. Span
d. Bias

B. Laboratory Projects
1. Determine flow through selected electric and pneumatic control valves at various positions by means of a standard volume tank.
2. Calibrate a piston-type valve positioner.

IX. Transmitters

A. Units of Instruction
1. Functions
a. Measure
b. Convert to signal
2. Operation
a. Differential pressure
b. Nozzle valve
c. Bellows
d. Amplifications
3. Adjustments
a. Span
b. Angularity
c. Output

B. Laboratory Projects
1. Calibrate a pneumatic transmitter over the full range of operation.
2. Demonstrate the operation of a differential pressure transmitter.

X. Blind Controllers

A. Units of Instruction
1. Functions
a. Combine signals
b. Produce output signal
2. Advantages
a. Fast acting
b. Located near measurement
c. Quick installation
d. Manual operation

B. Laboratory Projects
1. Make a volumetric check on a blind-control installation.

2. Demonstrate the function of a blind controller.

XI. Miniature Recorders

A. Units of Instruction

1. Advantages
   a. Space
   b. Chart size
   c. Interchangeability
   d. Longer period charts
   e. Dual recordings
2. Operation
   a. Signal received
   b. Bellows
   c. Rectilinear pen motion
   d. Test stand

B. Laboratory Projects

1. Perform routine maintenance check and calibration of a miniature recorder.
2. Demonstrate advantages of dual recordings.

XII. Graphic Panels

A. Units of Instruction

1. Purposes
2. Advantages
   a. Impersonal and complete
   b. Diagrams operation
   c. Protects instruments
   d. Central control point

B. Laboratory Projects

1. Detail a graphic panel to show the flow of liquid through a wastewater treatment plant.
2. Detail a graphic panel to show the flow of water through a rapid-sand filter.

Texts and References

DELAHOOKE. *Industrial Control Instruments.*

ECKMAN. *Industrial Instrumentation.*

FRIBANCE. *Industrial Instrumentation Fundamentals.*

HOLZBOCK. *Instruments for Measurement and Control.*

KIRK *and* RIMBOI. *Instrumentation.*

TYSON. *Industrial Instrumentation.*

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE, OFFICE OF EDUCATION. *Instrumentation Technology, A Suggested 2-Year Post High School Curriculum* (OE-80033).

Mathematics and Science Courses

MATHEMATICS I (TECHNICAL)

Hours Per Week

Class, 5; Laboratory, 0

Course Description

The topics studied and the order in which they are presented integrate mathematics with the technical courses in the curriculum. The real-number system is developed as an extension of natural numbers; various systems of numbers are introduced. Study of the slide rule occurs early in the course. Rather than practice use of the slide rule, significant figures, and scientific notation in separate, continuous study periods, a few minutes daily for several weeks may be set aside for practice. Fundamental and advanced algebraic operations, the rectangular coordinate system, and the analytic geometry of the straight line are studied intensively. Inequalities are considered along with equations and identities; determinants are introduced as a means of solving systems of equations; exponential and trigonometric relationships are explored; and fundamental trigonometric concepts and operations are studied, with emphasis on the right triangle and graphic representation of the functions.

The various topics should be introduced so as to emphasize the basic principles involved and the important role each plays in water and wastewater technology. Practical problems, many from the technical field, should be assigned to reinforce understanding of the topics studied.

Major Divisions

	Class Hours
I. Fundamentals of Real Numbers	2
II. Introduction to the Slide Rule	3
III. Algebraic Expressions and Operations	9
IV. Linear Functions	7
V. Correlation Between Algebra and Geometry	6
VI. Simultaneous Linear Equations	7
VII. Exponents and Radicals	6
VIII. Quadratic Equations in One Variable	7
IX. Inequalities	2
X. Variations	2
XI. Exponential and Trigonometric Functions	10
XII. Trigonometry of the Right Triangle	12
XIII. Geometric Representation of the Trigonometric Functions	7
Total	80

I. Fundamentals of Real Numbers

1. Representation of numbers on a number line
   a. Natural numbers
   b. Standard notation
   c. Integers
   d. Rational numbers—common and decimal fractions
   e. Irrational numbers
2. Fundamental operations
   a. Addition
   b. Subtraction
   c. Multiplication
   d. Division
   e. Operations involving zero
3. Basic axioms
   a. The commutative axiom
   b. The associative axiom
   c. The distributive axiom
4. Number bases
   a. Base 10
   b. Various bases
   c. Base 2

II. Introduction to the Slide Rule

1. *A, B, C, D* scales
2. Multiplication and division
3. Squares and square roots
4. Combined operations
5. Scientific notation and significant figures

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III. Algebraic Expressions and Operations

1. Literal numbers
2. Operations involving signed quantities
3. Symbols of grouping
4. Exponents
   a. Operations involving powers with like base
   b. Powers of 10
5. Operations involving algebraic expressions
   a. Addition and subtraction
   b. Multiplication and division
6. Equations and formulas involving one variable
7. Mental multiplications
8. Factoring
   a. Removing common factors
   b. Difference of two squares
   c. Trinomials
   d. Sum and difference of two cubes
   e. Factoring by grouping
9. Operations involving fractions
   a. Simple fractions
   b. Complex fractions

IV. Linear Functions

1. Identities
2. Equations
   a. Independent and dependent variables
   b. Absolute and arbitrary constants
   c. Equations involving fractions

V. Correlation Between Algebra and Geometry

1. Rectangular coordinate system
   a. Location of points
   b. Distance between points
2. Graphing linear functions
3. Slope of a line
   a. Parallel lines
   b. Perpendicular lines
4. Determining the equation of a straight line
   a. Slope-intercept form
   b. Point-slope form
   c. Two-point form
   d. Intercept form

VI. Simultaneous Linear Equations

1. Graphical solutions
2. Algebraic solution of equations in two and three unknowns
   a. Addition or subtraction
   b. Substitution
3. Determinants
   a. Definitions and symbols
   b. Fundamental theorems and operations
   c. Evaluation techniques
   d. Second-order determinants
   e. Third-order determinants
   f. Higher order determinants
   g. Solving systems of linear equations by use of determinants

VII. Exponents and Radicals

1. Laws of exponents
2. Fractional exponents and radicals
3. Simplifying radicals
4. Operations with radical quantities
   a. Addition and subtraction
   b. Multiplication
   c. Division
5. The number j

VIII. Quadratic Equations in One Variable

1. Definitions and standard form, $ax^2 + bx + c = 0$
2. Solutions of quadratic equations
   a. Factoring
   b. Completing the square
   c. Formula
   d. Graphical solutions
3. Evaluating the discriminant
   a. Nature of roots
   b. Graphical implications
4. Equations involving radicals

IX. Inequalities

1. Properties and symbols of unequal quantities
2. Graphical solutions
3. Algebraic solutions
4. Inequalities involving absolute values

X. Variations

1. Ratio and proportion
2. Variation
   a. Constant of proportionality
   b. Direct variation

c. Inverse variation
d. Joint variation

XI. Exponential and Trigonometric Functions

1. Definitions and basic concepts
2. Geometric representation
   a. Graphing exponential functions
   b. Graphing logarithmic functions
3. Logarithmic bases
   a. Any base
   b. Base 10
   c. Introduction to base e
   d. Changing bases
4. Theorems on logarithmic operations
5. Computations involving tables of mantissa
   a. Products
   b. Quotients
   c. Powers
   d. Roots
6. Exponential and logarithmic equations
7. Log scales on the slide rule
8. Graphs on logarithmic paper
9. Logarithmic interpretation of pH

XII. Trigonometry of the Right Triangle

1. Vectors on the rectangular coordinate plan
2. Functions of an acute angle
3. Cofunctions and reciprocal functions
4. Angular measurement: degrees, minutes, seconds
5. Trigonometric tables
6. Trigonometric scales on the slide rule
   a. The *S* scale
   b. The *T* scale
   c. The *ST* scale
7. Solving right triangles using definitions of the functions

XIII. Geometric Representation of the Trigonometric Functions

1. Functions of any angle or number
   a. Signs of the trigonometric functions
   b. Radian measure of angles
   c. Functions of angles greater than 90°
   d. Functions of the quadrant angles: 0°, 90°, 180°, 270°
2. Graphs of the trigonometric functions
   a. Graph of the *sine* function
   b. Graph of the *cosine* function
   c. Graph of the *tangent* function
   d. Graph of the *cotangent* function
   e. Graph of the *secant* function
   f. Graph of the *cosecant* function
3. Periodic functions
   a. Rotating vectors
   b. The angle as a function of time
4. Graphs of periodic trigonometric functions
   a. Graphs of $Y = A \sin x$ and $Y = A \cos x$
   b. Graphs of $Y = A \sin (bx + c)$ and $Y = A \cos (bx + c)$
5. Composite trigonometric curves
6. Lissajous figures

Texts and References

ALLENDOERFER *and* OAKLEY. *Fundamentals of Freshman Mathematics.*

ANDRÉE. *Introduction to Calculus with Analytical Geometry.*

ANDRES *and* OTHERS. *Basic Mathematics for Science and Engineering.*

FORD *and* FORD. *Calculus.*

JUSZLI. *Analytic Geometry and Calculus.*

JUSZLI *and* RODGERS. *Elementary Technical Mathematics.*

KLINE *and* OTHERS. *Foundations of Advanced Mathematics.*

KRUGLAK *and* MOORE. *Basic Mathematics for the Physical Sciences.*

RICE *and* KNIGHT. *Technical Mathematics.*

TUITES. *Basic Mathematics for Technical Courses.*

WASHINGTON. *Basic Technical Mathematics with Calculus.*

MATHEMATICS II (TECHNICAL)

Hours Per Week

Class, 4; Laboratory, 0

Course Description

This course is a continuation of Mathematics I. Advanced algebraic and trigonometric topics are studied intensively. These topics include solution of oblique triangles, complex numbers as vectors, trigonometric identities and equations, and the binomial expansion and progressions. The fundamental concepts of analytic geometry and differential and integral calculus are introduced which include graphing techniques, geometric and algebraic interpretation of the derivative, differentials, rate of change, the integral, and basic integration techniques. Application of these concepts to practical situations are studied, with emphasis given to applying these principles to water and wastewater technology.

Major Divisions

		Class Hours
I.	Solution of Oblique Triangles	10
II.	The *j*-Operator	7
III.	Properties of Trigonometric Functions	5
IV.	Inverse Trigonometric Functions	2
V.	Binomial Expansions and Progressions	5
VI.	Elements of Analytic Geometry	10
VII.	Derivatives and Applications	15
VIII.	Integration and Applications	10
	Total	64

I. Solution of Oblique Triangles

1. Reduction to right triangles
2. Law of *sines*
3. Law of *cosines*
4. Law of *tangents*
5. Half-angle laws

II. The *j*-Operator

1. Imaginary and complex numbers
2. Operations with complex numbers
3. Graphical representation of complex numbers
4. Polar form of a complex number
5. Exponential form of a complex number
6. Products, quotients, powers, and roots of complex numbers
7. De Moivre's Theorem

III. Properties of the Trigonometric Functions

1. Fundamental trigonometric identities
   a. Reciprocal identities
   b. Pythagorean identities
2. Functions of two angles
   a. *Sine* of the sum and difference of two angles
   b. *Cosine* of the sum and difference of two angles
   c. *Tangent* of the sum and difference of two angles
3. Double-angle formulas
   a. *Sine* of a double angle
   b. *Cosine* of a double angle
4. Half-angle formulas
   a. *Sine* of half of an angle
   b. *Cosine* of half of an angle
5. Trigonometric equations

IV. Inverse Trigonometric Functions

1. Definitions and symbols of inverse trigonometric functions
2. Principle values
3. Graphs of the inverse trigonometric functions
   a. Graphs of $Y = \arcsin x$
   b. Graphs of $Y = \arccos x$
   c. Graphs of $Y = \arctan x$

V. The Binomial Expansions and Progressions

1. Expanding a binomial to any power
2. The *n*th term of the binomial expansion
3. Applications of the binomial
   a. The number *e*
   b. Extraction of roots
   c. Rate of growth
4. Arithmetic progressions
   a. Definitions
   b. Equation for the *n*th term
   c. Equation for the sum of *n* terms
   d. Finding the common difference
   e. Applications
5. Arithmetic and geometric means
6. Infinite progressions

VI. Elements of Analytic Geometry

1. The general quadratic equation in two variables
2. The circle
   a. Definition and the general equation
   b. Circle with center at the origin
   c. Circle with center at any point
   d. Determination of the equation of a circle from given conditions
3. The parabola
   a. Definition and the general equation
   b. Geometric construction

c. Parabola with vertices at the origin
d. Parabola with vertices at any point
e. Determination of the equation of a parabola from given conditions
f. Falling bodies and parabola motion

4. The ellipse
   a. Definition and the general equation
   b. Geometric construction
   c. Ellipse with center at the origin
   d. Ellipse with center at any point
   e. Applications
5. The hyperbola
   a. Definition and general equation
   b. Hyperbola with center at the origin
   c. Asymptotes
   d. Hyperbola with center at any point
   e. Applications
6. Solution of systems of quadratic equations
   a. Graphical solution
   b. Algebraic solution

VII. Derivatives and Applications

1. Limits
   a. Theorems
   b. Average and instantaneous rate of change
2. The slope of the *tangent* to a curve
3. Functional notation
4. Definition of the derivative
5. Differentiation using the Delta method
6. Algebraic forms for differentiation
   a. Constant
   b. Sum of functions
   c. Product forms
   d. Quotient forms
   e. Power forms
7. The derivative as the slope of the *tangent* to a curve
8. Derivative with respect to time
9. Curve tracing
10. Applications to maxima and minima
11. Derivatives of higher order
12. Velocity and rates
    a. Distance
    b. Time
    c. Velocity
    d. Acceleration
13. Differentials
    a. Increment of a function
    b. Approximations by use of differentials

VIII. Integration and Applications

1. Basic concepts and definitions
   a. Integration as the inverse of differentiation
   b. Notation
2. The indefinite integral
3. Basic integration formulas
   a. The integral of a function
   b. The integral of the product of a constant and a function
   c. The integral of a sum of functions
   d. The power formula
4. The constant of integration
5. The definite integral
   a. The definite integral as an area
   b. Approximate integration
   c. Integration as a process of summation
   d. Areas by summation
6. Applications of the integral
   a. Volume of a solid of revolution
   b. Length of an arc
   c. Surface area of a solid of revolution
   d. Centroids
   e. Moment of inertia
   f. Work
   g. Hydrostatic pressure

Texts and References

ALLENDOERFER *and* OAKLEY. *Fundamentals of Freshman Mathematics.*

ANDRÉE. *Introduction to Calculus with Analytical Geometry.*

ANDRES *and* OTHERS. *Basic Mathematics for Science and Engineering.*

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RICE *and* KNIGHT. *Technical Mathematics.*

TUITES. *Basic Mathematics for Technical Courses.*

WASHINGTON. *Basic Technical Mathematics with Calculus.*

PHYSICS I (HEAT AND MECHANICS)

Hours Per Week

Class, 3; Laboratory, 3

Course Description

The objectives of this course extend beyond its immediate purpose of developing an understanding of the basic principles of heat and mechanics. Emphasis on the scientific method is important in laboratory and lecture. Instructors of physics and mathematics should coordinate subject matter so that students will have maximum opportunity for mastering both subjects. In the laboratory, emphasis should be on applying material learned in Mathematics I and II and on using the slide rule for computing. Heat is studied first to permit the student to progress more in mathematics before studying mechanics.

Major Divisions

	Hours Class	Hours Laboratory
I. Basic Measurement	4	3
II. Properties of Solids, Liquids, and Gases	7	6
III. Heat, Temperature, and Calorimetry	6	6
IV. Fusion, Vaporization, Critical Temperature, and Pressure	2	6
V. Heat, Work, and Heats of Formation and Combustion	4	3
VI. Statics	7	6
VII. Rectilinear Motion and Momentum	4	6
VIII. Angular and Simple Harmonic Motions	2	3
IX. Work, Energy, and Power	4	3
X. Gas Laws	2	0
XI. Heat Transfer	2	3
XII. Thermodynamics	4	3
Total	48	48

I. Basic Measurement

- A. Units of Instruction
  1. Science and measurement: units of measurement
     - a. The scientific method and measurement
     - b. Dimensional analysis
     - c. Systems of measurement
       - (1) Traditional–metric and English
       - (2) Modern—cosmic, atomic, and industrial
  2. Methods of measurement
     - a. U.S. standards of measurement
     - b. Aids to measurement—vernier, micrometer, planimeter, optical flats, comparators, spherometer, and diffraction grating
- B. Laboratory Projects
  1. Use vernier and micrometer calipers in measurement.
  2. Use planimeter and spherometer in measurement.

II. Properties of Solids, Liquids, and Gases

- A. Units of Instruction
  1. Structure of matter
     - a. Atoms—the periodic table
     - b. Elements, compounds, crystals
  2. Elasticity and rigidity
     - a. Units of measure: Young's modulus, torsion
     - b. Deformation—stress, strain, fatigue
     - c. Hooke's law
  3. Hydrostatics–properties of fluids
     - a. Density, specific gravity, buoyancy
     - b. Statement and application of Pascal's and Archimedes' law
     - c. Phenomena of viscosity, capillarity, surface tension
     - d. Bernoulli's theorem and applications
     - e. Orifice: pressure flow, loss of head
  4. Properties of gases
     - a. Bernoulli's theorem
     - b. Measurement of pressure
- B. Laboratory Projects
  1. Calculate the densities of solids and liquids.
  2. Determine the elastic properties of materials and become familiar with their specifications and limitations.
  3. Compute the modulus of rigidity of a rod.
  4. Measure buoyancy of liquids.

III. Heat, Temperature, and Calorimetry

A. Units of Instruction
1. Definition of heat
a. Energy from the sun—radiant energy (electromagnetic)
b. Changes in metals in heat treating
2. Definition of temperature
a. Temperature scales
b. Fixed points—boiling and freezing
c. Temperature—indicating devices
3. Expansion of solids, liquids, and gases
4. Calorimetry and heat units
a. Thermal capacity defined
b. Mass
c. Quantity of heat involved in temperature changes

B. Laboratory Projects
1. Confirm Charles' law using the constant volume air thermometer.
2. Calculate the coefficient of linear expansion of various materials.
3. Determine the specific heat of various solids.
4. Determine the specific heat of various liquids.

IV. Fusion, Vaporization, Critical Temperature, and Pressure

A. Units of Instruction
1. Fusion and the heat quantities involved
a. Relative values of heats and fusion
b. Change in volume
(1) Importance of container design
(a) Water containers
(b) Chemical containers
(2) Design factors for safety
c. Melting points
d. Cooling curves
e. Supercooling
2. Vaporization defined
a. Evaporation—effects of temperature, pressure, and area
b. Boiling—definition
c. Humidity—relative and absolute
3. Critical points defined
a. Values for different gases
b. Behavior of real gases
c. Liquefaction of gases
d. Fractional distillation

B. Laboratory Projects
1. Determine vapor pressure of a liquid at various temperatures.
2. Measure the heats of fusion and vaporization of a substance.
3. Measure absolute and relative humidity and relate these to industrial problems.

V. Heat, Work, and Heats of Formation and Combustion

A. Units of Instruction
1. The relationship between heat and work
a. Numerical relationship as discovered by Joule
b. Applications
c. Conditions affecting friction
2. Heats of combustion
a. Solid fuels—coal
b. Liquids—oil and alcohol
c. Gaseous
d. Electrical
3. Heats of formation
a. Relationship between heats of formation and heats of combustion
b. Practical applications
4. Nuclear energy
a. Fusion
b. Fission

B. Laboratory Projects
1. Determine the mechanical equivalent of heat.
2. Demonstrate heats of combustion.

VI. Statics

A. Units of Instruction
1. Composition of resolution of vectors
a. Definition of vector—examples
b. Components and composition
c. Resolution of vectors
d. Methods of handling
(1) Graphical
(2) Analytical—summation
2. Conditions of equilibrium
a. Forces and vector diagrams
b. Principle of transmissibility
3. Statics of structures, cranes, and trusses
4. Friction—coefficient of friction
5. Principle of moments
6. Application of moments to members of structures

B. Laboratory Projects
   1. Convert a system of concurrent forces into a vector diagram.
   2. Analyze a system of forces.
   3. Determine the coefficient of friction between simple objects.
   4. Determine the center of gravity of a series of forces and the reaction at supports of parallel forces.
   5. Calculate internal and external moments in members of a structure.

VII. Rectilinear Motion and Momentum

A. Units of Instruction
   1. Rectilinear motion—displacement and rates of change
   2. Systems of units—C.G.S., English, M.K.S.
   3. Newton's second law
   4. Law of universal gravitation—free fall, spatial problems
   5. Inertia of a body
   6. Physical aspects of momentum
      a. Transmission, impulse, impact, and collision
      b. Units and denominations
      c. Jet propulsion principles
   7. Motion of a projectile
B. Laboratory Projects
   1. Apply Newton's second law to forces in cables and hoists.
   2. Specify and measure the characteristics of the motion of a projectile and free-fall object.
   3. Measure one momentum of a body: ballistic pendulum.

VIII. Angular and Simple Harmonic Motions

A. Units of Instruction
   1. Forces on bodies in motion
   2. Circular motion—formulas and denominations
   3. Centrifugal action
      a. Vectors and components
      b. Applications in centrifuge, satellites, highways, and castings
   4. Harmonic motion
      a. Characteristics: amplitude, displacement, frequency, and period
      b. Equations and graphs
      c. Types: simple and compound pendulums, spring, and electronic
      d. Vibration in structures
   5. Gyroscopic action
B. Laboratory Projects
   1. Confirm the law of centripetal force.
   2. Confirm the law of centrifugal force.

IX. Work, Energy, and Power

A. Units of Instruction
   1. Physical concept of work
      a. Forces, directions, distances, and units
      b. Positive and negative character of work and energy
   2. Energy and its manifestations
   3. Conservation of energy
   4. Power as compared to work and energy
   5. Simple machines: inclined plane, pulleys, belts, and gears
      a. Aspects of work, energy, power, and efficiency
      b. Mechanical advantage
      c. Friction in machines
      d. Power transmission
B. Laboratory Projects
   1. Confirm conservation of energy in simple machines.
   2. Demonstrate friction in a mechanical system.

X. Gas Laws

A. Units of Instruction
   1. Ideal gases
   2. Real gases
B. Laboratory Projects (none)

XI. Heat Transfer

A. Units of Instruction
   1. Conduction
   2. Convection
   3. Radiation
B. Laboratory Projects
   1. Confirm Newton's law of cooling.
   2. Demonstrate radiation.

XII. Thermodynamics

A. Units of Instruction
   1. Gas laws
      a. Boyle's and Gay-Lussac's laws

b. Ideal gas equation
c. Adiabatic expansion and compression
2. First law of thermodynamics
a. Relationship between heat and work
b. Industrial applications
3. Second law of thermodynamics
a. Efficiency in heat conversion to work
b. Heat, engine cycles: Carnot, Rankine, Diesel, and Otto
c. The reversed cycle
d. Heat applied to chemical reactions

B. Laboratory Projects
1. Confirm Boyle's law.
2. Demonstrate heat exchange in a refrigeration unit.

Texts and References

BLACK and LITTLE. *An Introductory Course in College Physics.*
CONDON and ODISHAW. *Handbook of Physics.*
DE FRANCE. *General Electronics Circuits.*
HARRIS. *Experiments in Applied Physics.*
HARRIS and HEMMERLING. *Introductory Applied Physics.*
MILLER. *College Physics.*
OREAR. *Fundamental Physics.*
SEARS and ZEMANSKY. *College Physics, Part II.*
SMITH and COOPER. *Elements of Physics.*
WEBER and OTHERS. *College Physics.*
———. *Physics for Science and Engineering.*
WHITE. *Modern College Physics.*

Visual Aids

American Chemical Society, 1155 16th Street, NW., Washington, D.C. 20036.
Vibrations of Molecules (Prof. Linus Pauling and Prof. Richard M. Badger, collaborators). 16 mm., 12 min., color.

Encyclopedia Britannica Films, Inc., 1150 Wilmette Avenue, Wilmette, Ill. 60091.
Galileo's Laws of Falling Bodies. 16 mm., 6 min., sound, black and white.
Gas Laws and Their Application. 16 mm., 13 min., sound, black and white.
Heat—Its Nature and Transfer. 16 mm., 11 min., sound, black and white.
Laws of Motion. 16 mm., 13 min., sound, black and white.
Simple Machines. 16 mm., 11 min., sound, black and white.
Thermodynamics. 16 mm., 11 min., sound, black and white.

McGraw-Hill Book Co., Inc., 330 West 42nd Street, New York, N.Y. 10036.
Carnot Cycle (Kelvin Temperature Scale). 16 mm., 8 min., sound, black and white.
Diesel Engine. 16 mm., 8 min., sound, black and white.
Gasoline Engine. 16 mm., 8 min., sound, black and white.
Uniform Circular Motion. 16 mm., 8 min., sound, black and white.

Modern Learning Aids, 714 Spring Street, NW., Atlanta, Ga. 30308.
Gas Pressure and Mollecular Collisions (Prof. J. Arthur Campbell, collaborator). 16 mm., 21 min., black and white.
Ionization Energy (Prof. Bruce H. Mahan, collaborator). 16 mm., 22 min., color.

Norwood Films, 926 New Jersey Avenue, NW., Washington, D.C. 20001.
Basic Hydraulics. 16 mm., 9 min., sound, black and white.
Electron—An Introduction. 16 mm., 16 min., sound, black and white.
Principles of Dry Friction. 16 mm., 17 min., sound, black and white.
Principles of Momentum. 16 mm., 23 min., sound, black and white.
Principles of Refrigeration. 16 mm., 20 min., sound, black and white.
Verniers. 16 mm., 19 min., sound, black and white.

PHYSICS II (ELECTRICITY AND LIGHT)

Hours Per Week

Class, 3; Laboratory, 4

Course Description

This course introduces electrical circuitry and equipment and the study of light, stressing the concepts of physics and their pertinence to applied chemical science. Emphasis is placed on electronics because it involves applied solid-state physics with significant chemical implications and because of the electrical and electronic applications and controls used in sanitation research and processing. The increased use of spectroscopic and photoelectric methods for instrumental analyses makes it necessary to include the study of light in the education of water and wastewater technicians. The section on nuclear physics should provide the students with an understanding of the physical science principles underlying the radiobiographic techniques used in chemical and biological analysis and process control.

Major Divisions

	Hours Class	Hours Laboratory
I. Electricity and Magnetism	3	4
II. Basic Electric Circuits and Components	9	8
III. Alternating Current	5	4
IV. Electrical Instruments	5	8
V. Basic Electronics	6	8
VI. Electric Power	3	4
VII. Motors and Controls	4	8
VIII. Light	5	8
IX. Photochemical Applications	3	4
X. Nuclear Physics	3	4
XI. Use of Radioactive Materials	2	4
Total	48	64

I. Electricity and Magnetism

A. Units of Instruction

1. Nature of electricity—the electron theory
   a. Atomic structure—historical development
   b. Conductors—specific resistance
   c. Insulators—dielectric strength
2. Electrical units
   a. Coulomb—flowing electricity
   b. Ampere—current electricity
   c. Volts, ohms, and watts
3. Nature of magnetism
   a. Atomic theory of magnetism
   b. Permanent and electromagnets
   c. Law of magnets and magnetic field strengths
   d. Hysteresis curve: permeability, retentivity, saturation
   e. Applications of magnets

B. Laboratory Projects

1. Verify the laws of electrostatics and electrostatic induction; sketch electrostatic fields.
2. Confirm the law of magnets and sketch magnetic fields using permanent and electromagnets.

II. Basic Electric Circuits and Components

A. Units of Instruction

1. Ohm's law in DC series resistance circuits
2. Ohm's law in DC parallel resistance circuits
3. Measurement of resistance: voltammeter, Wheatstone bridge, and ohmmeter
4. Inductance in DC circuits
   a. Electromagnetic induction—Lenz's law
   b. Concept and units of self-inductance
   c. Rise and decay of current in an inductance
   d. Energy in inductive circuits
   e. Mutual induction—coefficient of coupling
   f. Series and parallel inductance
5. Capacitance in DC circuits
   a. Definition and units of capacitance
   b. Rise and decay of voltage in a capacitor
   c. Energy in capacitive circuits
   d. Series and parallel capacitors

B. Laboratory Projects

1. Work problems in series and parallel resistive DC circuits.
2. Measure direct current in series, parallel, and combination circuits.
3. Plot the rise and decay of voltage across a capacitor in a DC circuit. Calculate time constant.
4. Demonstrate electromagnetic generation and transmission equipment.

III. Alternating Currents

A. Units of Instruction

1. Electromagnetic generation of a *sine* wave
2. *Sine* wave terminology and vector representation
3. Inductive and capacitive reactance
   a. Definition and units of measure
   b. Vector representation—phase angle
   c. Impedance—vector diagrams
   d. Resonance—vector diagrams
4. AC circuits in resistance, capacitance, and inductance
5. Measurement of alternating current
6. The electromagnetic spectrum—high frequencies
7. Electrochemical analogies
   a. Resistance—friction; power consumption

b. Inductance—inertia; kinetic energy
c. Capacitance—potential energy
8. AC alternators and transformers

B. Laboratory Projects
1. Demonstrate and calculate AC circuit constants using vector analysis.
2. Make a measurement of alternating current.

IV. Electrical Instruments

A. Units of Instruction
1. Ammeters—types and uses
   a. Moving coil, permanent magnet
   b. Solenoid
   c. Movable iron
   d. Electrodynamometer
   e. Shunts and range-extension devices, use and calculation of capacity
2. Voltmeters—types and uses
   a. Single-range and multiple-range voltmeters
   b. Vacuum tube voltmeter
   c. Potentiometer
   d. Shunts and range-extension devices, use and calculation of capacity
3. Wheatstone bridge
   a. Principles and function
   b. Modifications
      (1) Capacitance
      (2) Inductance
4. Oscilloscopes—types and uses
   a. Principles and function
   b. Frequency spectrum and high frequency phenomena
   c. Oscilloscopic measurement applications
5. Application of instruments to industrial processes
   a. Temperature
   b. Acidity—alkalinity (*pH*)
   c. Speed
   d. Strain
   e. Pressure
   f. Thickness
   g. Vibration

B. Laboratory Projects
1. Demonstrate use of various types of ammeters.
2. Extend the range of an ammeter of calculated amount.
3. Demonstrate use of various types of voltmeters.
4. Demonstrate use of Wheatstone bridge to measure resistance.
5. Determine the high-frequency wave length using an oscilloscope.
6. Determine the amount of electric current from a thermocouple in an oxidizing flame and in a reducing flame.
7. Determine the *p*H of a $\frac{1}{10}$th normal solution of magnesium chloride using a *p*H meter.
8. Measure relative humidity and calculate the amount of water in the system.

V. Basic Electronics

A. Units of Instruction
1. Controlling electric current: historical development, rheostat, vacuum tube, and transistor
2. The diode tube
   a. Thermionic emission
   b. Characteristic curves
   c. Rectification—principles and use
3. The triode tube
   a. Grid control—electrostatic fields
   b. Characteristic curves
   c. Concept of amplification
   d. Applications
4. Solid-state devices
   a. Sophistication of solid-state conduction
   b. Mechanism of conduct in semiconductors
5. Chemistry of solid-state devices
   a. Nature of materials
   b. Effect of impurities
   c. Effect of physical flaws
   d. Resistance to heat, shock, and chemical action
6. Electronic measuring instruments
   a. Measuring devices
   b. Applications
7. Applications of electronics
   a. Communications
   b. Industrial processing and control
   c. Applications in chemical research
   d. Applications in chemical production systems

B. Laboratory Projects
   1. Measure the characteristics of a diode tube and observe its action as a rectifier on an oscilloscope.
   2. Measure and calculate the amplification factor of a triode tube.
   3. Demonstrate electronic control equipment.

VI. Electric Power

A. Units of Instruction
   1. Sources of electric power
      a. Electrical generators and alternators
         (1) The electromotive series
         (2) Thermocouple—application and uses
         (3) Chemical heat cells
      b. Photoelectricity
         (1) Kinds of photoelectric cells
         (2) Emerging use of solar cells
      c. Chemical action
         (1) Primary cells
         (2) Secondary cells
         (3) Edison, cadmium, lead, and other batteries
   2. Power in DC and AC circuits
   3. Physical uses of electric power
      a. Heat and light—principles of common devices
      b. Electric (resistance) furnace; chemical industry uses
      c. Electric arc—uses in furnacing, refining, and welding of metals
      d. Electron beam—use in melting and welding metals
   4. Chemical uses of electricity
      a. Electrolysis—principles and applications
         (1) Chlorine—caustic soda production
         (2) Production of hydrogen
      b. Electrodeposition and electrorefining of metals
         (1) Refinement of copper, lead, and zinc
         (2) Electroplating
      c. Electric conversions
         (1) Manufacture of silicon carbide
         (2) Vacuum electric furnace melting of pure metals

B. Laboratory Projects
   1. Make field trips to industrial installations.
   2. Demonstrate industrial control equipment.
      a. Spot welders
      b. Induction heating units
      c. Instrumentation

VII. Motors and Controls

A. Units of Instruction
   1. Operating characteristics of direct current motors
      a. Shunt
      b. Series
      c. Compound
   2. DC motor controllers
   3. AC motor types and characteristics
   4. Control and protection of AC equipment

B. Laboratory Projects
   1. Measure speed-load and torque characteristics of DC and AC motors.
   2. Demonstrate a variable speed electric motor controller.

VIII. Light

A. Units of Instruction
   1. The electromagnetic spectrum
      a. Measurement units of wave length
      b. Light spectrum from ultraviolet to infrared
   2. The nature of light
      a. Speed
      b. Energy
      c. Doppler effect
      d. Emission, interference, and absorption of light
   3. Reflection and refraction of light
      a. Lenses
      b. Systems of lenses in scientific equipment
      c. Reflection
      d. Reflection—prismic refractions and refractive index
      e. Spherical and chromatic aberration
   4. Diffraction of light
      a. Diffraction of gratings
      b. Power of resolution
      c. X-ray diffraction
      d. Electron microscope
      e. White- and dark-line spectra
   5. Polarization of light
   6. Lasers—description and use
   7. Sources of light
      a. Quanta

b. Cavity radiators
c. Planck's radiation formula
d. Photoelectric effect
e. Photon theory
f. Relationship of matter, energy, and light

B. Laboratory Projects
1. Demonstrate the spectrum from sunlight.
2. Demonstrate polarization of light.
3. Demonstrate strain concentrations in transparent plastic material using polarized light.
4. Demonstrate several lenses and confirm the mathematic description of their characteristics.
5. Determine the index of refraction of a substance.
6. Demonstrate diffraction gratings.
7. Demonstrate white- and dark-line spectra.
8. Demonstrate Fraunhofer's lines in a sodium flame.
9. Demonstrate a laser light beam.
10. Demonstrate an X-ray defraction.

IX. Photochemical Applications

A. Units of Instruction
1. Photography
2. Spectroscopic analyses
3. Spectrophotometry
4. Refractometry
5. Polarimetry
6. X-ray diffraction applications

B. Laboratory Projects
1. Demonstrate spectroscopic analysis of sodium vapor light.
2. Demonstrate polarimetric differentiation of compounds.

X. Nuclear Physics

A. Units of Instruction
1. Atomic structure
a. Early interpretation
(1) Nucleus and electron
(2) Periodic arrangement of the elements
(3) Chemical implications of outer shell of atom
b. Present interpretation
(1) Protons, neutrons
(2) Isotopes
c. Other nuclear particles—beta particles, positrons (positive electrons), alpha particles; deuteron, triton, gamma ray
d. Nuclear physicist's table of the elements
(1) Nuclides
(2) Chemical reactions compared to nuclear reactions
2. Radioactivity
a. Natural radioactivity—decay of complete nuclei of heavy elements
b. Induced radioactivity by nuclear reactions—alpha, beta, and gamma radiation
c. Radiation shielding
(1) Radiation units
(2) Half-life of isotopes
(3) Half-thickness of shielding
(4) Radiation-detection devices

B. Laboratory Projects
1. Use a Geiger counter and calculate radiation per unit mass of a substance.
2. Demonstrate shielding and calculate thickness of shield for a given radiation.

XI. Use of Radioactive Materials

A. Units of Instruction
1. Areas of use
a. Medical--diagnostic and therapeutic
b. Industrial—radioactive isotope-tracer analyses, gamma ray applications
2. Radiographic tracer techniques
a. Materials used
b. Equipment and apparatus used
c. Special laboratory procedures peculiar to radiography

B. Laboratory Projects
1. Demonstrate use of an isotope tracer in a fluid flow system to check rate of flow through the system.
2. Demonstrate gamma ray method for rapid measurement of thickness of material.

Texts and References

BLACK and LITTLE. *An Introductory Course in College Physics.*

CONDON and ODISHAW. *Handbook of Physics.*

DE FRANCE. *General Electronics Circuits.*

ERIC

HARRIS. *Experiments in Applied Physics.*

HARRIS *and* HEMMERLING. *Introductory Applied Physics.*

MILLER. *College Physics.*

OREAR. *Fundamental Physics.*

SEARS *and* ZEMANSKY. *College Physics, Part II.*

SMITH *and* COOPER. *Elements of Physics.*

WEBER *and* OTHERS. *College Physics.*

———. *Physics for Science and Engineering.*

WHITE. *Modern College Physics.*

Visual Aids

Encyclopedia Britannica Films, Inc., 1150 Wilmette Avenue, Wilmette, Ill. 60091.

Electro-Dynamics. 16 mm., 11 min., sound, black and white.

Magnetism. 16 mm., 16 min., sound, black and white.

Series and Parallel Circuits. 16 mm., 11 min., sound, black and white.

What is Electricity? 16 mm., 13 min., sound, black and white.

Norwood Films, 926 New Jersey Avenue, NW., Washington, D.C. 20001.

Capacitance. 16 mm., 31 min., sound, black and white.

Diodes: Principles and Applications. 16 mm., 17 min., sound, black and white.

Ohm's Law. 16 mm., 19 min., sound, black and white.

RCL—Resistance Capacitance. 16 mm., 34 min., sound, black and white.

Voltaic Cell, Dry Cell, and Storage Battery. 16 mm., 18 min., sound, black and white.

U.S. Atomic Energy Commission (obtainable from any regional office).

The International Atom. 16 mm., 27 min., sound, black and white.

Auxiliary or Supporting Technical Courses

GENERAL DRAFTING

Hours Per Week

Class and Laboratory, 8

Course Description

This course is for students who have had little or no previous experience in drafting. It is designed to develop the student's understanding of drafting rather than his skill as a draftsman. The objectives of the course are to provide an elementary but practical understanding of orthographic projection; an elementary understanding of the principles of descriptive geometry and their applications; experience in using handbooks and other resource materials; an elementary understanding of design principles and the use of simplified drafting practices in industry; and some skill in orthographic, isometric, and oblique sketching and drawing. Several specialized drafting areas are introduced because of their value to the water and wastewater technician in the interpretation of plant and process drawings. Drawings and sketches should relate to the details of water and wastewater plants or treatment. The course should be taught in a drawing laboratory and include informal lecturing when appropriate.

Major Divisions

	Hours for Class and Laboratory
I. Fundamentals	10
II. Technical Sketching; Orthographic Projection	16
III. Isometric and Oblique Pictorial Sketching	14
IV. Dimensioning	10
V. Sections	10
VI. Auxiliary Views	14
VII. Architectural Drawing Principles	10
VIII. Structural Drafting Principles	8
IX. Electrical and Electronics Drafting Principles	8
X. Pipe Drawings and Diagrams	8
XI. Welding Drawings	6
XII. Topographic Drawing Principles	8
XIII. Plan and Profile Drawing Principles	6
Total	128

I. Fundamentals

A. Units of Instruction
1. Function of drafting in design and production
2. Drafting instruments, materials, and equipment
   a. Care and use
   b. Current drafting practices in industry
3. Lettering
   a. Construction of vertical Gothic capitals
      (1) Proportion and spacing
      (2) Numerals and fractions
   b. Identification of other styles and alphabets
   c. Lettering instruments: tools and devices
4. Geometrical construction (accurate notes required)
   a. Geometric forms and shapes
   b. Geometry applied to drafting problems
   c. Constructions involving straight lines, angles, circles, arcs, tangents, ellipses, parabolas, hyperbolas, helices, involutes, and cycloids

B. Laboratory Projects
1. With pencil, draw on vellum or tracing paper, single views of two or more mechanical parts of objects which provide opportunity to use basic drawing instruments; stress accuracy in full-scale measurement; use vertical Gothic lettering; use basic geometrical constructions; and make typical sheet layouts.
2. Produce first drawings as a device for critical analysis of line quality; compare with quality of good industrial prints. (This is done periodically throughout the course.)

II. Technical Sketching; Orthographic Projection

A. Units of Instruction
1. Sketching materials
2. Sketching techniques

3. Theory of third-angle orthographic projection
   a. Definition
   b. Planes of projection
      (1) Frontal
      (2) Horizontal
      (3) Profile
   c. Basic principles of descriptive geometry
      (1) Locating points in space
      (2) Locating lines in space
      (3) Locating surfaces in space
   d. Edges and surfaces
      (1) Parallel
      (2) Inclines
      (3) Oblique
      (4) Curved
      (5) Truncated
   e. Fillets, rounds, and runouts
4. Multiview sketches: 2-view; 3-view
   a. View relationships
      (1) Principles of projection
      (2) Selection of views for best shape description
   b. Steps in sketching
      (1) Estimating size and proportion of objects
      (2) Determination of appropriate scale for sketch
      (3) Centering sketch on pad or sheet selected
      (4) Blocking in shapes of views
         (a) Construction lines
         (b) Solid lines
         (c) Center lines
         (d) Hidden lines
      (5) Projecting views
         (a) Spaces between views
         (b) Transfer of measurements
      (6) Order of sketching
      (7) Quality of finished sketch
   c. Techniques for sketching circles, ellipses, and other shapes
   d. Analysis of engineering drawings and sketches from industry
   e. Alphabet of lines
   f. Explanation of first-angle projection

B. Laboratory Projects
1. Examine several 3-view drawings and sketch in any missing lines.
2. Select several problems where two views of an object are given and sketch the third view.
3. Sketch 3-view drawings from pictorial representations of selected machine parts or objects, using cross-section paper.
4. Sketch 3-view drawings from actual machine parts or objects, using sketch pad or tracing paper.
5. Using drafting instruments and equipment, make 3-view drawings of selected machine parts involving the principles and techniques covered in the units of instruction; draw on vellum or tracing paper.
6. Reproduce one or more of the mechanical drawings as a basis for discussion of line equality.

III. Isometric and Oblique Pictorial Sketching

A. Units of Instruction
1. Isometric sketching
   a. Materials
   b. Principles
      (1) Isometric projection
      (2) Isometric drawing
   c. Techniques
      (1) Blacking in
      (2) Isometric and non-isometric lines
      (3) Angles in isometric drawing
      (4) Isometric ellipses
      (5) Arcs and curves
      (6) Sections
      (7) Intersections
2. Oblique sketching
   a. Cavalier drawing principles
   b. Cabinet drawing principles
   c. Positioning of object
   d. Steps in oblique drawing
   e. Offset measurements
   f. Ellipses
   g. Arcs and curves
   h. Angles
   i. Sections

B. Laboratory Projects
1. On isometric paper, make several isometric sketches from 3-view drawings supplied by the instructor; apply principles and techniques covered in division III, unit 1.
2. Make several oblique drawings on cross-section paper, sketching from drawings or objects supplied by the instructor; apply

principles and techniques covered in division III, unit 2.

IV. Dimensioning

A. Units of Instruction
1. Theory of dimensions
a. True-position dimensions
b. Maximum material position
2. Techniques
a. Lines
b. Arrowheads
c. Fractional and decimal dimensions
d. Leaders
e. Fillets and rounds
f. Finish marks
g. Notes
3. Selection of dimensions
4. Placement of dimensions
5. Analysis and interpretation of dimensioning practices on engineering drawing or prints from local industry.
6. Rules for dimensioning isometric and oblique drawings.

B. Laboratory Projects
1. Add the needed dimensions and notes to the drawings made in division II and division III projects.
2. Sketch, or use drafting instruments, to make a more complex 3-view drawing from pictorial views or actual objects; use models with inclined surfaces, holes, rounds, and unusual shapes, requiring several dimensioning techniques and considerable judgment in selection and placement of dimensions and notes.

V. Sections

A. Units of Instruction
1. Functions of sectional views
2. The cutting plane
a. Representation on working drawing
b. Location of cutting plane line
c. Direction of sight
3. Conventions
a. Cutting plane lines
b. Section lines (ASA)
c. Spokes, arms, ribs, and lugs in section
d. Breaks
4. Classification of sections
a. Full sections
b. Half sections
c. Broken out sections
d. Revolved sections
e. Aligned sections
5. Dimensioning

B. Laboratory Projects
1. Sketch or draw section views from drawings requiring several types of sections. Drawings may be provided by the instructor and completed by the student, or made entirely by the student.
2. Sketch a section on a working drawing.

VI. Auxiliary Views

A. Units of Instruction
1. Function of auxiliary views
2. Classification of surfaces
3. Primary auxiliary views—width, depth, height, auxiliaries
a. Direction of sight
b. Reference plane
c. Projection technique
d. Transfer of measurements
e. Auxiliary view from a principal view
f. Principal view from an auxiliary view
g. Dihedral angles
h. Plotted curves
4. Partial auxiliary views
5. Half auxiliary sections
6. Auxiliary sections
7. Secondary auxiliary views
8. Descriptive geometry applied to true measurements of lines, angles, and surfaces

B. Laboratory Projects
1. From 2- or 3-view drawings supplied by the instructor, sketch auxiliary views in their proper relationship to the given views.
2. Using instruments, make a working drawing which includes both primary and secondary auxiliary views.

VII. Architectural Drawing Principles

A. Units of Instruction
1. Classification
a. Floor plans
b. Elevations
c. Special layouts
d. Sections and details

2. Architectural drawing standards
   a. Symbols
   b. Units
   c. Handbooks
3. Architectural drawing techniques

B. Laboratory Projects
1. Analyze and interpret typical architects' blueprints, particularly those dealing with factory or commercial buildings.
2. Draw typical detail sections

VIII. Structural Drafting Principles

A. Units of Instruction
1. Classification of structural drawings
2. Structural steel
   a. Shapes
   b. Connectors
   c. Floor and erection plans
   d. Riveting
   e. Welding
   f. Calculations
   g. Handbook
   h. Working drawings and conventions
3. Timber structures
   a. Materials
   b. Trusses
   c. Connectors
   d. Working drawings and conventions
4. Masonry structures
   a. Materials
      (1) Brick
      (2) Tile and terra cotta
      (3) Stone
   b. Basic construction details
   c. Drafting conventions
5. Reinforced concrete
   a. Types of drawings
      (1) Engineering
      (2) Placing
   b. Manual of standard practice
   c. Drawings, sections, and conventions

B. Laboratory Projects
1. Make detail drawings from a structural assembly.
2. Prepare a bill of materials from an assembly drawing.

IX. Electrical and Electronics Drafting Principles

A. Units of Instruction
1. Diagrams
   a. Single-wire
   b. Schematic
2. Electrical drafting techniques
3. Electrical symbols
4. Typical electrical circuits
   a. Single and assembly
   b. Printed
5. Electrical charts
6. Drawing of electrical equipment
7. Study and interpretation of industrial prints

B. Laboratory Projects
1. Make a schematic diagram from a simple wiring diagram.
2. Sketch the wiring of a room like the classroom or laboratory. Include all necessary symbols.

X. Pipe Drawings and Diagrams

A. Units of Instruction
1. Types of pipes and tubes
   a. Steel and wrought iron
   b. Cast iron
   c. Copper
2. Pipe joints and fittings
   a. Fittings
   b. Joints
3. Valves
   a. Globe
   b. Check
   c. Gate
4. Pipe threads
5. Pipe hangers and supports
6. Pipe specifications and dimensions
7. American standard code
8. Piping symbols
9. Piping diagrams
10. Piping drawings
   a. Orthographic
   b. Isometric

B. Laboratory Projects
1. Make a diagrammatic drawing of a piping layout showing symbols for pipe fittings and valves.
2. Draw a typical pipe hanger.

XI. Welding Drawings

A. Units of Instruction
1. Use in design and fabrication of machines and structures

2. The welding process
   a. Pressure welding
   b. Nonpressure welding
   c. Resistance welding
   d. Other
3. Types of welded joints
4. Arc and gas welds and symbols
5. Resistance welds and symbols
6. Welding drawings
   a. Representation
   b. Notes
   c. Dimensioning

B. Laboratory Projects
1. Make sketches of various types of welds and their welding symbols.
2. Make a working drawing of a welded part showing dimensions and welding symbols.

XII. Topographic Drawing Principles

A. Units of Instruction
1. Contours
   a. Contour Interval
   b. Ground slopes
   c. Characteristics of contours
2. Contour map construction
   a. Choice of scale
   b. Choice of contour interval
   c. Conventional symbols

B. Laboratory Projects
1. Interpolate contour location and sketch a simple contour map using the grid method with elevation of all grid points given.
2. Indicate planimetric detail using conventional symbols.

XIII. Plan and Profile Drawing Principles

A. Units of Instruction
1. Determination of ground slopes from contour maps
   a. Calculation of percent slope and grade
   b. Station system of measurement
2. Plan and profile drawings
   a. Choice of scale
   b. Types of paper
   c. Information to be included
   d. Standards symbols and notation

B. Laboratory Projects
1. Choose a route between points on a standard contour map. Draw plan view on standard plan and profile sheets showing all necessary planimetric detail.
2. Plot ground profile on profile section, using proper scale. Layout a finished grade for a drainage ditch or sewer, noting the depth of cut at each half station.

Texts and References

AMERICAN INSTITUTE OF STEEL CONSTRUCTION. *Steel Construction: A Manual for Architects, Engineers, and Fabricators of Buildings and Other Steel Construction; and Structural Shop Drafting*, Vols. I and II.

AMISS *and* JONES. *Use of Handbook Tables and Formulas.*

BREED. *Surveying.*

DOUGLASS *and* ADAMS. *Elements of Nomography.*

FRENCH *and* TURNBULL. *Lessons in Lettering.*

FRENCH *and* VIERK. *Manual of Engineering Drawing for Students and Draftsmen.*

———. *Graphic Science: Engineering Drawing, Descriptive Geometry, Graphical Solutions.*

GIACHINO *and* BEUKEMA. *Engineering--Technical Drafting and Graphics.*

GIESECKE, MITCHELL, *and* SPENCER. *Technical Drawing.*

GRANT. *Engineering Drawing Problem Series I.*

HOELSCHER *and* SPRINGER. *Engineering Drawing and Geometry.*

LE GRAND. *New American Machinist's Handbook.*

LEUCHTMAN *and* VEZZANI. *The Use of Mechanics' Handbook.*

LUZADDER. *Fundamentals of Engineering Drawing.*

OBERG *and* JONES. *Machinery's Handbook.*

PARÉ *and* OTHERS. *Descriptive Geometry.*

RAMSEY *and* SLEEPER. *Architectural Graphic Standards.*

SLOANE *and* MONTZ. *Elements of Topographic Drawing.*

ZIPPRICH. *Freehand Drafting for Technical Sketching.*

ZOZZORA. *Engineering Drawing.*

Visual Aids

Pennsylvania State University Film Library, University Park, Penn. 16802.

According to Plan: Introduction to Engineering Drawing. 16 mm., 9 min., sound, black and white.

Auxiliary Views: Double Auxiliaries. 16 mm., 13 min., sound, black and white.

Auxiliary Views: Single Auxiliaries. 16 mm., 23 min., sound, black and white.

Drawing and the Shop. 16 mm., 15 min., sound, black and white.

Language of Drawing, The. 16 mm., 10 min., sound, black and white.

Orthographic Projection. 16 mm., 18 min., sound, black and white.

Pictorial Sketching. 16 mm., 11 min., sound, black and white.

Sections and Conventions. 16 mm., 15 min., sound, black and white.

Selection to Dimensions. 16 mm., 18 min., sound, black and white.

Shape Description, Parts I and II. 8 mm., 11 min., sound, black and white.

Size Description. 16 mm., 13 min., sound, black and white.

Purdue University, Lafayette, Ind. 49707.

Capital Letters. 16 mm., 21 min., sound, black and white.

Ink Tracing. 16 mm., 31 min., silent, black and white.

TECHNICAL REPORTING

Hours Per Week

Class, 2; Laboratory, 0

Course Description

An extension of *Communication Skills,* intended to help the student achieve greater facility in writing and speaking the language. Using the basic skills previously acquired, the student is introduced to the practical aspects of preparing reports and communicating within groups. The use of graphs, charts, sketches, diagrams, and drawings to present ideas and significant points is an important part of this course.

Emphasis is placed on techniques of collecting scientific data and effective ways to present the material in informal and formal reports and special types of technical papers. Forms and procedures for technical reports are studied, and a pattern is established for all forms to be submitted in this and other courses.

Much of the subject matter for this course may be necessary reports required for technical courses.

Major Divisions

	Class Hours
I. Reporting	3
II. Writing Technical Reports	12
III. Illustrating Technical Reports	4
IV. The Research Paper	3
V. Oral Reporting	4
VI. Group Communication and Participation	6
Total	32

I. Reporting

Units of Instruction

1. Nature and types of reports
2. Objective reporting
3. The problem concept
4. The scientific method
   a. Definition
   b. Characteristics of the scientific method
   c. Essentials of scientific style
   d. Importance of accuracy and objectivity in observation and recording
   e. Legal importance of recorded data and log books
5. The techniques of exposition
   a. Definitions
   b. Progression
   c. Elements of style
   d. Analysis of examples
   e. Methods of slanting a report
6. Critical evaluation of a report

II. Writing Technical Reports

Units of Instruction

1. Characteristics of technical reports
2. Rep functions
3. Informal reports
   a. Written short-form reports
      (1) Memorandum reports
      (2) Business letter reports
      (3) Progress reports
      (4) Outline reports
   b. Oral reports
      (1) To individuals
      (2) To groups
4. The formal report
   a. Arrangement
      (1) Cover and title page
      (2) Table of contents
      (3) Summary of abstracts
      (4) Body of the report
      (5) Bibliography and appendix

(6) Graphs, drawings, or other illustrations
b. Preparation
(1) Collecting, selecting, and arranging material
(2) Writing and revising the report
5. Special types of papers
a. The abstract
b. Process explanations
c. The case history
d. The book review

III. Illustrating Technical Reports

Units of Instruction
1. Illustrations as aids to brevity and clarity
2. Use of technical sketches and drawings
3. Use of pictorial drawings and sketches
4. Use of diagrammatic representation
a. Electrical diagrams and symbols
b. Process flow diagrams
c. Instrumentation diagrams
d. Bar charts, pie diagrams, and similar presentation of data
5. Graphical presentation of data
a. Graphs—types of graph paper
b. Choice of scale for graphs
c. Points and lines; and use of data from graphs
6. Use of photographs
7. Selection of appropriate illustrations
a. Availability
b. Cost of preparation
c. Brevity and clarity of presentation

IV. The Research Paper

Units of Instruction
1. Subject and purpose
2. Source materials: bibliographical tools; periodical indexes; the library
3. Organization
a. A working bibliography
b. Notes and the outline
c. Rough draft
d. Quotes and documentation
e. Final paper
4. Oral and written presentation

V. Oral Reporting

Units of Instruction
1. Organization of material for effective presentation
2. Formal and informal reports
3. Use of notes
4. Use of slides, exhibits
5. Proper use of the voice
6. Elimination of objectionable mannerisms
7. Introductions

VI. Group Communication and Participation

Units of Instruction
1. The problem-solving approach
a. Stating and analyzing the problem
b. Proposing solutions
c. Selecting and implementing a solution
2. Participation in group communication
a. Duties and qualifications of the chairman
b. Rules of order
c. Panel discussion and symposium
d. Group investigation

Texts and References

BAIRD and KNOWER. *Essentials of General Speech.*

BORDEAUX. *How to Talk More Effectively.*

CROUCH and ZETLER. *Guide to Technical Writing.*

DEAN and BRYSON. *Effective Communication.*

HARWELL. *Technical Communication.*

HAYS. *Principles of Technical Writing.*

HICKS. *Successful Technical Writing.*

KEGEL and STEVENS. *Communication, Principles and Practice.*

MACRORIE. *The Perceptive Writer, Reader, and Speaker.*

MARDER. *Craft of Technical Writing.*

PERRIN and SMITH. *Handbook of Current English.*

RHODES. *Technical Report Writing.*

ROGET. *New Roget's Thesaurus of the English Language in Dictionary Form.*

SCHUTTE and STEINBERG. *Communication in Business and Industry.*

SHERMAN. *Modern Technical Writing.*

SOUTHER. *Technical Report Writing.*

THOMPSON. *Fundamentals of Communication.*

WARRINER and GRIFFITH. *English Grammar and Composition: A Complete Handbook.*

WITTY. *How to Become a Better Reader.*

YOUNG and SYMONIK. *Practical English, Introduction to Composition.*

ZETLER and CROUCH. *Successful Communication in Science and Industry: Writing, Reading and Speaking.*

Visual Aids

McMurry-Gold Productions, 139 South Beverly Drive, Beverly Hills, Calif. 91603.

Person to Person Communication. 16 mm., 13 min., sound, black and white.

National Educational Television Film Service, Audio-Visual Center, Indiana University, Bloomington, Ind. 47405.

Experience as Give and Take. 16 mm., 29 min., sound, black and white. Produced by S. I. Hayakawa (Language in Action Series).

Talking Ourselves Into Trouble. 16 mm., 29 min., sound, black and white. Produced by S. I. Hayakawa (Language in Action Series).

Words That Don't Inform. 16 mm., 29 min., sound, black and white. Produced by S. I. Hayakawa (Language in Action Series).

National Safety Council, 425 N. Michigan Avenue, Chicago, Ill. 60611.

It's An Order. 16 mm., 12 min., sound, black and white.

SURVEYING

Hours Per Week

Class, 2; Laboratory, 6

Course Description

This course provides the student with elementary and practical knowledge of surveying and plane surveying principles, and basic theory. Classroom study and laboratory practice include units on taping; differential and profile leveling; transit and transit-tape surveying; elementary topographic and construction surveying; determination of grades and slopes; and surveying of drainage areas. The student must learn to determine grade levels and perform elementary surveying tasks.

Major Divisions

	Hours: Class	Hours: Laboratory
I. Fundamentals of Distances	3	9
II. Measurement of Distances	3	9
III. Surveys With Tape	3	9
IV. Measurement of Difference in Elevation	2	6
V. Differential Leveling	3	10
VI. Profile Leveling	3	10
VII. Earthwork	4	10
VIII. Direction of a Line	3	9
IX. Transit Operation	4	12
X. Transit-Tape Surveys	4	12
Total	32	96

I. Fundamentals of Distances

A. Units of Instruction

1. Definition of plane surveying and geodetic surveying
2. Kinds of plane surveying
   - a. Control surveys
   - b. Land surveys
   - c. Topographic surveys
   - d. Route surveys
   - e. Underground surveys
   - f. Hydrographic surveys
   - g. Aerial surveys by photogrammetry
   - h. Construction surveys
3. Types of measurement
   - a. Linear measurement
   - b. Angular measurement
   - c. Area measurement
   - d. Volume measurement
4. Field work
   - a. Field practice
   - b. Care and handling of instruments
   - c. Signals used
   - d. Field notes
5. Office work
   - a. Computations
   - b. Checking
   - c. Significant figures
   - d. Use of logarithms
   - e. Use of slide rule
   - f. Use of calculating machines
6. Errors
   - a. Sources
   - b. Types
   - c. Theory of probability

B. Laboratory Projects
1. Demonstrate and practice care and handling of chain. Demonstrate "throwing" the chain. Student practice in taking up and "throwing" the chain.
2. Demonstrate and practice care and handling of the level.
3. Demonstrate and practice care and use of the level rod.
4. Demonstrate and practice care and handling of the transit and theodolite.

II. Measurement of Distances

A. Units of Instruction
1. Methods of measurement
   a. Pacing
   b. Ordinary chaining
   c. Precision chaining
   d. Baseline measurement
   e. Stadia
   f. Electronic devices
2. Linear measurements—precision required
3. Equipment used in chaining
   a. Tapes
   b. Chaining pins
   c. Range poles
   d. Plumb bobs
   e. Locke level
   f. Clinometer
   g. Spring balance
   h. Thermometer
4. Chaining on level ground
5. Chaining on uneven or sloping ground
   a. "Breaking the chain"
   b. Fitting chain to contour
6. Slope measurements
   a. Slope
   b. Difference in elevation
   c. Corrections for slope
7. Technical errors in chaining
   a. Length of tape
   b. Imperfect alignment
   c. Imperfections of observation
   d. Variations in temperature
   e. Variations in tension
   f. Sag in tape
8. Mistakes in chaining
9. Cumulative and compensation errors

B. Laboratory Projects
1. Practice pacing and chaining a 4-sided figure on level ground. Determine number of paces per 100 feet for each man.
2. Measure distance between tack points in stakes with spring balance. Record and correct for temperature.
3. Measure horizontal distance along a sloping surface requiring "breaking the tape."

III. Surveys With Tape

A. Units of Instruction
1. Measuring angles
2. Erecting perpendicular to line
3. Measuring obstructed distances
   a. Swing-offset method
   b. Parallel line method
   c. Similar triangle method
4. Tying in reference points

B. Laboratory Projects
1. Lay off a rectangular building site approximately 150 x 200 by erecting perpendiculars, using the chain. Check by measuring the diagonals.
2. Measure an obstructed distance, using one of the methods outlined in class.

IV. Measurement of Difference in Elevation

A. Units of Instruction
1. Definitions
   a. Elevation
   b. Datum
   c. Level line
   d. Difference in elevation
   e. Leveling
   f. Horizontal line
   g. Vertical angle
   h. Curvature
   i. Atmospheric refraction
2. Types of leveling
   a. Barometric
   b. Differential
   c. Profile
   d. Bench mark
3. Operation and care of leveling instruments
   a. Dumpy level

b. Self-leveling level
c. Self-reading rod
d. Target rod

B. Laboratory Projects
1. Practice setting up and leveling different types of levels on level and uneven ground, and on pavement.
2. Practice holding and reading self-reading and target rods.

V. Differential Leveling

A. Units of Instruction
1. Definitions
a. Differential leveling
b. Bench mark (B.M.)
c. Turning point (T.P.)
d. Backsight (B.S.)
e. Foresight (F.S.)
f. Height of instrument (H.I.)
2. Procedure for differential leveling
a. Balancing backsight and foresight distances
b. Differential level notes
3. Mistakes in leveling
4. Technical errors in ordinary leveling
5. Precision of differential leveling
a. Rough leveling
b. Ordinary leveling
c. Excellent leveling
d. Precise leveling
6. Checking leveling
a. Two sets of turning points
b. Complete loop
c. Mathematical check of notes
7. Error of closure
a. Computation
b. Adjustment
8. Differential level notes

B. Laboratory Projects
1. Demonstrate the "peg test" and have students run this test.
2. Run a line of differential levels from a bench mark over a course of approximately 3,000 feet and return to the bench mark. Repeat until closure is within .02 feet. Record all information in field book.
3. Run a line of levels over sloping ground from a bench mark to an overhead point and return to the bench mark. Record all information in field book.

VI. Profile Leveling

A. Units of Instruction
1. Station method of location
a. Full stations
b. Plus stations
2. Field technique of profile leveling
3. Profile level notes
4. Grade lines
a. Cut sheet
b. Batter boards

B. Laboratory Projects
1. Measure a selected line in stations with intermediate points or plus stations for sharp changes in grade or turns. Determine the elevation of all stations and plus stations. Record all information in field book. Show check of calculations. Plot the profile.
2. Lay out a sewer line on the profile, put in offset hubs, and make up a cut-sheet for construction.

VII. Earthwork

A. Units of Instruction
1. Leveling for earthwork
a. Preliminary cross sections
b. Final cross sections
c. Cuts and fills
d. Side slopes
e. Setting slope stakes
f. Excavation to predetermined surface
g. Trench excavation
h. Barrow pit excavation
2. Computing areas of cross sections
a. Geometric formulas
b. Planimeter
3. Computing volumes of earthwork
a. Average and area method
b. Prismoidal method
c. Earthwork volume on curves
d. Excavation tables and diagrams
4. Practical applications
a. Volumes from road profiles
b. Barrow pit quantities

5. Precision of determining quantities

B. Laboratory Projects

1. Using a typical set of cross section notes for irregular road cross sections, compute the cross sectional areas for several stations.
2. Compute the volume in cubic yards between stations, using the above computed areas.

VIII. Direction of a Line

A. Units of Instruction

1. Types of meridians
   a. Astronomical meridian
   b. True meridian
   c. Magnetic meridian
   d. Assumed meridian
   e. Grid meridian
2. Azimuth of a line
3. Bearing of a line
   a. Types of bearings
   b. Relation between azimuth and bearings
4. Magnetic compass
   a. Determining direction
   b. Magnetic declination
   c. Correction for declination
   d. Correction for local attraction
   e. Sources of errors
5. Relation between the true and magnetic bearings and azimuths

B. Laboratory Projects

1. Stake a closed traverse on the ground. Use a compass to determine the bearing of all sides.
2. Given the angles and the bearing of one side of a closed traverse, compute the bearing of the other sides.

IX. Transit Operation

A. Units of Instruction

1. Operation and care of the engineer's transit
2. Operation and care of the theodolite
3. Checking the transit
4. Measuring horizontal angles
   a. Direct reading
   b. Repetition
5. Field operations with the transit
   a. Measuring interior angles
   b. Measuring exterior angles to the right
   c. Measuring deflection angles
   d. Measuring azimuth angles
   e. Laying off angles
   f. Prolonging a straight line
   g. Balancing-in
   h. Intersection of two straight lines
   i. Prolonging a line past an obstacle
   j. Establishing parallel lines
   k. Locating a point
6. Errors in transit work
   a. Instrumental errors
   b. Personal errors
   c. Natural errors

B. Laboratory Projects

1. Turn angles between distant points making 360°.
2. Stake off a 5-sided figure and do the following:
   a. Turn interior angles
   b. Turn exterior angles to the right
   c. Turn deflection angles
   d. Determine azimuth angles, using the compass
   e. Compute angular closure and adjust angles

X. Transit-Tape Survey

A. Units of Instruction

1. General surveying
   a. Establish horizontal control
   b. Locate details
   c. Transit and tape traverse
2. Building construction staking
   a. Foundation staking
   b. Offset hubs for building construction

B. Laboratory Projects

1. Stake an "L"-shaped building for basement excavation, one side of basement to be parallel to an existing right of way.
2. Put in offset hubs and compute cut-sheet.
3. Calculate the amount of excavation.

Texts and References

BOUCHARD *and* MOFFITT. *Surveying*
BREED. *Surveying.*

DAVIS. *Elementary Plane Surveying.*

DAVIS *and* FOOTE. *Surveying: Theory and Practice.*

KISSAM. *Surveying.*

———. *Surveying Practice.*

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE, OFFICE OF EDUCATION. *Civil Technology, Highway and Structural Options: Suggested 2-Year Post High School Curriculum* (OE-80041).

CONTRACTS, SPECIFICATIONS, CODES, AND ESTIMATES AND COSTS

Hours Per Week

Class, 3; Laboratory, 4

Course Description

A course designed to teach the procedures for completing an engineering contract which involves two or more parties and code and cost limitations. A technician must understand estimating, design and specifications, and bidding in order to properly interpret design fundamentals or apply these to projects and problems related to water and wastewater technology. Areas of study include: contract essentials; model specification; building codes and requirements; and detailed estimating procedures, including practice in making one complete quantity take-off and detailed estimate followed by a bid-letting exercise.

Major Divisions

	Hours	
	Class	*Laboratory*
I. Contracts	4	4
II. Design and Specification Notes	3	4
III. Codes	4	4
IV. Introduction to Estimating	5	4
V. Estimating Costs of Construction Equipment	2	4
VI. Estimating Costs of Handling and Transporting Materials	2	0
VII. Estimating Earthwork and Excavation Costs	3	4
VIII. Estimating Piling Costs	3	0
IX. Estimating Concrete Costs	6	4
X. Estimating Costs of Floor Systems and Finishes	2	0
XI. Estimating Masonry Costs	2	0
XII. Estimating Wood Construction Costs	3	0
XIII. Estimating Costs of Lathing, Plastering, Painting, Glazing, Roofing, Flashing	3	0
XIV. Estimating Structural Steel Costs	3	4
XV. Estimating Costs of Highways and Pavements	3	4
XVI. Specifications, Contract, and Cost Estimates for a Combined Project Related to Water and Wastewater Technology	0	28
Total	48	64

I. Contracts

A. Units of Instruction

1. Elements of contracts
   a. Classification
      (1) Origin
      (2) Participant
      (3) Obligation
      (4) Completion
      (5) Form
      (6) Legality
   b. Essentials
      (1) Two or more competent parties
      (2) Mutual agreement
      (3) Valuable consideration
      (4) Legal obligations
      (5) Form
2. Contract documents
   a. Advertisement
      (1) Name
      (2) Location
      (3) Received
      (4) Opened

(5) Addressing
(6) General description
(7) Plans and specification location
(8) Copies obtainable
(9) Owner statement
(10) Bid bond
(11) Special requirement
(12) Name of individual publishing

b. Instructions to bidders
   (1) Description
   (2) Proposals
   (3) Bid requirement
   (4) Contract data
   (5) Bond
   (6) Time limits
   (7) Standard specifications
   (8) Estimates
   (9) Contract documents

c. Proposals
   (1) Form
   (2) Lump-sum
   (3) Unit price
   (4) Witness

d. General conditions
   (1) Intent
   (2) Definitions
   (3) Bond requirements
   (4) Reports and payments
   (5) Modification of contractual relations
   (6) Business details
   (7) Conduct
   (8) Completion and acceptance

e. Agreement
   (1) Parties involved
   (2) Scope of work
   (3) Time
   (4) Price
   (5) Payment
   (6) Proof of outstanding invoices

f. Performance bond
   (1) Surety company
   (2) Amount

g. General specifications
   (1) Importance of completeness
   (2) Clarity
   (3) Brevity
   (4) Definitiveness
   (5) Arbitrary
   (6) Unfair
   (7) Severe

h. Detailed specifications
   (1) Prepared outlines
   (2) Published specifications
   (3) Contractor-furnished specifications
   (4) Common, standard specifications

B. Laboratory Projects
   1. Compare a completed contract, in the locality, to the American Institute of Architects' standard form to see if all the required elements have been included.
   2. Write a short contract for the purchase of various types of construction material, and include all items necessary for a complete transaction.

II. Design and Specification Notes

A. Units of Instruction
   1. Investigation
   2. Contractor's risk
   3. Difficulties
   4. Deep wells
   5. Geological formation
   6. Design basis
   7. Estimates

B. Laboratory Projects
   1. Prepare a check list of difficulties expected in several localities for a particular type of excavation.
   2. Compile the important factors to be considered in a preliminary estimate that does not include material take-off.

III. Codes

A. Units of Instruction
   1. Codes
      a. Purposes
         (1) Health
         (2) Safety
         (3) Welfare
      b. Model building codes
         (1) *National Code*
         (2) *Uniform Building Code*
         (3) *Southern Standard Building Code*
         (4) *Basic Building Code*
         (5) *National Electrical Code*
         (6) *National Plumbing Code*
   2. General code study—local and other pertinent building codes
      a. General restrictions
         (1) Zoning

(2) Dimensions
(3) Encroachment
(4) Occupancy
b. Light and ventilation
(1) Windows
(2) Skylights
(3) Mechanical
c. Exits
(1) Stairways
(2) Ramps
(3) Halls
(4) Doorways
(5) Other types
d. Types of constructions
(1) Fireproof
(2) Semifireproof
(3) Heavy timber
(4) Wood frame
(5) Metal
e. Materials and design loads
(1) Materials
(2) Tests
(3) Live loads
(4) Wind loads
f. Construction requirements
(1) Working stresses
(2) Bearing values
(3) Drainage
(4) Fire partition
g. Chimneys, flues, and vents
(1) Metal
(2) Cupola chimneys
(3) Gas vents and flues
h. Construction safeguards and sanitation requirements
(1) Scaffolds
(2) Hoists
(3) Lights
(4) Sanitation

B. Laboratory Projects
1. Determine code requirements for a specific type of building.
2. Check classroom for compliance with code requirements.

IV. Introduction to Estimating

A. Units of Instruction
1. Purpose of estimating
2. Types of estimates
a. Quantity-survey estimates
b. Approximate estimates
c. Detailed estimates
(1) Unit-cost estimates
(2) Lump-sum estimates
(3) Cost-plus estimates
d. Complete estimates
e. Contractor's estimates
f. Architect's or engineer's estimates
g. Progress estimates
h. Final estimates
3. Qualifications of an estimator
4. Subdivisions of estimating
a. Materials
(1) Quantities
(2) Cost
b. Labor
(1) Labor hours
(2) Production rates for labor
(3) Cost of labor
c. Plant costs
(1) General overhead
(2) Job overhead
d. Profit
5. Taxes
a. Social security
b. Unemployment compensation
6. Contractor's insurance
a. Workmen's Compensation and employer's liability insurance
b. Fire insurance
c. Extended coverage insurance
d. Automatic builder's risk insurance
e. Completed value builder's risk insurance
f. Comprehensive general liability insurance
7. Contract surety bonds
a. Bid or proposal bond
b. Contractor's performance bond
(1) Class *A* contracts
(2) Class *A–1* contracts
(3) Class *B* contracts
8. Sources of errors
9. Bidding procedures and related factors
a. Advertisement for bids
b. Bidding period
c. Availability of plans and specifications
d. Subcontractors' bids
e. Mechanics of bidding
f. Bidding ethics

10. Sequence of estimating
11. Importance of neatness and order
12. Check list of operations
13. Plans and specifications
14. Examination of site
15. Checking the estimate

B. Laboratory Projects
1. Calculate workmen's compensation insurance costs for a project, based on current rates and classifications.
2. Compute the cost of a performance bond for an estimate of a construction project.

V. Estimating Costs of Construction Equipment

A. Units of Instruction
1. Sources of equipment
   a. Rental
   b. Purchase
2. Estimating equipment costs
   a. Rental
   b. Ownership and operation
      (1) Estimating depreciation
         (a) Straight-line method
         (b) Declining-balance method
         (c) Sum-of-digits method
      (2) Maintenance and repairs
      (3) Investment costs
         (a) Interest
         (b) Insurance
         (c) Taxes
         (d) Storage
      (4) Fuel and lubricants

B. Laboratory Projects
1. Use three methods for calculating the depreciation on a particular piece of construction equipment.
2. Determine the operational cost per hour for a particular piece of construction equipment, including the initial cost and the cost of fuel and repairs.

VI. Estimating Costs of Handling and Transporting Materials

Units of Instruction
1. Handling costs
   a. Unloading, loading, and piling materials by manual labor
   b. Shoveling
   c. Unloading and loading materials with power equipment
2. Transportation costs
   a. Method of transporting materials
   b. Use of vehicles
   c. Vertical transportation of materials
3. Combined handling and transportation costs
   a. Hauling lumber from railroad cars to the job
   b. Unloading sand and gravel from railroad cars and hauling to job site
   c. Unloading and hauling bricks
   d. Hauling aggregate from quarry to highway job site using tractor-pulled dump trailers

VII. Estimating Earthwork and Excavation Costs

A. Units of Instruction
1. Preliminary considerations
   a. Clearing site
   b. Stripping and storing top soil
2. Classes of excavation
   a. General or mass excavation
   b. Special excavation
3. Kinds of soil
   a. Light soil
   b. Medium or ordinary soil
   c. Heavy or hard soil
   d. Hard-pan or shale
   e. Rock
4. Factors affecting excavation costs
5. Building-foundation excavation
   a. Types of equipment and labor
      (1) Tractor
      (2) Bulldozer
      (3) Power shovel
      (4) Power hoe
      (5) Dragline
      (6) Clamshell
   b. Handwork—special excavation
   c. Soil disposal
   d. Bracing the excavation
   e. De-watering the excavation
      (1) Pumping
      (2) Well-point system
      (3) Backfilling
      (4) Costs of labor, material, and equipment
6. Drainage-structure excavations
   a. Culverts
   b. Bridge foundations

(1) Equipment
(2) Bracing
(3) De-watering
(4) Costs of labor, material, and equipment

7. Trenching
   a. Types of equipment or labor
      (1) Manual labor
      (2) Trenching machines
         (a) Wheel-type
         (b) Ladder-type
         (c) Vertical-boom type
   b. Bracing
   c. Backfilling
   d. Costs of labor, material, and equipment
8. Highway-subgrade excavation
   a. Types of equipment and labor
      (1) Bulldozer
      (2) Scrapers
         (a) Wheel-type, tractor-pulled scraper
         (b) Crawler-type, tractor-pulled scraper
      (3) Grader
   b. Shaping and compacting earthwork
   c. Costs of labor, material, and equipment
9. Rock excavation
   a. Drilling and blasting
   b. Type of equipment required
   c. Costs of labor, material, and equipment

B. Laboratory Projects
   1. Estimate the cost of moving a specific quantity of lumber from one location to another.
   2. Estimate the cost per yard of transporting gravel for a definite distance from pit to job site, using specific equipment.

VIII. Estimating Piling Costs

Units of Instruction
   1. Types of piling
      a. Wood-sheet
      b. Steel-sheet
      c. Wood
      d. Precast, concrete
      e. Cast-in-place, concrete
      f. Steel
   2. Costs of labor, materials, and equipment

IX. Estimating Concrete Costs

A. Units of Instruction
   1. Various types of wall forms
      a. Built-in-place forms, with sheathing
      b. Plywood forms
      c. Prefabricated form panels
      d. Commercial prefabricated forms
      e. Accessories
   2. Tilt-up concrete walls
   3. Column forms
      a. Wooden forms
      b. Steel forms
      c. Sonotube forms
      d. Accessories
   4. Forms for concrete beams and girders
      a. Types of shores
      b. Spacing of shores
   5. Forms for flat, slab-type concrete floors
   6. Forms for slabs for beam- and slab-type concrete floors
   7. Forms for metal-pan and concrete-joist type concrete floors
   8. Bridge piers
   9. Design of the above form work, using charts and tables
   10. Costs of labor, materials, and equipment for the above superstructures, including:
      a. Formwork
      b. Placing reinforcing steel
      c. Pouring concrete
      d. Curing concrete
      e. Stripping forms
      f. Possible re-use of forms

B. Laboratory Projects
   1. Estimate the cost of concrete, steel and forms for beam- and slab-type construction of definite dimensions.
   2. Estimate the cost of concrete, steel, and forms for a cantilever retaining wall.

X. Estimating Costs of Floor Systems and Finishes

Units of Instruction
   1. Floor finishes
      a. Quantity take-off
         (1) Concrete-floor finishes
            (a) Monolithic topping
            (b) Separate concrete topping
         (2) Terrazzo floors
         (3) Asphalt tile

b. Costs of labor, materials, and equipment for the floors
2. Floor systems
a. Quantity take-off
(1) Steel-joist floor system
(2) Cellular-steel floor system
(3) Combined corrugated-steel forms and reinforcement for floor systems
b. Costs of labor, materials, and equipment for the floor systems

XI. Estimating Masonry Costs

Units of Instruction
1. Quantity take-off
a. Materials for brick masonry
(1) Face brick
(2) Common brick
b. Concrete blocks
c. Hollow clay tile
d. Stone masonry
e. Mortar for various types of masonry
2. Costs of labor, materials, and equipment

XII. Estimating Wood Construction Costs

Units of Instruction
1. Heavy timber (mill) construction
a. Quantity take-off
b. Cost of labor, materials, and equipment
2. Light wood construction
a. Rough carpentry work
(1) Quantity take-off
(a) Framing
i. Sills
ii. Studs
iii. Joists
iv. Rafters
v. Plates
vi. Beams
vii. Posts
viii. Girders
(b) Boarding, sheathing, subflooring, roofing
(c) Furring and grounds
(d) Door and window frames
(e) Insulation
(2) Costs of labor, materials, and equipment for rough carpentry work
b. Finished carpentry work
(1) Classification
(a) Exterior finish
i. Walls—siding and shingling
ii. Trim
iii. Windows and doors
iv. Roofing and flashing
v. Steps
vi. Porches
vii. Exterior hardware
(b) Interior finish
i. Floors
ii. Trim
iii. Stairs
iv. Windows and doors
v. Cabinet and mill work
vi. Shelves
vii. Interior hardware
(2) Quantity take-off for finished carpentry
(3) Costs of labor, materials, and equipment for above items

XIII. Estimating Costs of Lathing, Plastering, Painting, Glazing, and Roofing and Flashing

Units of Instruction
1. Lathing and plastering
a. Quantity take-off
b. Costs of labor, materials, and equipment
2. Painting
a. Quantity take-off
b. Costs of labor, materials, and equipment
3. Glazing
a. Quantity take-off
b. Costs of labor, materials, and equipment
4. Roofing and flashing
a. Types of roofing
(1) Asphalt shingles
(2) Asbestos shingles
(3) Slate roofing
(4) Built-up roofing
(5) Metal roofing
b. Quantity take-off for the types of roofing
c. Costs of labor, materials, and equipment for types of roofing, including the flashing

XIV. Estimating Structural Steel Costs

A. Units of Instruction
1. Quantity take-off—materials required

2. Items of cost in a structural steel estimate
   a. Structural steel shapes at the fabricating shop
   b. Drawings for use by the fabricating shop
   c. Handling structural steel shapes and fabricating into finished members
   d. Shop painting, if required
   e. Ship overhead, sales, profit
   f. Transporting steel from shop to the job site
   g. Erecting the steel, including costs of equipment, labor, bolts, rivets, or welding
   h. Field painting the steel structure
   i. Job overhead, general overhead, insurance, taxes
   j. Profit

B. Laboratory Projects
   1. Estimate the cost of structural steel for a building, including the base price, fabrication, transportation, erection, and painting.
   2. Estimate the cost of general overhead for project 1.

XV. Estimating Costs of Highways and Pavements

A. Units of Instruction
   1. Clearing and grubbing the land
   2. Concrete pavements
      a. Quantity take-off
      b. Costs of labor, material, and equipment
         (1) Preparing subgrade
         (2) Handling, batching, and hauling materials
         (3) Placing reinforcement
         (4) Mixing, placing, and finishing concrete
         (5) Joists
         (6) Curing concrete pavement
         (7) Landscaping
   3. Asphalt pavements
      a. Quantity take-off
         (1) Aggregates
         (2) Asphalts
      b. Costs of labor, material, and equipment
   4. Asphaltic-concrete pavements
      a. Cold-mix
         (1) Quantity take-off
         (2) Costs of labor, material, and equipment
      b. Hot-mix
         (1) Quantity take-off
         (2) Costs of labor, material, and equipment

B. Laboratory Projects
   1. Estimate the cost of paving a section with concrete, including clearing and grubbing the land.
   2. Estimate the cost of paving a section with hot-mix asphaltic concrete, including crushed stone base.

XVI. Specifications, Contract, and Cost Estimates of a Project Related to Water and Wastewater Technology

Prepare specifications, contract, and cost estimates for a typical construction project related to water and wastewater technology.

Texts and References

COOPER. *Building Construction Estimating.*

FOSTER. *Construction Estimates for Take-Off to Bid.*

LEHMAN. *Practical Law.*

MEAD *and* OTHERS. *Contracts, Specifications, and Engineering Relations.*

MERRITT. *Building Construction Handbook.*

N.C. DEPARTMENT OF INSURANCE. *North Carolina State Building Code.*

PEURIFOY. *Estimating Construction Costs.*

PULVER. *Construction Estimates and Costs.*

WALKER. *Building Estimator's Reference Book.*

WATSON. *Specifications Writing for Architects and Engineers.*

General Courses

COMMUNICATION SKILLS

Hours Per Week

Class, 3; Laboratory 0

Course Description

This course is designed to develop or strengthen language and writing skills and to help the student become more proficient in oral expression. Emphasis is on written exercises and practice in oral communication and listening. Each student's weaknesses and strengths should be analyzed. The time allotted for studying various units will be determined by the needs of the class.

Technical Reporting is studied briefly because of its role in orienting students to the types of oral and written reports required of technicians.

Major Divisions

	Class Hours
I. Communication and the Technical Specialist	2
II. Sentence Structure	6
III. Using Resource Materials	4
IV. Written Expression	20
V. Talking and Listening	10
VI. Improving Reading Efficiency	6
Total	48

I. Communication and the Technical Specialist

1. Importance of proficiency in the art of communication
2. Need for language and writing skills
   a. Statement of facts
   b. Expression of ideas
   c. Technical reporting
      (1) Formal
      (2) Informal
   d. Graphics for illustrating written reports
3. Need for proficiency in oral expression
   a. Person-to-person communication
   b. Verbal reporting
4. Diagnostic tests

II. Sentence Structure

1. Review of parts of speech, their functions
2. The complete sentence
3. Use and position of modifiers: words, phrases, or clauses
4. Conciseness and clarity
5. Exercises in sentence structure

III. Using Resource Materials

1. The school library
   a. Location of reference materials, *Readers' Guide to Periodical Literature,* etc.
   b. Mechanics for effective use
   c. Dewey decimal system
2. Dictionaries
   a. Types of dictionaries
   b. Use of dictionaries
   c. Diacritical and accent marks
3. Other reference sources
   a. Technical manuals and pamphlets
   b. Bibliographies
   c. Periodicals
   d. *Industrial Arts Index*
4. Exercises in use of resource materials
   a. *Readers' Guide,* etc.
   b. Atlases
   c. Encyclopedias
   d. Other references

IV. Written Expression (emphasis on student exercises)

1. Diagnostic test
2. Paragraphs
   a. Development
   b. Topic sentence
   c. Coherence
3. Methods of clarifying ideas
   a. Inductive and deductive reasoning
   b. Figures of speech
   c. Analogies
   d. Syllogisms
   e. Cause and effect
   f. Other methods

4. Written exercises in paragraph development
5. Descriptive reporting
   a. Organization and planning
   b. Emphasis on sequence, continuity, and objectivity
6. Letter writing
   a. Business letters
   b. Personal letters
7. Mechanics
   a. Capitalization
   b. Punctuation and its use
      (1) Period, question mark, and exclamation point
      (2) Comma
      (3) Semicolon
      (4) Colon
      (5) Dash
      (6) Parentheses
      (7) Apostrophe
      (8) Quotation marks
   c. Spelling
      (1) Word division—syllabification
      (2) Prefixes and suffixes
      (3) Word analysis and meaning—context clues, phonetics, etc.
8. Exercises in mechanics

V. Talking and Listening (emphasis on student exercises)

1. Diagnostic testing
2. Organization of topics or subject
3. Directness in speaking
4. Gesticulation and use of objects to illustrate
5. Conversational courtesies
6. Listening faults
7. Taking notes
8. Understanding words through context clues
9. Exercises in talking and listening

VI. Improving Reading Efficiency

1. Diagnostic test
2. Reading habits
   a. Correct reading posture
   b. Light sources and intensity
   c. Developing proper eye span and movement
   d. Scanning
   e. Topic sentence reading
3. Footnotes, index, bibliography, cross references, etc.
4. Techniques of summarizing
   a. Outline
   b. Digest or brief
   c. Critique
5. Exercises
   a. Reading for speed
   b. Reading for comprehension

Texts and References

BAIRD and KNOWER. *Essentials of General Speech.*

———. *General Speech: An Introduction.*

BEARDSLEY. *Thinking Straight: Principles of Reasoning for Readers and Writers.*

BORDEAUX. *How to Talk More Effectively.*

BUCKLER and MCAVOY. *American College Handbook of English Fundamentals.*

COWAN and MCPHERSON. *Plain English Please.*

CROUCH and ZETLER. *A Guide to Technical Writing.*

DEAN and BRYSON. *Effective Communication.*

DE VITIS and WARNER. *Words in Context: A Vocabulary Builder.*

GERBER. *Writer's Resource Book.*

HARWELL. *Technical Communication.*

JENNINGS and TRACY. *Handbook for Technical Writers.*

KEGEL and STEVENS. *Communication, Principles and Practices.*

LEE. *Language Habits in Human Affairs: An Introduction to General Semantics.*

MACRORIE. *The Perceptive Writer, Reader, and Speaker.*

MARDER. *Craft of Technical Writing.*

PERRIN and SMITH. *Handbook of Current English.*

ROGET. *New Roget's Thesaurus of the English Language.*

SCHUTTE and STEINBERG. *Communication in Business and Industry.*

STEWART and OTHERS. *Business English and Communication.*

STRUNK. *Elements of Style.*

THOMPSON. *Fundamentals of Communication.*

WARRINER and GRIFFITH. *English Grammar and Composition: A Complete Handbook.*

WITTY. *How to Become a Better Reader.*

YOUNG and SYMONIK. *Practical English, Introduction to Composition.*

ZETLER and CROUCH. *Successful Communication in Science and Industry: Writing, Reading, and Speaking.*

Visual Aids

Coronet Films, Inc., Coronet Building, Chicago, Ill. 60601.
Improve Your Punctuation. 16 mm., 11 min., sound, black and white or color.

National Education Television Film Service, Bloomington, Ind. 47405.

The Definition of Language. 16 mm., 29 min., sound, black and white. Produced by Henry Lee Smith (Language in Linguistics Series).

Dialects. 16 mm., 29 min., sound, black and white or color. Produced by Henry Lee Smith (Language in Linguistics Series).

How to Say What You Mean. 16 mm., 29 min., sound, black and white. Produced by S. I. Hayakawa (Language in Action Series).

Language and Writing. 16 mm., 29 min., sound, black and white. Henry Lee Smith (Language in Linguistics Series).

The Task of the Listener. 16 mm., 29 min., sound, black and white. S. I. Hayakawa (Language in Action Series).

What is the Meaning? 16 mm., 29 min., sound, black and white. Produced by S. I. Hayakawa (Language in Action Series).

DuArt Film Laboratories, Inc., 245 West 55th Street, New York, N.Y. 10019.

Effective Writing. 16 mm., 19 min., sound, black and white. Produced by U.S. Department of the Air Force.

Practical English Usage, Lecture 1: The Tools of Language. 16 mm., 30 min., sound, black and white. Produced by U.S. Department of Defense.

Practical English Usage 1, Lecture 10: Writing Clear Sentences; Making Words Agree. 16 mm., 30 min., sound, black and white. Produced by U.S. Department of Defense.

Practical English Usage I, Lecture 13: Dressing Up Sentences; Parallelism; Avoidance of Shifts. 16 mm., 30 min., sound, black and white. Produced by U.S. Department of Defense.

Practical English Usage I, Lecture 14: Dressing Up Sentences; Word Economy (Word Reduction). 16 mm., 30 min., sound, black and white. Produced by U.S. Department of Defense.

Practical English Usage I, Lecture 15: Dressing Up Sentences; Variation. 16 mm., 30 min., sound, black and white. Produced by U.S. Department of Defense.

Practical English Usage I, Lecture 15: Dressing Up Sentences; Vocabulary. 16 mm., 30 min., sound, black and white. Produced by U.S. Department of Defense.

GENERAL AND INDUSTRIAL ECONOMICS

Hours Per Week

Class, 3; Laboratory, 0

Course Description

A course designed to develop an understanding of basic economic concepts and their implications for technicians; and the ability to manage personal income, economize, and buy intelligently. The relation of cost control to success in industrial enterprise is studied. The programs or problems involved in water and wastewater research, installation, or operation must ultimately be measured by a cost analysis. For this reason, students must have a knowledge of elementary economics to function in the cost-conscious environment of employment. The instruction should be based on this pragmatic approach and students should study actual problems of industry as they learn about industrial cost analysis, competition, creation of demand, economic production, and other related aspects of applied economics.

Major Divisions

		Class Hours
I.	Introduction	2
II.	Economic Forces and Indicators	3
III.	Natural Resources—the Basis of Production	3
IV.	Capital and Labor	3
V.	Business Enterprise	7
VI.	Industrial Production Costs	8
VII.	Price, Competition, and Monopoly	5
VIII.	Distribution of Income	2
IX.	Personal Income Management	2
X.	Insurance, Personal Investments, and Social Security	3
XI.	Money and Banking	3
XII.	Government Expenditures—Federal, State, and Local	3
XIII.	Fluctuations in Production, Employment, and Income	2
XIV.	The U.S. Economy in Perspective	2
	Total	48

I. Introduction

1. Basic economic concepts
2. Implications for technicians

II. Economic Forces and Indicators

1. Economics defined

2. Modern specialization
3. Increasing production and consumption
4. Measures of economic activity
   a. Gross national product (GNP)
   b. National income
   c. Disposable personal income
   d. Industrial production
   e. Employment and unemployment

III. National Resources—the Basis of Production

1. Utilization and conservation
2. Renewable resources
3. Nonrenewable resources
4. Future sources

IV. Capital and Labor

1. Tools (Capital)
   a. Importance of savings and investments
   b. Necessity for markets
2. Large-scale enterprise
3. Labor
   a. Population characteristics
   b. Vocational choice
   c. General education
   d. Special training
   e. Management's role in maintaining labor supply

V. Business Enterprise

1. Types of business enterprise
   a. Individual proprietorship
   b. Partnership
   c. Corporation
2. Types of corporate securities
   a. Common stocks
   b. Preferred stocks
   c. Bonds
3. Mechanics of financing business
4. Plant organization and management

VI. Industrial Production Costs

1. Buildings and equipment
   a. Initial cost and financing
   b. Repair and maintenance
   c. Depreciation and obsolescence
2. Materials
   a. Initial cost and inventory value
   b. Handling and storage
3. Processing and production
   a. Methods of cost analysis
   b. Cost of labor
   c. Cost of supervision and process control
   d. Losses in percentage of original product compared to finished product (yield), in chemical operations
4. Packaging and shipping
5. Overhead costs
6. Taxes
7. Cost of selling
8. Process analysis, a means to lower costs
9. Profitability and business survival

VIII. Price, Competition, and Monopoly

1. Function of prices
2. Price determination
   a. Competitive cost of product
   b. Demand
   c. Supply
   d. Interactions between supply and demand
3. Competition, benefits, and consequences
   a. Monopoly and oligopoly
   b. Forces that modify and reduce competition
   c. History of government regulation of competition
4. How competitive is our economy

VIII. Distribution of Income

1. Increasing real incomes
2. Marginal productivity
3. Supply in relation to demand
4. Incomes resulting from production
   a. Wages
   b. Interest
   c. Rents
   d. Profits
5. Income distribution today

IX. Personal Income Management

1. Consumption—the core of economics
2. Economizing defined
3. Personal and family budgeting
4. Analytical buying
   a. Applying quality standards
   b. Consumer's research and similar aids
5. Use of credit
6. Housing—own or rent

X. Insurance, Personal Investments, and Social Security

1. Insurance defined
2. Life insurance
   a. Group, industrial, and ordinary life insurance
   b. Types of policies—their advantages and disadvantages
3. Casualty insurance
4. Personal investments
   a. Savings accounts and Government bonds
   b. Corporation bonds
   c. Corporation stocks
   d. Annuities
   e. Pension plans
5. Social security
   a. Old-Age and Survivors Insurance (OASI)
   b. Unemployment compensation
   c. Medicare

XI. Money and Banking

1. Functions of money
2. The Nation's money supply
3. Organization and operation of a bank
   a. Sources of deposits
   b. The reserve ratio
   c. Expansion of bank deposits
   d. Sources of reserves
4. Federal Reserve System (FRS)
   a. Service functions
   b. Control of money supply
5. Federal Deposit Insurance Corporation (FDIC)

XII. Government Expenditures—Federal, State, and Local

1. Economic effects
2. Functions of Government
3. Analysis of Government spending
4. Future outlook
5. Financing Government spending
   a. Criteria of sound taxation
   b. Tax revenues in the United States
   c. Federal and State personal income taxes
   d. Corporate income tax
   e. Property taxes
   f. Commodity taxes

XIII. Fluctuations in Production, Employment, and Income

1. Changes in aggregate spending
2. Output and employment
3. Other factors affecting economic fluctuations
   a. Cost-price relationships
   b. Fluctuations in demand for durable goods
   c. Involuntary fluctuation of supply of commodities
   d. Inflation and deflation of currency value
   e. Economic effects of inventions and automation
4. Implementing fiscal policy
5. Government debt
   a. Purposes of Government borrowing
   b. How burdensome is debt
   c. Problems of debt management

XIV. The U.S. Economy in Perspective

1. Recent economic changes
   a. Increased productivity and well-being
   b. Effects of war and depression
   c. New products and industries
   d. Increased governmental controls
2. Present economic problems of U.S. economy
   a. The world market—a community of nations
   b. International cooperation
   c. Maintenance of prosperity and progress
   d. Economic freedom and security
3. Communism: Nature and control by Soviet Government
4. Fascism
5. Socialism
6. Problems common to all economic systems

Texts and References

ARIES *and* NEWTON. *Chemical Engineering Cost Estimation.*

DONALDSON *and* PFAHL. *Personal Finance.*

DUNLOP. *Automation and Technological Change.*

DYE *and* OTHERS. *Economics: Principles, Problems, and Perspectives.*

EDWARDS. *The Nation's Economic Objectives.*

GORDON. *Economics for Consumers.*

KATONA. *Mass Consumption Society.*

LYNN. *Basic Economic Principles*

REYNOLDS. *Economics: A General Introduction.*
———. *Labor Economics and Labor Relations.*
SAMUELSON. *Economics: An Introductory Analysis.*
SCHULTZ. *Economic Value of Education.*

Visual Aids

McGraw-Hill Book Co., 330 West 42nd Street, New York, N.Y. 10036.

Basic Economic Concepts. 35 mm., set of 4 filmstrips (average 40 frames each), black and white.

Business Cycles and Fiscal Policy. 35 mm., filmstrip, black and white.

Money, Prices, and Interest. 35 mm., filmstrip, black and white.

Savings and Investment. 35 mm., filmstrip, black and white.

Supply and Demand. 35 mm., filmstrip, black and white.

INDUSTRIAL ORGANIZATIONS, INSTITUTIONS, AND GOVERNMENT

Hours Per Week

Class, 3; Laboratory, 0

Course Description

The roles of labor and management in the economy of the United States are described and analyzed. Approximately half of the time is devoted to studying labor-management relations, including the evolution of the labor movement and the development and organizational structure of American business management. A study is made of the legal framework within which labor-management relations are conducted in a democratic government. The remaining half of the course pertains to labor-economics as applied to the forces affecting labor supply and demand, employment stabilization, and wage determination. Emphasis centers on current aspects of industrial society, with historical references intended only as background.

Major Divisions

	Class Hours
I. Labor in an Industrial World	9
II. Management in an Industrial Society	9
III. The Collective Bargaining Process	12
IV. Dynamics of the Labor Market	8
V. Wage Determination	7
VI. The Balance Sheet of Labor-Management Relations	3
Total	48

I. Labor in an Industrial World

1. The nature and scope of the Industrial Revolution
   a. The factory system
   b. Occupational trends
   c. Mechanisms of adjustments
2. The evolution of American labor unions
   a. Nature of early unions: basic system of craft unions
   b. Organization by unions for solving problems
   c. Emergence of business unionism
   d. The changing role of government
3. Structure and objectives of American unions
   a. Objectives in collective bargaining
   b. Political objectives and tactics
   c. Structure of craft and industrial unions
   d. Movement toward unity—the AFL-CIO merger

II. Management in an Industrial Society

1. The rise of big business
   a. Economic factors
   b. Dominance of the corporate firm
   c. Government, public policy, and big business
2. The managerial revolution
   a. Changing patterns of ownership and management
   b. Scientific management
   c. Twentieth-century trends
3. Structure and objectives of American industry
   a. Production for profit: an affluent society
   b. Structure of industry—organizational forms
   c. Ethics in a competitive economy

III. The Collective Bargaining Process

1. Legal framework
   a. Common law provisions
   b. The growth of statute laws
      (1) The antitrust laws; aid to emergence of collecting bargaining
      (2) The Adamson and La Follette Laws
      (3) Norris-La Guardia Act
      (4) Wagner Act
      (5) Taft-Hartley Act
      (6) Landrum-Griffin Act, and beyond
2. Management and collective bargaining
3. Bargaining procedures and tactics, including conciliation and mediation process
4. Issues in collective bargaining
   a. Security issues
   b. Working conditions
   c. Safety provisions and safety education
   d. Money matters
5. Strikes and lockouts; tactics and prevention
6. Evaluation of collective bargaining

IV. Dynamics of the Labor Market

1. Labor supply and the market
   a. Levels and composition of the labor force
   b. Changing patterns of employment
   c. Some questions about labor supply and market
2. Reduction and control of unemployment
   a. Types of unemployment
   b. Proposed schemes for employment stabilization
   c. Continuing problems
3. Labor mobility
   a. Types of labor mobility
   b. Deterrents to labor mobility
   c. Suggested programs to improve labor mobility

V. Wage Determination

1. Wages, process, and employment
   a. Meaning of wages
   b. Wages and the productive process
   c. The problem of inflation
2. Wages and the national income
   a. Concepts of measurement and productivity
   b. Determinants of productivity
   c. The distribution of national income
3. Wage structures
   a. Occupational differences
   b. Geographic patterns
   c. Industry patterns
   d. Wage determination: plant level, individual wages

VI. The Balance Sheet of Labor-Management Relations

1. Control and elimination of poverty in a modern industrial state
   a. The extent of poverty
   b. The attack on poverty
   c. Trends and portents
2. Justice and dignity for all in an industrial democracy
   a. The worker—status and goals
   b. Management—rights and responsibilities
   c. The future of a capitalistic society

Texts and References

ADRIAN. *State and Local Governments.*

BACH. *Economics: An Introduction to Analysis and Policy.*

BELL. *Crowd Culture.*

BIESANZ *and* BIESANZ. *Modern Society: An Introduction to Social Science.*

BISHOP *and* HENDEL. *Basic Issues of American Democracy.*

BLOOM *and* NORTHRUP. *Economics of Labor Relations.*

CARR, BERSTEIN, *and* MORRISON. *American Democracy in Theory and Practice.*

CHAMBERLAIN. *Sourcebook on Labor.*

CHINOY. *Society: An Introduction to Sociology.*

FAULKNER. *American Economic History.*

IRISH *and* PROTHRO. *Politics of American Democracy.*

MARK *and* SLATER. *Economics in Action.*

OGG *and* RAY. *Essentials of American Government.*

PELLING. *American Labor.*

PHELPS. *Introduction to Labor Economics.*

ROSS. *Fabric of Society.*

SLICHTER *and* OTHERS. *The Impact of Collective Bargaining on Management.*

SULTAN. *Labor Economics.*

WALETT. *Economic History of the United States.*

WOLFBEIN. *Employment and Unemployment in the United States.*

ERIC

Visual Aids

Brookings Institution, 1775 Massachusetts Avenue, NW., Washington, D.C. 20036.

Big Enterprise in the Competitive System. 40 min., 16 mm., sound, color.

Coronet Films, Inc., Coronet Building, Chicago, Ill. 60604.

Labor Movement: Beginnings and Growth in America. 13½ min., 16 mm., sound, black and white or color.

Encyclopaedia Britannica Films, Inc., 1150 Wilmette Avenue, Wilmette, Ill. 60091.

Productivity—Key to Plenty. 22 min., 16 mm., sound, black and white.

Working Together (A Case History in Labor Management Cooperation). 24 min., 16 mm., sound, black and white.

Indiana University, Bloomington, Ind. 47405.

Decision: Constitution and The Labor Union. 29 min., 16 mm., sound, black and white.

McGraw-Hill Book Co., Text Film Dept., 30 West 42d Street, New York, N.Y. 10036.

Internal Organization. 10 min., 16 mm., sound, black and white.

Job Evaluation. 13 min., 16 mm., sound, black and white.

Teaching Film Custodians, 25 West 43d Street, New York, N.Y. 10036.

Bargaining Collectively. 10 min., 16 mm., sound, black and white.

LIBRARY FACILITIES AND CONTENTS

In the evaluation of any technology program, the library's physical facilities, organization, quality and quantity of pertinent content, and the librarian's qualifications are tangible evidence of the program's strength.

The pace of new developments and changes in technological science and practice make it necessary for students in technology programs to know how to use the library.

Instruction in the technologies should be oriented to the library so that students will know how to use it as a tool in learning and as a source for available information and reference relating to a particular field of study. This knowledge helps the student to develop a professional attitude and to understand that success as an employed technician will be determined by his ability to keep abreast of new developments in his field.

Instructors should keep the student aware of the extent to which he can depend on library facilities for information related to his curriculum. This can be done by assigning study projects which require the student to cull and compile pertinent information from reference material in the library. In addition, instructors could plan open-book examinations during regular class periods which require library research, giving the student a chance to assess his competence and resourcefulness in using the library within a limited period of time.

Instructors could select books from their personal collections to discuss during a teacher-student conference, thereby stimulating a student's interest in literature related to his field. But, a central library, supervised by a professional librarian, is needed because of its importance to the success of a technology program. A central library insures the acquisition of appropriate reference material and the systematic organization of library content according to accepted library practice. It also provides the physical facilities which make its contents accessible to the users, and has a controlled and orderly system for lending books to students. The book-lending system is typical of public libraries, which students will use later as employed technicians.

The library plan should include ample space for in-library study of reference data. This space should be properly lighted and secluded to avoid distraction.

Library Staff and Budget

The head librarian usually reports to the top administrative office of the school and has full faculty status.

American Library Association standards state that "two professional librarians or the minimum number required for effective service in any junior college with an enrollment up to 500 students (full-time equivalent). In addition, there should be at least one nonprofessional staff member. The larger the institution, the more appropriate it will be to employ a higher proportion of nonprofessional staff members. Great care should be taken that professional staff members do not spend their time doing work that is essentially clerical, because this is not only wasteful but also demoralizing."

According to the American Library Association, the library budget should be determined in relation to the institution's total budget for educational and general purposes, but the amount allocated to the library should be sufficient for operating a library program which supports the school's goals. The operation of the library program, as outlined in the Association's standards, normally requires a minimum of 5 percent of the total budget for educational and general purposes. This minimum allows for establishing a well organized library, with the required staff and an adequate reference collection. The minimum would have to be augmented if there is a rapid increase in enrollment or course offerings; and again if the library is responsible for an audio-visual program. The library budget for a newly organized institution should be considerably higher than 5 percent.

Another criterion for the library budget, approved by the American Library Association, is that the funds allotted for new library materials should equal or exceed the cost of the total library staff. This applies to established libraries, but expenditures for materials should be substantially greater for new libraries, or if major additions to curriculum have been made.

Library Content

The library must include adequate literature which pertains to all the subjects in a curriculum and extends beyond the learning activities of the classroom. References on highly specialized subjects may be added as needed, or borrowed on an interlibrary-loan basis from other libraries.

The library should serve the needs of full-time students and part-time students. In addition, its content should complement the teachers' need to keep abreast of new developments in their special fields.

Because of the highly specialized nature of reference material related to water and wastewater technology, the department head or chief instructor of the technology should be a member of the library committee and responsible for final approval of all material selected for the technology and related courses. The librarian, as chairman of the committee, should assist the head of the water and wastewater technology department by keeping him informed of new literature and materials which become available. The librarian should consult with the department head to insure that the required materials will be purchased.

Library content may be classified into *basic encyclopedic and reference index material, reference books pertinent to the technology, periodicals and journals, and visual aids.*

Encyclopedic and Reference Index Material

This category is basic in that it contains the broadly classified and organized cataloging of all available knowledge pertinent to the objectives of the library and the program it serves.

The following list is an example of the type of general reference material found in a publicly controlled technical institute. Though many are general references, all have some bearing on water and wastewater technology. Therefore, some or all of these are appropriate for a library which supports a water and wastewater technology program. This list is not complete, since there are many other references and guides which relate to water and wastewater technology. When ordering any of the following references for a library collection, the latest edition should be requested.

AMERICAN COLLEGE DICTIONARY: Random House, Inc., 457 Madison Avenue, New York, N.Y. 10022.

APPLIED SCIENCE & TECHNOLOGY INDEX: H. W. Wilson Co., 950 University Avenue, Bronx, N.Y. 10452.

ASTM STANDARDS: American Society for Testing Materials, 1916 Race Street, Philadelphia, Pa. 19103.

BIBLIOGRAPHY INDEX, THE: H. W. Wilson Co., 950 University Avenue, Bronx, N.Y. 10452.

BUSINESS PERIODICALS INDEX: H. W. Wilson Co., 950 University Avenue, Bronx, N.Y. 10452.

CHEMICAL ABSTRACTS: American Chemical Society, 1155 16th Street, NW., Washington, D.C. 20036.

CHEMICAL INDUSTRY FACTS BOOK, THE: Manufacturing Chemists Association, Inc., 1825 Connecticut Avenue NW., Washington, D.C. 20009.

COLLIER'S ENCYCLOPEDIA: Collier-Macmillan Library Service Division, 60 Fifth Avenue, New York, N.Y. 10011.

COMMERCIAL ATLAS AND MAILING GUIDE: Rand McNally & Co., Box 7600, Chicago, Ill. 60680.

CUMULATIVE BOOK INDEX: H. W. Wilson Co., 950 University Avenue, Bronx, N.Y. 10452.

DICTIONARY OF APPLIED CHEMISTRY: J. Thorpe, John Wiley & Sons, Inc., 605 3d Avenue, New York, N.Y. 10016.

ENCYCLOPEDIA AMERICANA, THE: Americana Corporation, 575 Lexington Avenue, New York, N.Y. 10022.

ENCYCLOPAEDIA BRITANNICA: Encyclopaedia Britannica, Inc., 425 N. Michigan Ave., Chicago, Ill. 60611.

ENCYCLOPEDIA OF CHEMICAL REACTIONS: C. A. Jacobson and Clifford A. Hampel, Reinhold Publishing Corp., Book Division, 430 Park Avenue, New York, N.Y. 10022.

ENCYCLOPEDIA OF CHEMISTRY, THE: Clark and Hawley, Reinhold Publishing Corp., Book Division, 430 Park Avenue, New York, N.Y. 10022.

ENCYCLOPEDIA OF MICROSCOPY, THE: George L. Clark, Reinhold Publishing Corp., Book Division, 430 Park Avenue, New York, N.Y. 10022.

ENCYCLOPEDIA OF THE SOCIAL SCIENCES: The Macmillan Co., 60 5th Avenue, New York, N.Y. 10003.

ENCYCLOPEDIC DICTIONARY OF PHYSICS: J. Thewlis, Pergamon Press, 44-91 21st St., Long Island City, N.Y. 11101.

ENGINEERING INDEX: Engineering Index, Inc., 29 West 39th St., New York, N.Y. 10013.

ENGINEERING MATERIALS HANDBOOK: Charles L. Mantell, McGraw-Hill Book Co., Inc., 330 W. 42d St., New York, N.Y. 10036.

HANDBOOK OF CHEMISTRY AND PHYSICS: Chemical Rubber Publishing Co., 2310 Superior Avenue, NE., Cleveland, Ohio 44114.

INTERNATIONAL CRITICAL TABLES: McGraw-Hill Book Co., Inc., 330 W. 42d Street, New York, N.Y. 10036.

INTERNATIONAL DICTIONARY OF PHYSICS AND ELECTRONICS: D. Van Nostrand Co., Inc., Princeton, N.J. 08540.

LABOR POLICY AND PRACTICE: Bureau of National Affairs, Inc., 1231 24th Street, NW., Washington, D.C. 20037.

LIBRARY OF CONGRESS CATALOG: U.S. Library of Congress, Washington, D.C. 20540.

MANUAL FOR PROCESS ENGINEERING CALCULATIONS: McGraw-Hill Book Co., Inc., 330 W. 42d St., New York, N.Y. 10036.

McGRAW-HILL ENCYCLOPEDIA OF SCIENCE AND TECHNOLOGY: McGraw-Hill Book Co., Inc., 330 W. 42d St., New York, N.Y. 10036.

METALS HANDBOOK: American Society for Metals, Technical Book Dept., Novelty, Ohio 44073.

MOODY'S INDUSTRIAL MANUAL: Moody's Investor's Service, 65 Broadway, New York, N.Y. 10004.

NUCLEAR SCIENCE ABSTRACTS: U.S. Atomic Energy Commission, Washington, D.C. 20545.

OXFORD ENGLISH DICTIONARY: Oxford University Press, Inc., 417 5th Avenue, New York, N.Y. 10016.

POOR'S REGISTER OF CORPORATIONS, DIRECTORS, AND EXECUTIVES: Standard and Poor's Corp., 345 Hudson St., New York, N.Y. 10014.

READER'S GUIDE TO PERIODICAL LITERATURE, THE: H. W. Wilson Co., 950 University Avenue, Bronx, N.Y. 10452.

RESEARCH AND DEVELOPMENT ABSTRACTS: U.S. Atomic Energy Commission, Washington, D.C. 20545.

SCIENTIFIC AND TECHNICAL SOCIETIES OF THE UNITED STATES AND CANADA: National Academy of Sciences, National Research Council, 2101 Constitution Avenue, NW., Washington, D.C. 20037.

STATISTICAL ABSTRACT OF THE UNITED STATES: U.S. Department of Commerce, Washington, D.C. 20230.

SWEET'S INDUSTRIAL CONSTRUCTION FILE: Sweet's Catalog Service, F. W. Dodge Corp., 119 W. 40th Street, New York, N.Y. 10014.

TEMPERATURE—ITS MEASUREMENT AND CONTROL IN SCIENCE AND INDUSTRY: American Institute of Physics, 335 East 45th Street, New York, N.Y. 10017.

THOMAS REGISTER: Thomas Publishing Co., 461 Eighth Avenue, New York, N.Y. 10001.

VAN NOSTRAND'S SCIENTIFIC ENCYCLOPEDIA: D. Van Nostrand Co., Inc., Princeton, N.J. 08540.

WEBSTER'S INTERNATIONAL DICTIONARY: G. & C. Merriam Co., 47 Federal Street, Springfield, Mass. 01105.

WELDING HANDBOOK: American Welding Society, 345 East 47th Street, New York, N.Y. 10017.

Technical Journals, Periodicals, and Trade Magazines

These authoritative publications present the most recent and complete information about a specific area of applied science. It is therefore essential that both instructors and students make frequent and systematic use of these publications.

Selectivity should be exercised in determining which periodicals should be bound, or microfilmed as reference material. Some, especially the trade journals, should not be bound and retained as permanent reference material because any important information which they contain is usually incorporated into a handbook or textbook, or a condensed version is presented for use within a few years.

The following list gives examples of the technical journals, periodicals, and trade magazines which should be in the library as well as suggests publications to be considered by those concerned with libraries serving water and wastewater technology programs.

AEROSPACE MANAGEMENT: Clinton Co., Chestnut and 56th Street, Philadelphia, Pa. 19106.

AIR CONDITIONING, HEATING AND VENTILATING: Industrial Press, 93 Worth Street, New York, N.Y. 10013.

AMERICAN CERAMIC SOCIETY BULLETIN: American Ceramic Society, Inc., 4055 North High Street, Columbus, Ohio 43214.

ANALYTICAL CHEMISTRY: American Chemical Society, 1155 16th Street, NW., Washington, D.C. 20036.

BATTELLE TECHNICAL REVIEW: Battelle Memorial Institute, 505 King Avenue, Columbus, Ohio 43201.

BELL LABORATORIES RECORD: Bell Telephone Laboratories, Inc., 463 West Street, New York, N.Y. 10014.

CHEMICAL AND ENGINEERING NEWS: American Chemical Society, 1155 16th Street, NW., Washington, D.C. 20036.

CHEMICAL ENGINEERING: McGraw-Hill Publishing Co., 330 West 42d Street, New York, N.Y. 10032.

CHEMICAL ENGINEERING PROGRESS: American Institute of Chemical Engineers, 345 East 47th Street, New York, N.Y. 10036.

CHEMICAL WEEK: McGraw-Hill Publishing Co., 330 West 42d Street, New York, N.Y. 10036.

CHEMISTRY: American Chemical Society, 1155 16th St., NW., Washington, D.C. 20036.

CLINICAL CHEMISTRY: (American Association of Clinical Chemicals, Inc.), Paul B. Hoeber, Inc., 49 East 33d Street, New York, N.Y. 10016.

ENGINEERING AND MINING JOURNAL: McGraw-Hill Publishing Co., 330 West 42d Street, New York, N.Y. 10036.

GLASS INDUSTRY: The Glass Publishing Co., Inc., 660 Madison Ave., New York, N.Y. 10021.

HYDROCARBON PROCESSING & PETROLEUM REFINER: Gulf Publishing Co., Box 2608, Houston, Tex. 77001.

INDUSTRIAL AND ENGINEERING CHEMISTRY: American Chemical Society, 1155 16th Street, NW., Washington, D.C. 20036.

INDUSTRIAL BULLETIN: Industrial Bulletin, Inc., 450 East Ohio Street, Chicago, Ill. 60611.

INDUSTRIAL EQUIPMENT NEWS: Thomas Publishing Co., 461 Eighth Avenue, New York, N.Y. 10001.

INDUSTRIAL GAS: Moore Publishing Co., Inc., Ojibway Building, Duluth, Minn. 55802.

INDUSTRIAL HEATING: National Industrial Publishing Co., Union Trust Building, Pittsburgh, Pa. 15219.

INSTRUMENTATION: Honeywell Industrial Products Group, Wayne and Windrim Ave., Philadelphia, Pa. 19140.

IRON AGE: Chilton Co., Inc., Chestnut and 56th Streets, Philadelphia, Pa. 19106.

IRON AND STEEL ENGINEER: Association of Iron and Steel Engineers, 1010 Empire Building, Pittsburgh, Pa. 15222.

JOURNAL OF THE AMERICAN CERAMIC SOCIETY: American Ceramic Society, Inc., 4055 North High Street, Columbus, Ohio 43214.

JOURNAL OF AMERICAN CHEMICAL SOCIETY: American Chemical Society, 1155 16th St., NW., Washington, D.C. 20036.

JOURNAL OF AMERICAN CONCRETE INSTITUTE: American Concrete Institute, P.O. Box 4754, Redford Station, Detroit, Mich. 48219.

JOURNAL OF APPLIED PHYSICS: American Institute of Physics, 335 East 45th St., New York, N.Y. 10017.

JOURNAL OF CHEMICAL EDUCATION: Division of Chemical Education of American Chemical Society, 500 Fifth Avenue, New York, N.Y. 10036.

JOURNAL OF RESEARCH (NATIONAL BUREAU OF STANDARDS), PART A, PHYSICS AND CHEMISTRY: U.S. Government Printing Office, Washington, D.C. 20402.

JOURNAL WATER POLLUTION CONTROL FEDERATION: 3900 Wisconsin Avenue, NW., Washington, D.C. 20016.

LUBRICATION: Texaco, Inc., 135 East 42d Street, New York, N.Y. 10017.

MATERIALS IN DESIGN ENGINEERING: Reinhold Publishing Corp., 430 Park Avenue, New York, N.Y. 10022.

MATERIALS RESEARCH AND STANDARDS: American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pa. 19103.

METAL PROGRESS: American Society for Metals, Metals Park, Novelty, Ohio 44072.

METALS REVIEW: American Society for Metals, Metals Park, Novelty, Ohio 44072.

MISSILES AND ROCKETS: American Aviation Publications, 1001 Vermont Avenue, NW., Washington, D.C. 20005.

MODERN PLASTICS: Modern Plastics, Inc., 575 Madison Avenue, New York, N.Y. 10022.

NUCLEONICS: McGraw-Hill Publishing Co., 330 West 42d Street, New York, N.Y. 10036.

PHYSICS TODAY: American Institute of Physics, 335 East 45th Street, New York, N.Y. 10017.

PLASTICS TECHNOLOGY: Bill Brothers Publishing Corp., 630 Third Avenue, New York, N.Y. 10017.

POPULAR PHOTOGRAPHY: Ziff-Davis Publishing Co., 1 Park Avenue, New York, N.Y. 10016.

POPULAR SCIENCE MONTHLY: Popular Science Publishing Co., Inc., 355 Lexington Avenue, New York, N.Y. 10017.

PRECISION METAL MOLDING: The Industrial Publishing Corp., 812 Huron Road, Cleveland, Ohio 44115.

PRODUCT ENGINEERING: McGraw-Hill Publishing Co., 330 West 42d Street, New York, N.Y. 10036.

PRODUCTION: Bramson Publishing Co., Box 1, Birmingham, Mich. 48012.

REVIEW OF SCIENTIFIC INSTRUMENTS: American Institute of Physics, 335 East 45th St., New York, N.Y. 10017.

SCIENCE NEWS LETTER: Science Service, Inc., 1719 N Street, NW., Washington, D.C. 20036.

SCIENTIFIC AMERICAN: Scientific American, Inc., 415 Madison Avenue, New York, N.Y. 10017.

SOCIETY OF PLASTICS ENGINEERS JOURNAL: Society of Plastics Engineers, Inc., 65 Prospect Street, Stamford, Conn. 06902.

TECHNICAL EDUCATION NEWS: McGraw-Hill Book Co., 330 West 42d Street, New York, N.Y. 10036.

TECHNOLOGY REVIEW: Alumni Association of Massachusetts Institute of Technology, Room 1–281, Cambridge, Mass. 02139.

TOOL AND MANUFACTURING ENGINEERING: American Society of Tool Engineers, 10700 Puritan Avenue, Detroit, Mich. 48227.

WELDING ENGINEER: Welding Engineer Publications, Inc., 5826 Dempster Street, P. O. Box 28, Morton Grove, Ill. 60053.

WELDING JOURNAL: American Welding Society, 345 East 47th Street, New York, N.Y. 10018.

WOOD AND WOOD PRODUCTS: Vance Publishing Corp., 59 East Monroe Street, Chicago, Ill. 60603.

WOOD PRESERVING NEWS: C. Miles Burpee, ed., 111 West Washington Street, Chicago, Ill. 60602.

The Book Collection

According to the American Library Association, "a 2-year institution of up to 1,000 students (full-time equivalent) cannot discharge its mission without a carefully selected collection of at least 20,000 volumes, exclusive of duplicates and textbooks. Institutions with broad curriculum offerings will tend to have larger collections; an institution with a multiplicity of programs may need a minimum collection of 2 or 3 times the basic figure of 20,000 volumes. The book holdings should be increased as the enrollment grows and the complexity and depths of course offerings expand. Consultation with many junior college librarians indicates that for most, a convenient yardstick would be the following: The bookstock should be enlarged by 5,000 volumes for every 500 students (full-time equivalent) beyond 1,000."

At the initiation of a water and wastewater technology program, the department head and the librarian should review current reference books and select references for the library. A recommended policy is to exclude those books which are used as texts for the various water and wastewater technology courses.

At the beginning of a water and wastewater technology program, the library should have from 200 to 300 reference books on the technology and its related fields, particularly the field of sanitary engineering. Then, from year to year, additional references should be acquired regularly and systematically, eventually weeding out obsolete references.

Visual Aids

The librarian and the department head should review and evaluate visual aids as they become available; and those selected should either be borrowed for special use, or purchased for regular use if the library is responsible for an audio-visual program.

Because of current research into methods of teaching the fundamentals and theory of atomic structure and other scientific principles, many new visual aid materials will become available in the future.

In addition to the visual aids now available for teaching physical science and chemical principles, there are and will be other films and descriptive materials to select from and use for teaching water and wastewater technology.

ERIC

General Planning of Facilities

Special laboratory facilities are required for teaching water and wastewater technology. The sanitary chemistry and biology laboratory, the hydraulics laboratory, the mobile water quality testing laboratory are essential to this curriculum and must be adequately planned and equipped for the courses. The laboratory work for biology and microbiology may be taught in an existing laboratory or in one that can be shared with other programs. Classroom areas and faculty offices do not require special considerations other than being conveniently located within the same building.

The laboratory arrangements, facilities, and equipment shown in this section are designed to accommodate a maximum of 24 first-year students and 16 second-year students. More than one section of first- or second-year students could be taught by allowing for this in scheduling use of the laboratories.

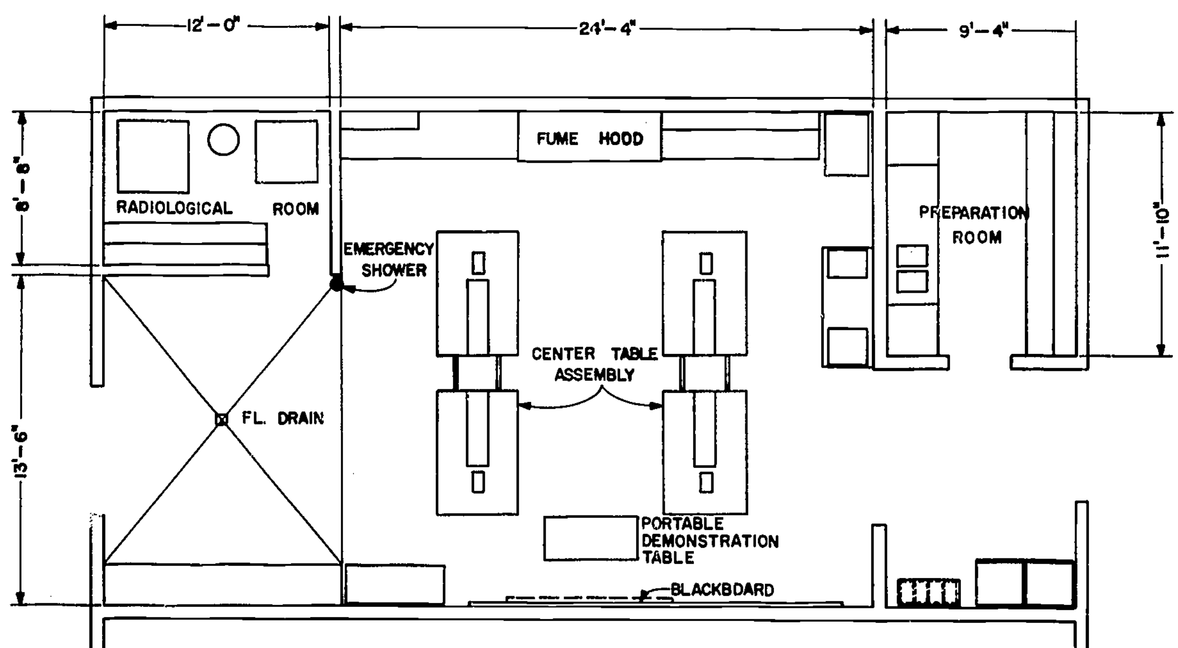
Sanitary Chemistry and Biology Laboratory

Figures 9 through 15 show a suggested layout for a floor plan, wall elevations, student work areas, and a demonstration table for a sanitary chemistry and biology laboratory. The plans show the approximate dimensions of work areas and equipment, and furniture is detailed sufficiently so that it may be easily identified for purchase.

Floor, Wall, and Ceiling Coverings. A 100-percent vinyl floor covering has been found to give excellent service in chemistry and biology laboratories because it is resistant to chemicals, easy to clean, durable, and attractive. It also reduces the strain and fatigue of standing for long periods.

Glazed tile coverings for walls are expensive, but require little or no maintenance. The surface is easy to clean because it is resistant to stains caused by chemical fumes. Concrete blocks or similar wall-covering material are often used but these surfaces

FIGURE 9.



SANITARY CHEMISTRY BIOLOGY LABORATORY
SUGGESTED LAYOUT

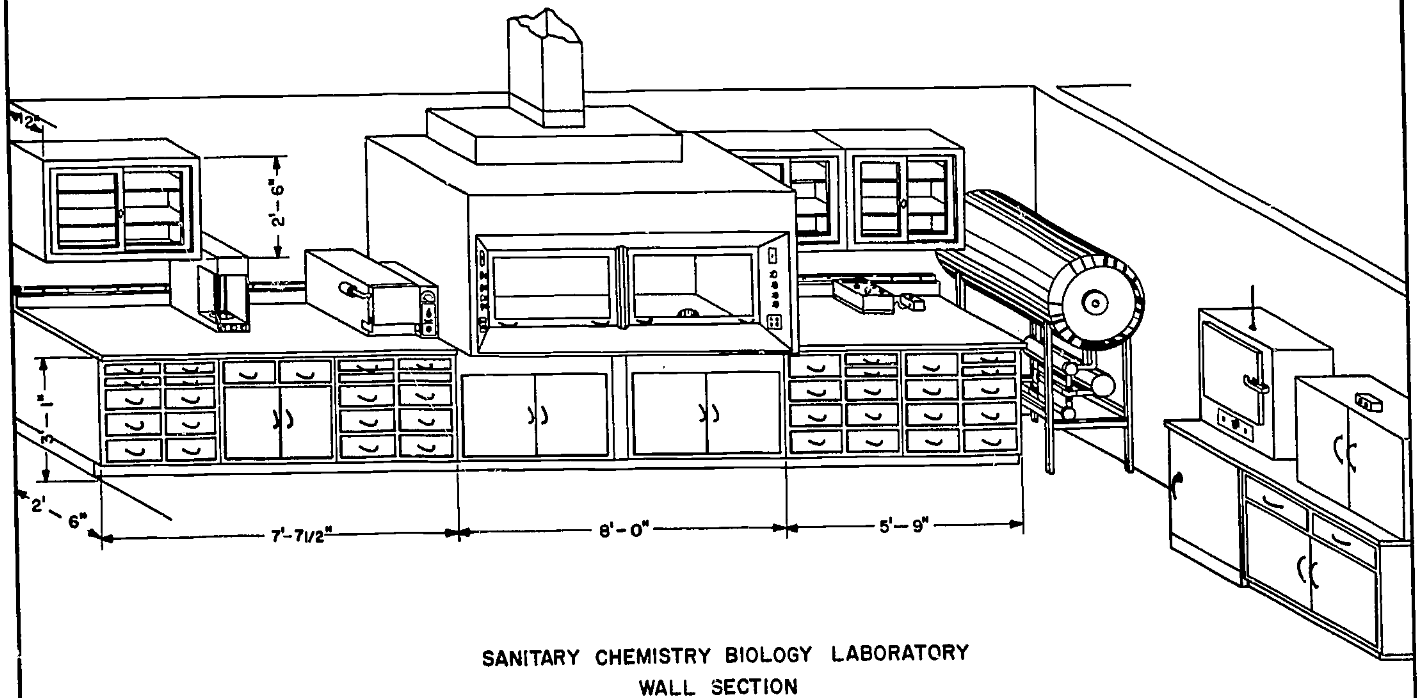


FIGURE 10.

require frequent painting. Chemical-resistant paint should be used on walls and ceilings.

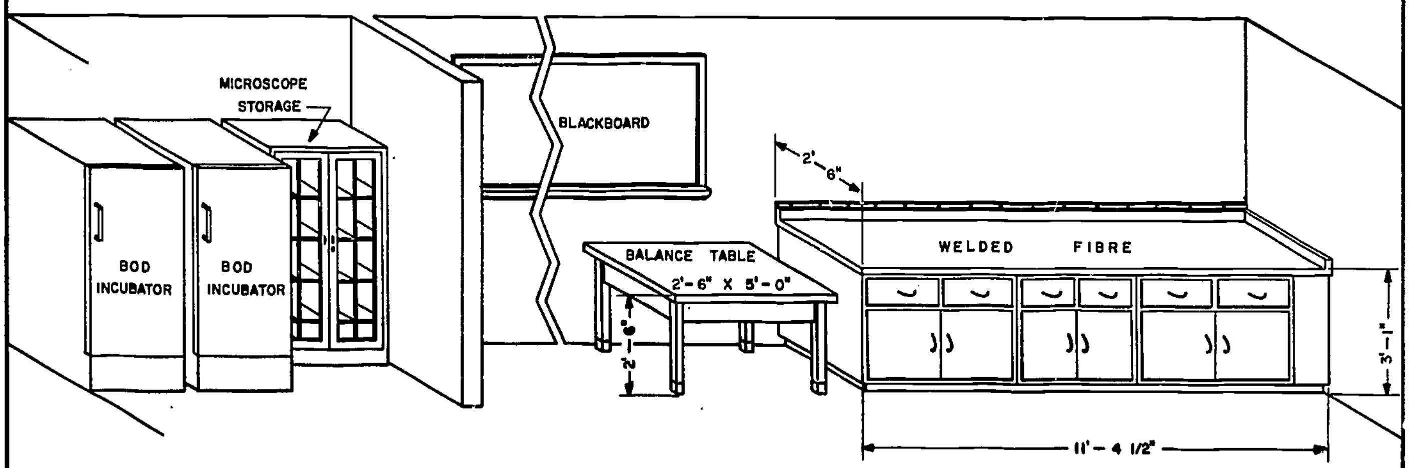
The ceilings in sanitary chemistry and biology laboratories should be finished so that all metal beams or framework are covered completely. This minimizes accumulation of dust and dirt and the corrosion of metal beams.

Lighting. Laboratories and lecture demonstration rooms should be well lighted. For evening classes and on dark days, the lighting should be equivalent to 50-foot candles[6] at the bench tops. Since many experiments require color matching or involve color changes, the sanitary chemistry and biology laboratory should be located on the north side of the building, because bright sunlight makes it difficult to detect many color changes. Many of the optical instruments must be used in a darkened room for which light-tight curtains must be provided. Analytical balances should not be stored or used where there is direct sunlight.

Disposal of Waste Liquids. Laboratory facilities for liquid waste disposal require special planning. At times, the liquids emptied into the laboratory draining system may contain more concentrated acid or alkali than is desirable for immediate disposal. Therefore, laboratory facilities for water and wastewater technology should be located so that the effluent from the sanitary chemistry and biology laboratory will empty into the school sewer system. This arrangement makes it possible for the wastes to be diluted by wastewater from the building before flowing into the final exit sewer system.

Fume Disposal. The fumes generated in the sanitary chemistry and biology laboratory are best removed by fume hoods which have sufficient capacity to draw them from the laboratory and exhaust them directly into the atmosphere, a short distance above the roof of the building. Many chemical reactions which generate corrosive fumes can be conducted in the fume hoods. If fume-causing experiments must be conducted outside of the hoods, the fumes can be drawn into the partially opened door of the fume hood and exhausted. All fume hoods should have adequate exit filters and the ducts should be lined with transite or other noncorrosive material.

6 Harry F. Lewis, *Laboratory Planning for Chemistry and Chemical Engineering*. New York: Reinhold Publishing Corp. 1962. p. 60.



SANITARY CHEMISTRY BIOLOGY LABORATORY
WALL SECTION

FIGURE 11.

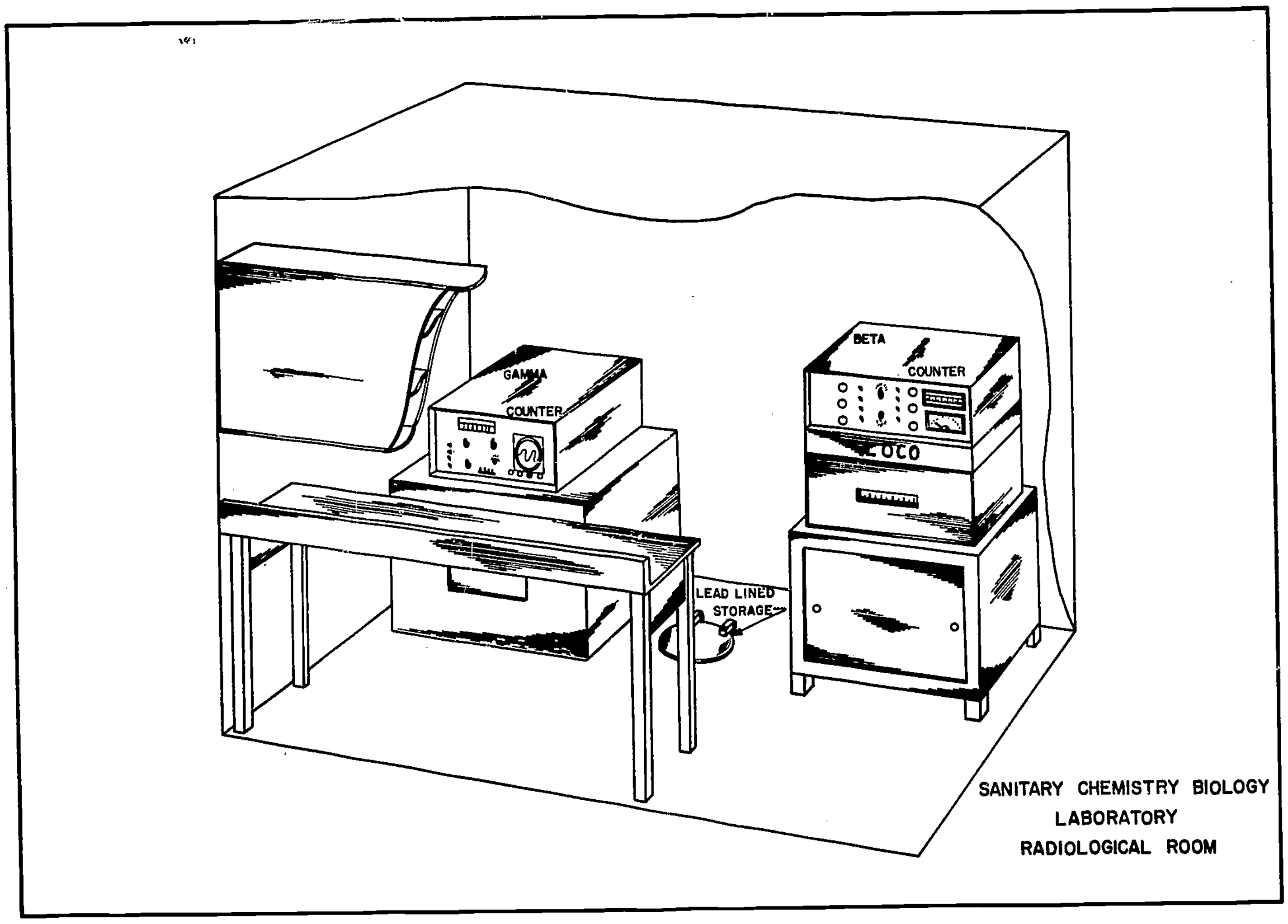
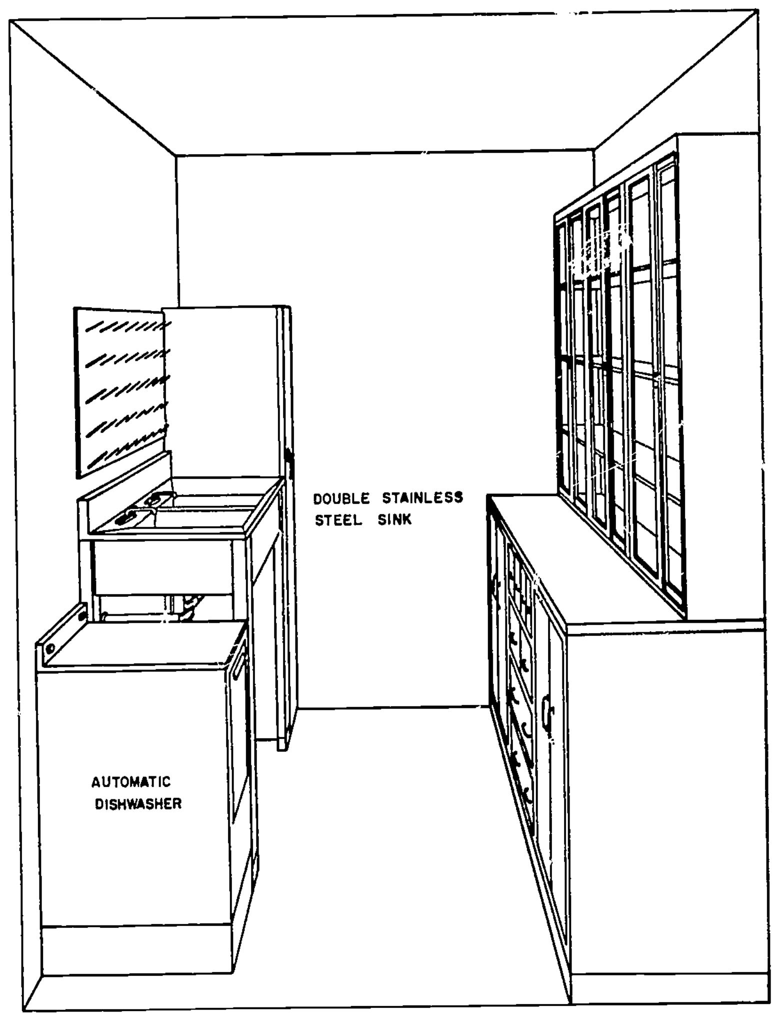

GAMMA COUNTER
BETA
COUNTER
LEAD LINED STORAGE
SANITARY CHEMISTRY BIOLOGY
LABORATORY
RADIOLOGICAL ROOM

FIGURE 12.



SANITARY CHEMISTRY BIOLOGY LABORATORY
PREPARATION ROOM

FIGURE 13.

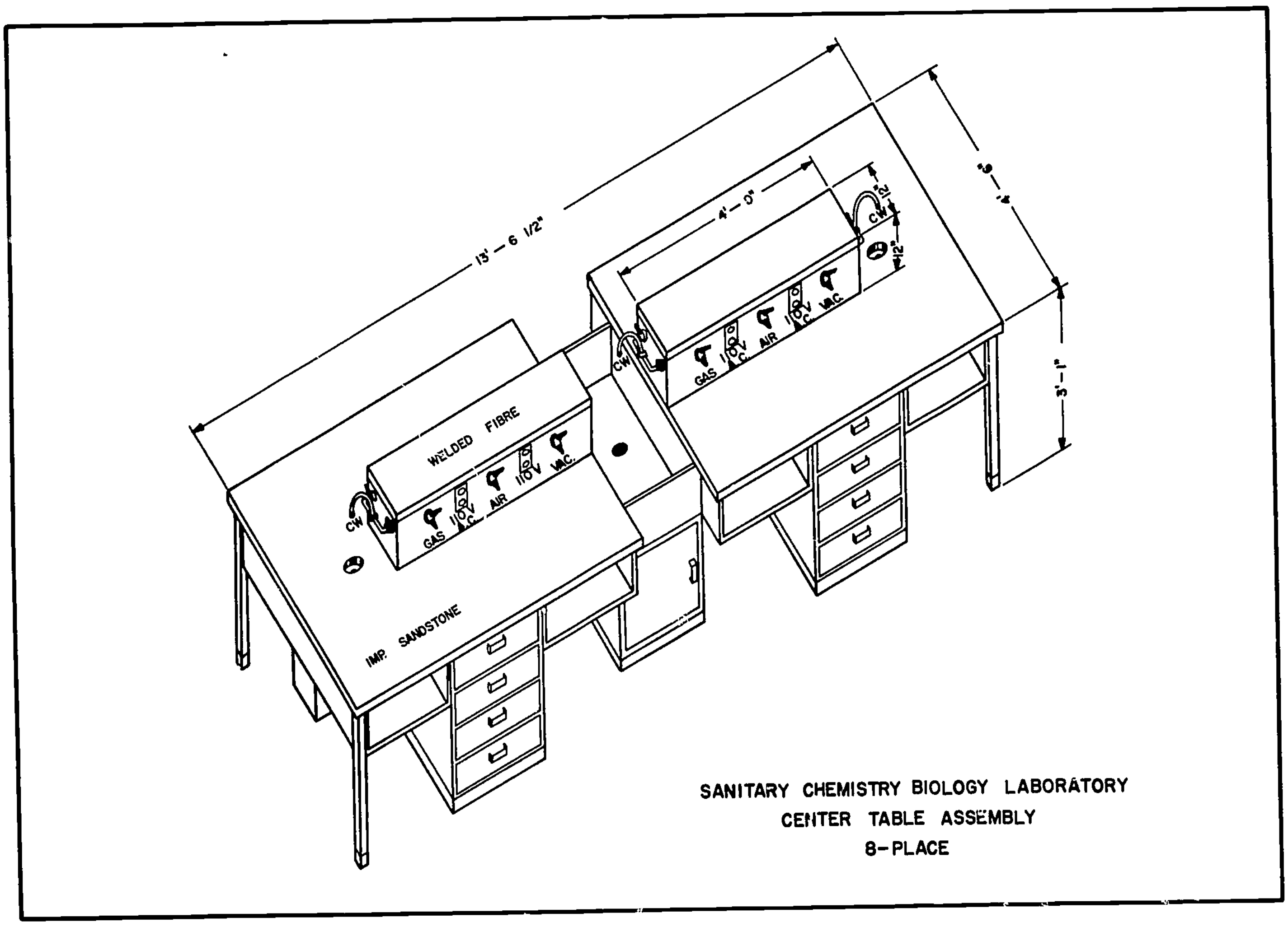
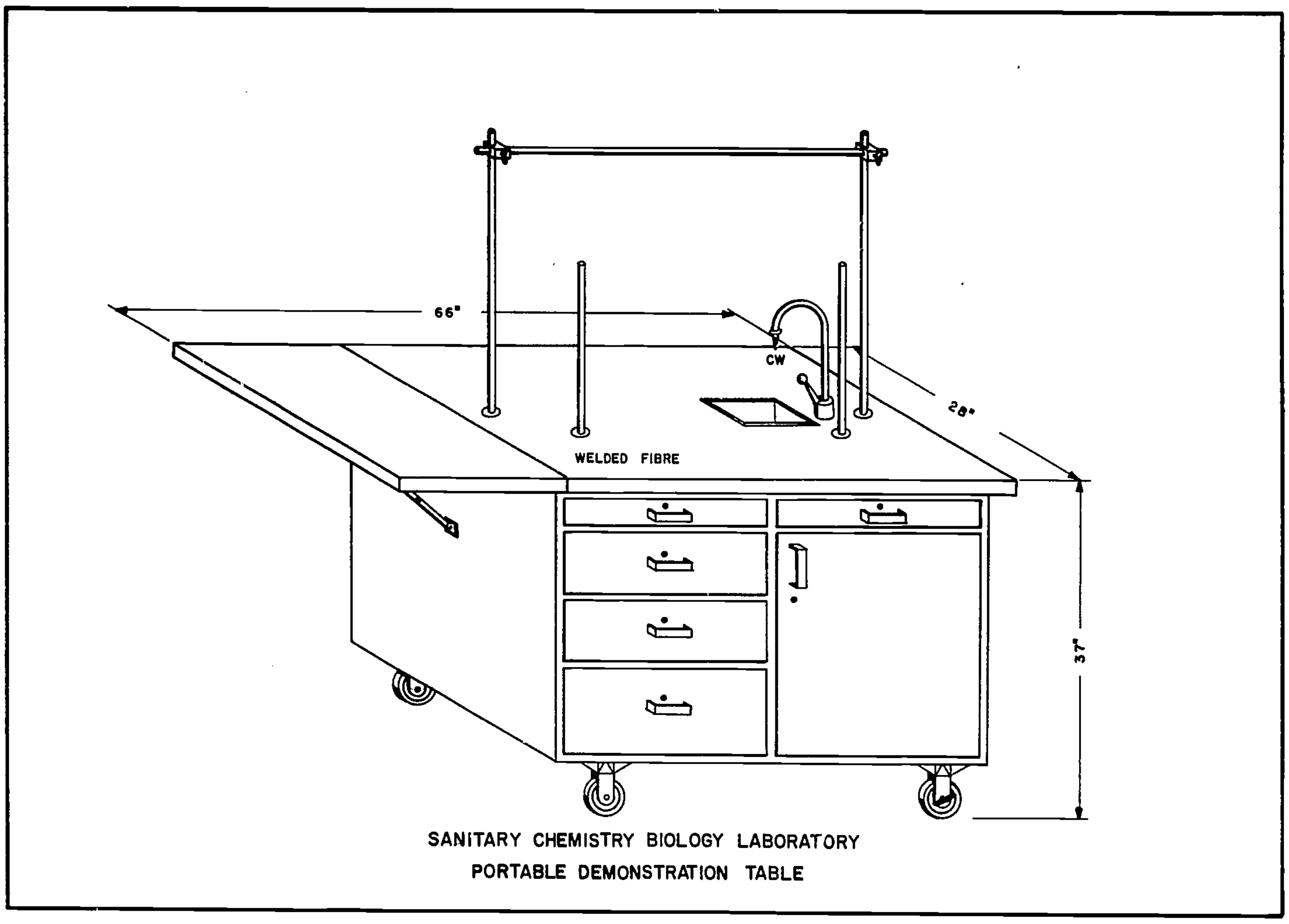

13' – 6 1/2"
4' – 0"
4' – 6"
3' – 1"
WELDED FIBRE
IMP. SANDSTONE
CW
GAS
110V
AIR
VAC.
SANITARY CHEMISTRY BIOLOGY LABORATORY
CENTER TABLE ASSEMBLY
8-PLACE

FIGURE 14.



66"
CW
28"
WELDED FIBRE
37"
SANITARY CHEMISTRY BIOLOGY LABORATORY
PORTABLE DEMONSTRATION TABLE

FIGURE 15.

Hydraulics Laboratory

Figures 16 and 17 show the laboratory facilities and equipment needed for teaching hydraulics to water and wastewater technicians. The facilities consist primarily of two wet pits, a dry pit, and a small water plant together with the necessary piping, pumps, metering equipment, and power supply. The pits should be located below floor level to provide the head room needed for performing hydraulic experiments.

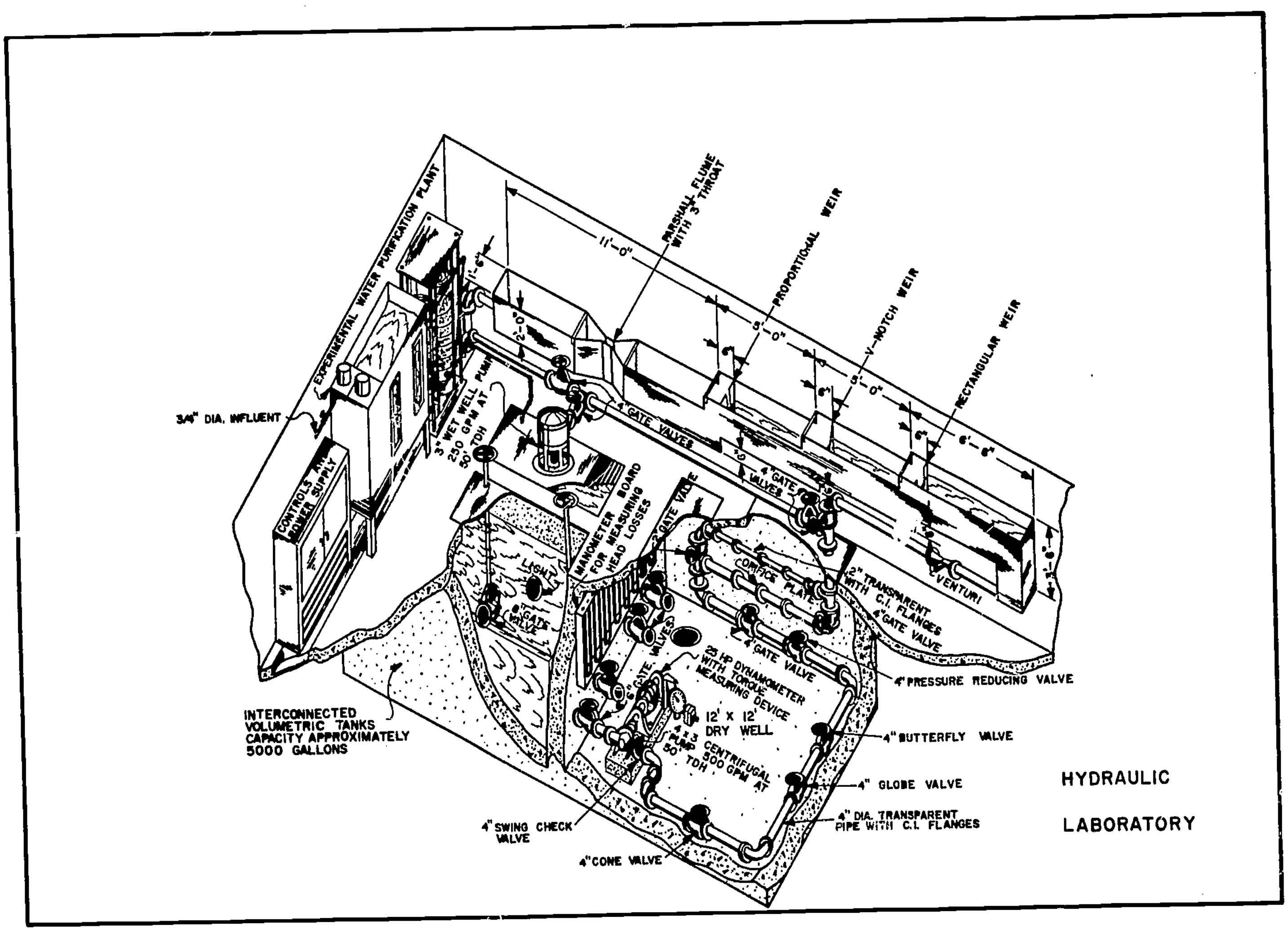
Pump capacities must be moderately large and piping must be carefully planned so that pump efficiencies as well as head loss through the several alternate flow systems can be measured. Figures 16 and 17 include most of the types of valves that may be used in water works facilities and the standard types of flow-measuring devices for both closed-conduit and open-channel flow. Two types of pumps are shown, but it is recommended that three or four sizes or types of pumps be available so that they can be interchanged to permit a wide variety of experiments.

The experimental water plant is arranged so that several types of underdrains as well as different filter media may be used.

The hydraulics laboratory is an expensive facility to equip but it is a key facility in water and wastewater technology and must be constructed so that students can make realistic measurements. Pump efficiencies cannot be calculated with miniature equipment, and open-channel flow cannot be adequately measured with miniature-flow equipment. Many of the elements in water works plants are manufactured only in those sizes recommended for the hydraulics laboratory used in this program.

No special materials or design specifications are necessary for the construction of the hydraulics laboratory pits, except that the pits must be water tight. For this, reinforced concrete is satisfactory and is probably the most economical construction material. The pits should be covered with adequate grating and equipped with the required stairs or ladders. Remaining floor space in the hydraulics laboratory can house the waste-treatment plant's equipment and be used for pilot plant studies and for disassembly, inspection, and reassembly of various types of valves and pumps.

FIGURE 16.



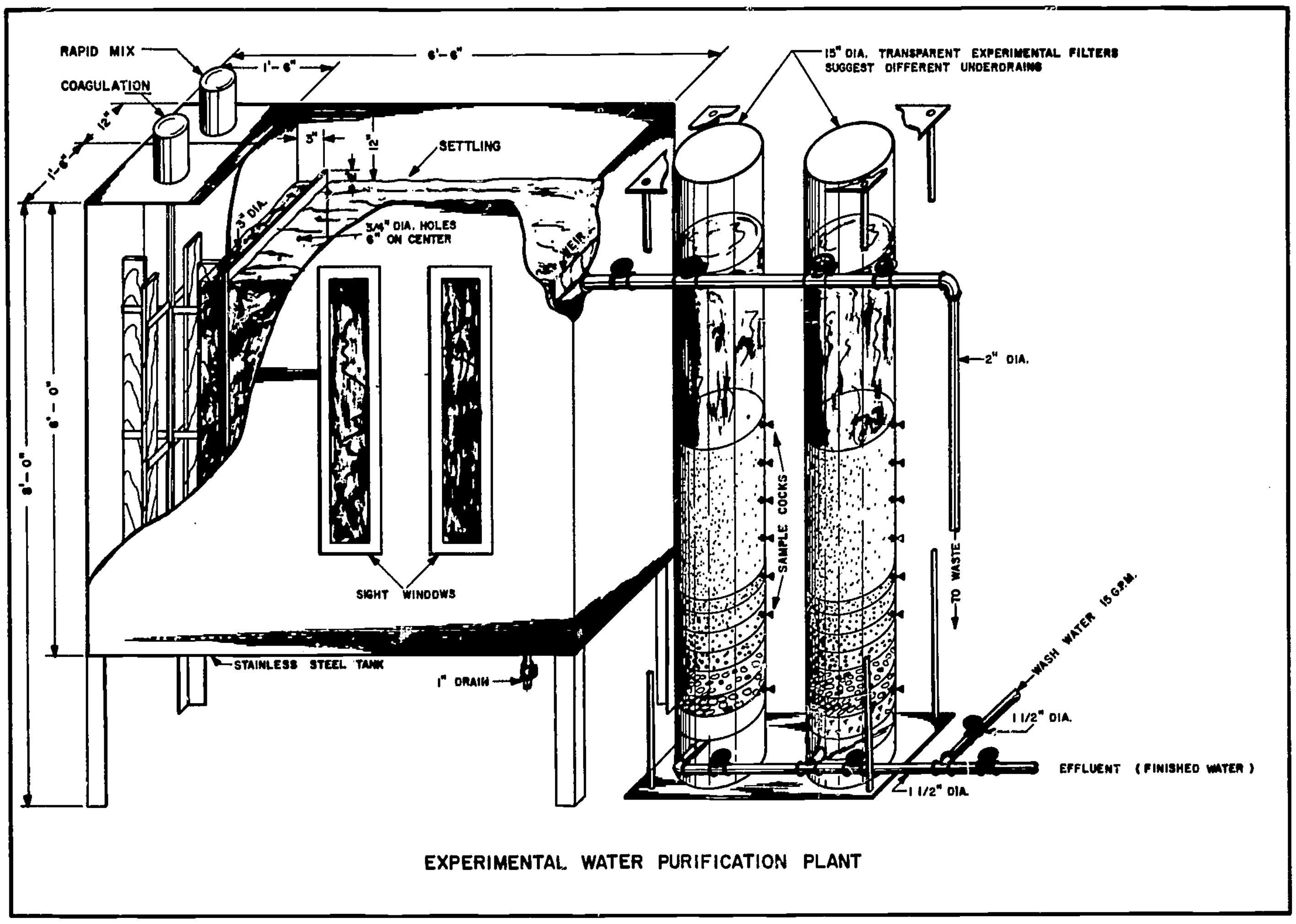

RAPID MIX
COAGULATION
1'-6"
6'-6"
12"
1'-6"
3"
SETTLING
3/16" DIA. HOLES
6" ON CENTER
WEIR
15" DIA. TRANSPARENT EXPERIMENTAL FILTERS
SUGGEST DIFFERENT UNDERDRAINS
2" DIA.
SAMPLE COCKS
TO WASTE
WASH WATER 15 G.P.M.
1 1/2" DIA.
EFFLUENT (FINISHED WATER)
1 1/2" DIA.
SIGHT WINDOWS
STAINLESS STEEL TANK
1" DRAIN
6'-0"
8'-0"
EXPERIMENTAL WATER PURIFICATION PLANT

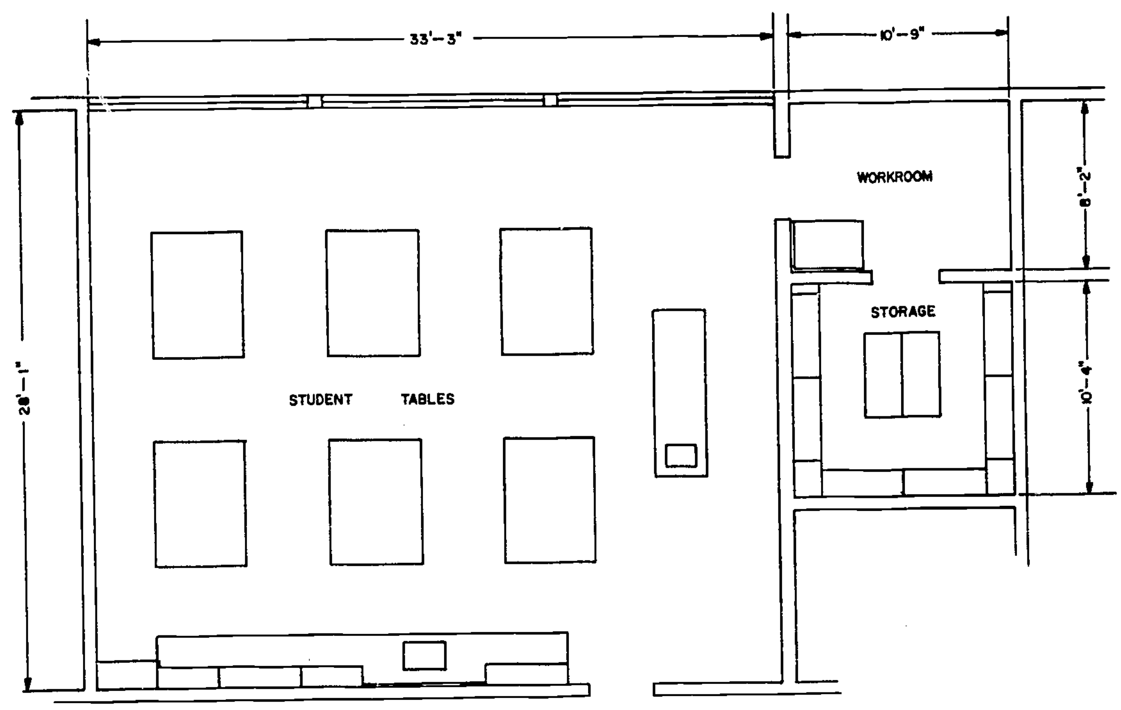
Figure 17.

Biology and Microbiology Laboratory

Figures 18 through 22 show a general floor plan, the wall elevations, student work areas, and the arrangement of a demonstration table for a biology and microbiology laboratory. The illustrations give the approximate overall dimensions of the equipment and show sufficient details to facilitate purchase of equipment for the entire laboratory.

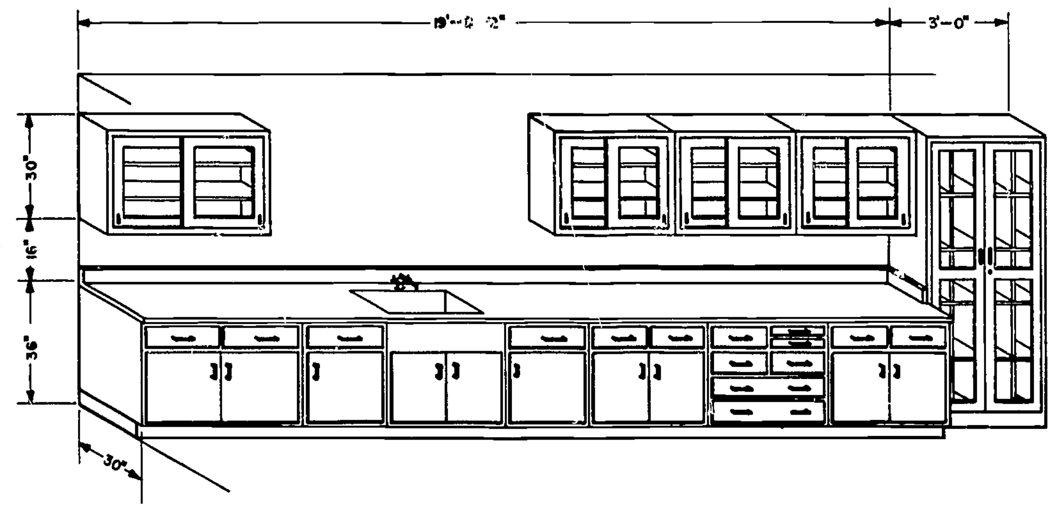
Some institutions will have facilities that can be used for the biology and microbiology laboratory. There are no unusual requirements for this laboratory, and the information and sketches shown are guides for schools that do not have a biology and microbiology laboratory for a water and wastewater technology program.

FIGURE 18.



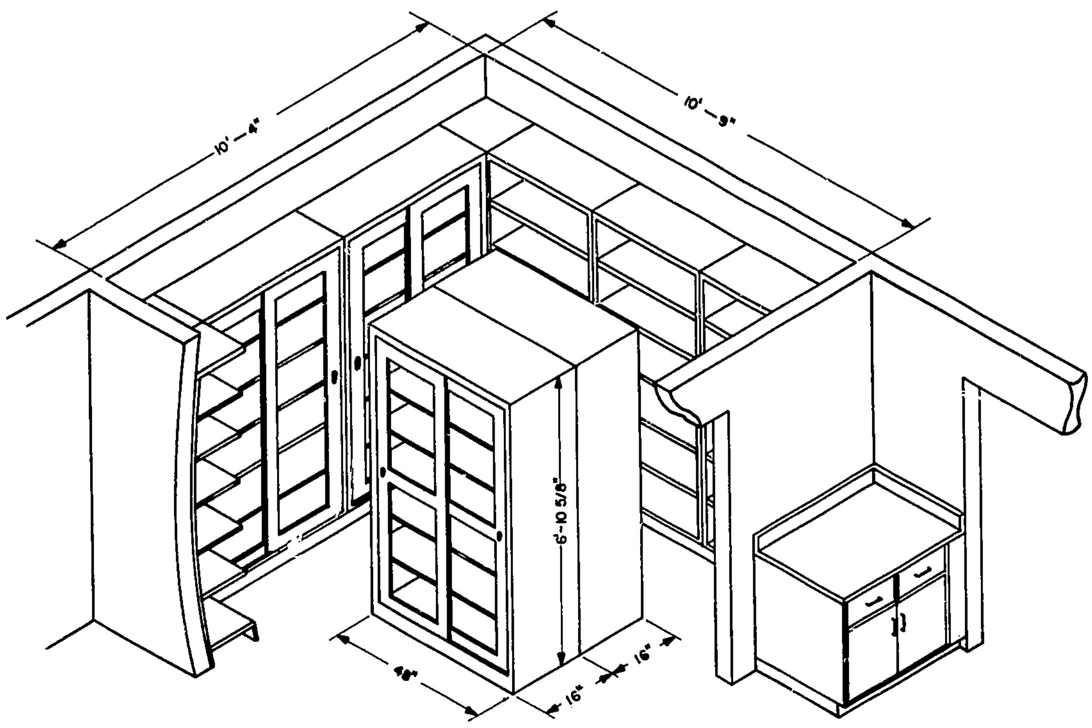
BIOLOGY & MICROBIOLOGY LABORATORY

SUGGESTED LAYOUT



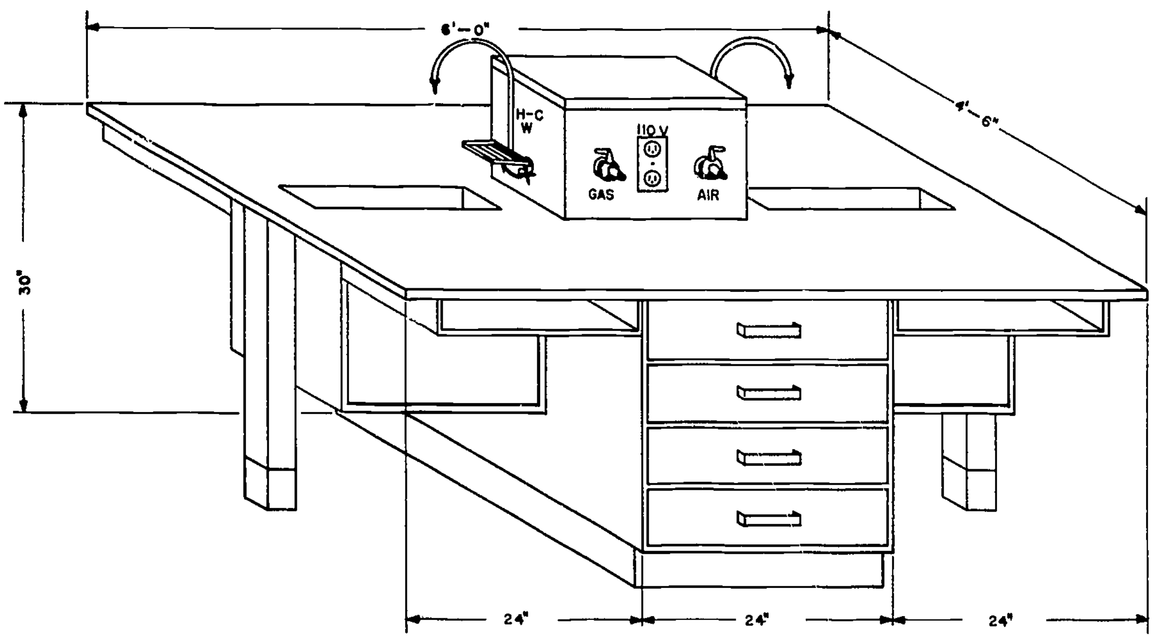
BIOLOGY & MICROBIOLOGY LABORATORY
WALL SECTION

FIGURE 19.



BIOLOGY & MICROBIOLOGY LABORATORY
WORKROOM & STORAGE

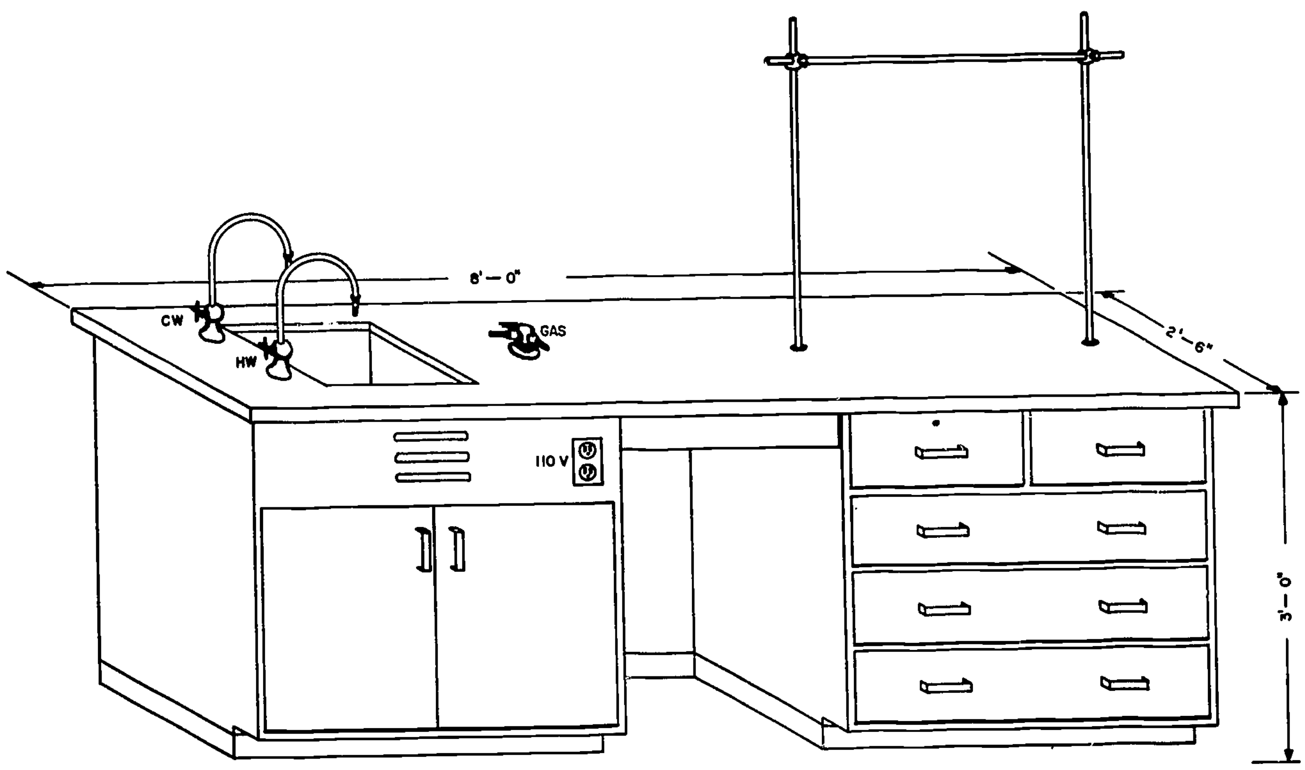
FIGURE 20.



BIOLOGY & MICROBIOLOGY LABORATORY

STUDENT DESK

FIGURE 21.



BIOLOGY & MICROBIOLOGY LABORATORY

INSTRUCTOR'S DESK

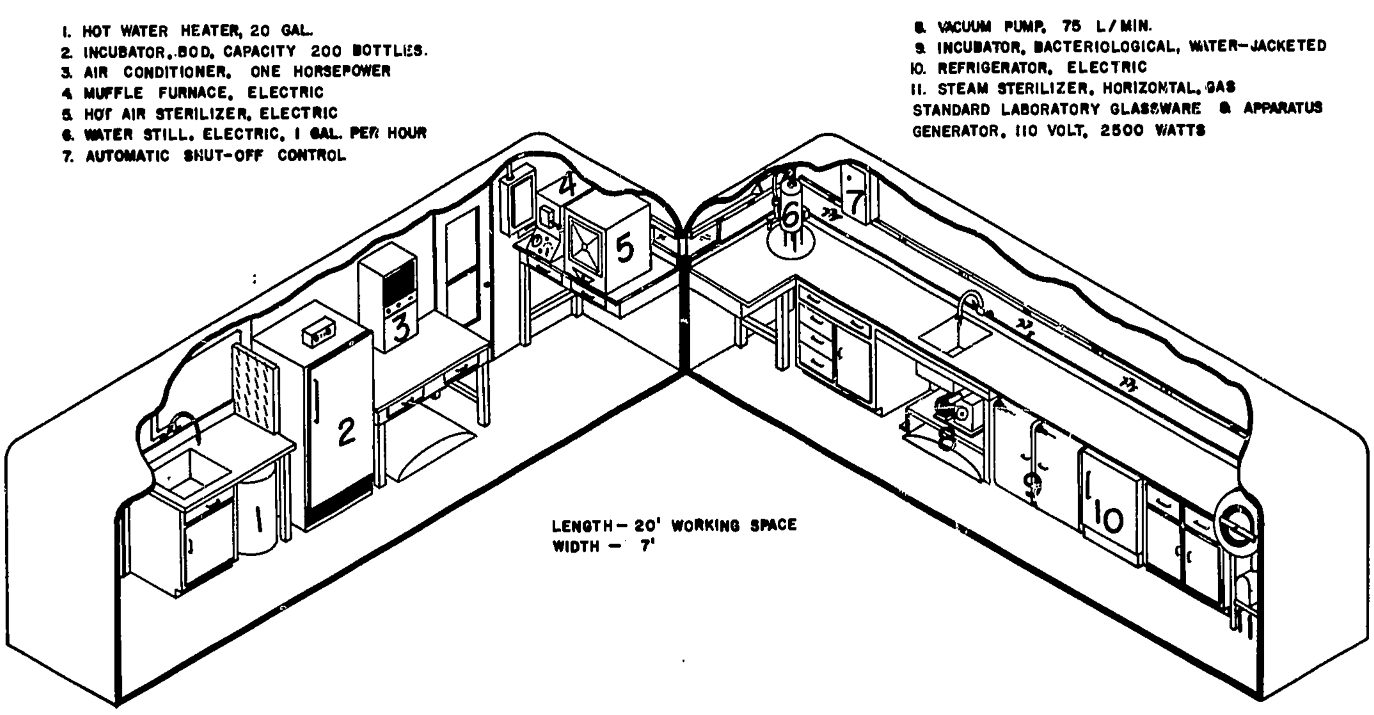
FIGURE 22.

Mobile Water-Quality Testing Laboratory

Stream studies are a necessary part of the water and wastewater technology curriculum. Plant studies and sampling wastes from many different collection points provide the range of experience required in the program. The mobile laboratory is necessary to permit students to make on-the-spot analyses of many samples which deteriorate if transported or stored for even a short period of time.

A suggested layout for a mobile laboratory is shown in figure 23. This laboratory can be a separate trailer facility and towed by a pick-up truck, or it can be a self-propelled unit. In either case, the mobile unit can take students to the point of sampling and contains the necessary facilities for making on-the-spot analysis. The laboratory's working space accommodates eight students, and with proper scheduling the entire class can use the mobile facility and gain adequate experience.

FIGURE 23.



MOBILE WATER QUALITY LABORATORY

LABORATORY EQUIPMENT AND COSTS

Equipping laboratories for water and wastewater technology is expensive. It is, of course, advantageous to start a program with laboratories that are fully equipped; but, if necessary, it is feasible to build laboratories, install work stations, and provide the *minimum of laboratory equipment* required for starting the program. This means that the program can be started with a minimum outlay of funds, and permits the buying of additional equipment required for the teaching facility to be spread over a period of time.

The department head or instructor should make the final decisions on the choice of laboratory equipment because of his knowledge of technical details and to avoid costly mistakes.

Surplus property from either private or public organizations can be a source of good materials and hardware for equipping water and wastewater laboratories. Government surplus property may be a source of either standard or specialized components, units, assemblies, mechanisms, instruments and systems which can be purchased for a small fraction of their cost for new materials. Educational institutions are high on the priority list of agencies to which government surplus property is made available.[7]

Distribution of surplus property within the States must be made through State agencies for surplus property. Most State agencies maintain one or more distribution centers at which authorized representatives of eligible schools or school systems select material for educational use. Usually one or more officials of a school or school system are designated as authorized representatives. Technical educators should communicate with their authorized school or school system representative, if one exists, to arrange to visit the State agency's distribution center, or write to the director of their State agency for surplus property to obtain information regarding the procedures to be followed in acquiring equipment.

Each State director of vocational and technical education can provide specific information on the persons in charge and the location of the government surplus property agency in his area. Information on the government surplus property may also be obtained from the:

Chief, Surplus Property Utilization Division
U.S. Department of Health, Education, and Welfare
Washington, D.C. 20201

When acquiring surplus equipment, the department head or instructor should apply the same elements of judgment and selectivity used in buying new equipment. Specific plans for the equipment's use and sound justification for its need should be clearly established before purchasing *any* surplus equipment. In addition, a careful analysis should be made of its total effectiveness; of its cost, including initial cost, transportation, space required, cost of installation, repair or tune-up (if incomplete), and maintenance; and its pertinence in terms of obsolescence.

FIGURE 24—*The different types of gravimetric balances in this sanitary chemistry-biology laboratory help broaden the student's experience. Variety in types of equipment should be provided, and should be selected by teachers of the courses.*

7 U.S. Department of Health, Education, and Welfare. Office of Field Administration. Division of Surplus Property Utilization.
Directory: Directors of State Agencies for Surplus Property and Regional Representatives, Division of Surplus Property Utilization, Department of Health, Education, and Welfare. 1965.
How to Acquire Federal Surplus Personal Property for Health, Education, and Civil Defense Purposes and Federal Surplus Real Property for Health and Educational Purposes. 1965.
Surplus Material and Science Education. 1964.
Washington: U.S. Government Printing Office.

Competent, responsible, and imaginative persons should select surplus equipment, and then only after a thorough on-site inspection to prevent purchase of obsolete, irrelevant, bulky, or excessive equipment. The resourceful department head or instructor can usually obtain quantities of components and materials (often by disassembling units of systems), meters, instruments, apparatus, and other essential up-to-date equipment for laboratories at a very reasonable cost.

Two types of suppliers probably will be used in establishing or refurnishing water and wastewater technology laboratories. The manufacturer supplies the major units of permanently installed equipment such as utilities, work tables, fume hoods, sinks, and specialized storage cabinets. These are usually purchased under contract which includes installation. Suppliers usually will provide engineering and consulting services free of charge as well as the drawings, specifications, and plans that may be used for soliciting competitive bids.

The second type of supplier sells specialized equipment such as gravimetric balances, glassware, chemicals, hot plates, muffle furnaces, and drying ovens.

Suppliers are listed in *Thomas's Register* or in any other directory which lists suppliers of chemical and scientific laboratory equipment.

Sanitary Chemistry and Biology Laboratory

Items	Quantity Required
Demonstration tables	1
Projection equipment for visual aids and periodic chart of chemical elements	1
Basic work stations	16
Fume hood, installed	2
Wall cabinets, installed	20
Lockers for student-locker inventory	16
Autoclave, horizontal, 22" inside diameter, 35" long	1
Analytical balances, capacity 100 grams, sensitivity 0.02 mg	2
Analytical balances, capacity 200 grams, sensitivity 0.1 mg	2
Balance, triple beam, capacity 311 grams, sensitivity 0.01 grm	12
Bacteriological incubator (B.O.D.) low temperature, 0.2° sensitivity	2
Colony counting apparatus, Quebec, 4½ x lens	6
Infrared lamps and stands, 150 volts, 250 watts	12
Kjeldahl distillation rack, 6 place, 500 or 800 ml. flask	1
Oven, merhanical convection, 0-200°C	1
Pump, pressure and vacuum, rotary	2
Pipetting machine, 0-61 ml., syringe adapter	1
Pipette washer, stainless steel, 6" diameter, 22½" tall, cycling	1
Microscopes, compound, binocular, condenser movable stage, 10 x 20 x eye piece, 40 x 100 x objective	12
Microscopes, wide field, dissecting, 10 x eye piece, 2 x, 3 x, 6 x, 8 x objective	6
Microscope lamps, iris diaphragm, blue and ground glass	12
Stage micrometer, 75 x 25 mm., rules 0.1 and 0.01 mm.	12
Hydrogen-ion meter, *p*H, battery operated, field	1
Furnace, muffle, 0–2,000°F	1
Hydrogen-ion meter, *p*H, line operated, laboratory	2
Universal spectrophotometer 325–825 mu	2
Sterilizer, hot air, 0–400°F	1
Sampler, A.P.H.A., B.O.D.	2
Stirring apparatus, magnetic	6
Telethermometer, reel type, 50 feet leads, battery	1
Water bath, right holes	1
Water bath, utility 0–100°C	1
Watch, stop, 1/15 second	3
B & L spectronic 20, model 340, with water methods manual	1
Kjeldahl digestion rack, 6 units, 500–800 ml	1
Incubator, water jacketed, sensitivity 0.3°C±	1
Oxygen analyzer, battery field, 20 foot leads	1
Conductivity meter, field, battery, 20 foot leads	1
Membrane filter holding units, stainless steel, 47 mm	12
Low beta, low level counting system service LB-100	1

ERIC

Spectrometer 400 channel gamma __________ 1

Miscellaneous chemicals, glassware, test kits, protective clothing, tubing, supports and samples

Estimated cost of sanitary chemistry and biology laboratory and equity ________________ $73,200 to $82,900

Student-locker inventory (see appendix B) 16 lockers at $55 to $70 each (figures rounded) $ 900 to $ 1,100

Total estimated cost of sanitary chemistry and biology laboratory and equipment _________ $74,100 to $84,000

Hydraulics Laboratory and Experimental Purification Plant

Weir flume, weirs, parshall flume, and connections

D.C. motor, dynamometer, and controls

Pumps, double suction, submersible

Pump, single suction, submersible

Pipe, elbows, reducers, and specials

Valves: gate, globe, plug, and check

Venturi meter and recorders

Instrumentation: manometers, gages and recorders

Total Estimated Cost _________ $20,000 to $24,000

Biology and Microbiology Laboratory

Demonstration table

Projection equipment and visual aids will be used jointly with sanitary chemistry and biology laboratory

Basic work stations: storage cabinets and facilities, installed

Student lockers for 24 students

Major laboratory equipment—microscopes, biological incubators, autoclaves, balances, etc., will be used jointly with sanitary chemistry and biology laboratory

Miscellaneous chemicals, glassware, test kits, prepared slides, protective clothing, tubing, supports, and samples

Estimated Cost of Biology and Microbiology Laboratory ____ $16,200 to $19,800

Student locker inventory (see appendix B) 24 lockers at $60 to $70 each (figures rounded) __________ $1,500 to $1,700

Total Estimated Cost of Biology and Microbiology Laboratory _ $17,700 to $21,500

Mobile Water-Quality Testing Laboratory

Items	Quantity Required
Hot water heater	1
Incubator (B.O.D.)	1
Air conditioner	1
Muffle furnace	1
Sterilizer (hot air)	1
Still	1
Vacuum pump	1
Incubator (bacteriological)	1
Refrigerator	1
Autoclave	1

Estimated Cost of Equipment, Installed ___________________ $5,000 to $ 5,500

Estimated Cost of Vehicle ______ 4,000 to 4,500

Total Estimated Cost __________ $9,000 to $10,000

Summary of Costs

It is assumed that the institution planning a program to educate water and wastewater technicians *already* has adequate laboratory facilities for the drafting, surveying, and physics courses and sufficient facilities for regular classroom instruction.

The summary which follows shows estimated costs, based on prices in 1966, of the facilities and equipment required for teaching specialty courses in water and wastewater technology.

The equipment listed is basic, excluding items for specialized programs which may be related. In addition to the estimated cost of basic equipment, some $6,200 to $8,000 should be earmarked to cover cost of installing equipment and the built-in furnishings in the several laboratories; and $3,000 to $4,500 should be provided for purchasing expendable materials, replacement parts, and supplies.

Therefore, the initial cost of equipping laboratories for a water and wastewater technology program is estimated as follows:

Laboratory Facility	*Estimated Costs*	
Sanitary Chemistry and Biology Laboratory	$ 74,100 to	$ 84,000
Hydraulics Laboratory and Experimental Purification Plant	20,000 to	24,000
Biology and Microbiology Laboratory	17,700 to	21,500
Mobile Water-Quality Testing Laboratory	9,000 to	10,000
Installation of equipment and built-in furnishings	6,200 to	8,000
Expendable materials, replacement parts, and supplies	3,000 to	4,500
Total Estimated Cost of Laboratory Equipment, Parts, and Supplies	$130,000 to	$152,000

The foregoing estimates exclude the cost of the building which, if constructed for the program, may be calculated at $14 to $16 per square foot of unfurnished laboratory space. Such space with special utilities and built-in furnishings, without portable equipment, may be estimated at $28 to $32 per square foot.

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APPENDIX A

Selected Scientific and Technical Societies Pertinent to the Education of Water and Wastewater Technicians

AMERICAN WATER WORKS ASSOCIATION, INC. (AWWA), 2 Park Avenue, New York, N.Y. 10016.

History: Organized in 1881; incorporated, 1912. Has 33 geographic sections in the United States, Canada, and Cuba.

Purpose: To promote the advancement of knowledge of design, construction, operation, and management of water works.

Total membership: 16,700

Publication: AWWA *Journal,* monthly.

AIR POLLUTION CONTROL ASSOCIATION (APCA), 4400 5th Avenue, Pittsburgh, Pa. 15213.

History: Organized 1906 as International Association for the Prevention of Smoke; name changed to Smoke Prevention Association in 1915; incorporated in 1923; name changed to Smoke Prevention Association of America in 1940; name changed to Air Pollution and Smoke Prevention Association of America in 1950; name changed to present title in 1952.

Purpose: To improve air sanitation and foster control of atmospheric pollution affecting health and/or causing damage to property, nuisance to the public, and waste of natural resources; to encourage public acceptance of the necessity for atmospheric pollution prevention and assist governmental units toward a solution of this problem; to encourage the development and adoption of apparatus, equipment, and operating procedures that will economically prevent pollution of the atmosphere; to promote research in the solution of problems embracing all sources of atmospheric pollution; to prepare and distribute literature and publications pertaining to the problems involved in providing cleaner air; and to maintain a library and information service of professional papers, technical articles and publications, and descriptive material pertaining to cause, effect, and remedy of processes involving atmospheric pollution.

Total membership: 2,582

Publications: *Journal,* bimonthly; APCA *Abstracts,* monthly; various directories and technical journals annually.

AMERICAN ACADEMY OF ENVIRONMENTAL ENGINEERING, P.O. Box 9728, Washington, D.C. 20016.

History: Incorporated 1955 as American Sanitary Engineering Intersociety Board.

Purpose: To improve the practice, elevate the standards, and advance the cause of sanitary engineering; to grant and issue to engineers, duly licensed by law to practice engineering, certificates of special knowledge in the various fields of sanitary engineering.

Total membership: 1,016

Publications: *Sanitary Engineering Education Directory; Qualifications for Accreditation of Advanced Degree Curricula in Sanitary Engineering.*

AMERICAN INDUSTRIAL HYGIENE ASSOCIATION (AIHA), 14125 Prevost Street, Detroit, Mich. 48227.

History: The first meeting was held as the Midwest Conference on Occupational Disease, in Detroit, Mich., May 1937. In May 1939, at the Cleveland meeting, the Conference met jointly with the Association of Industrial Physicians and Surgeons with the name of the American Conference on Occupational Diseases and Industrial Hygiene. It was at this meeting that the American Industrial Hygiene Association was formally organized.

Purpose: To increase the knowledge of industrial hygiene through interchange and dissemination of information; to promote the study and control of environmental factors affecting the health and well-being of industrial workers; to correlate such activities as are conducted by individuals and agencies throughout industrial, educational, and governmental groups; to bring together persons interested in the various phases of industrial hygiene.

Total membership: 1,400

Publications: AIHA *Journal,* bimonthly; numerous other publications on air pollution, noise, respirators, and other pertinent subjects; periodical.

AMERICAN METEOROLOGICAL SOCIETY, 45 Beacon Street, Boston, Mass. 02108.

History: Founded 1919. All the individuals and groups concerned with scientific and professional meteorology are provided representation and media for communication.

Purpose: To promote the development and dissemination of knowledge of meteorology in all its phases and applications and the advancement of its professional ideals.

Total membership: 8,500

Publications: *Bulletin,* monthly; *Journal of Applied Meteorology,* bimonthly; *Meteorological and Geoastrophysical Abstracts,* monthly; *Weatherwise,* bimonthly. *Journal of the Atmospheric Sciences,* bimonthly.

CONFERENCE OF STATE SANITARY ENGINEERS, New York State Department of Health, 84 Holland Avenue, Albany, N.Y. 12208.

History: Organized 1920.

Purpose: To promote public health in all phases; to coordinate public health engineering activities of official State and territorial health organizations; to encourage interchange of experience among State sanitary engineers in official administrative positions; to make available to all such officials information and data which might assist them in fulfillment of their duties.

Total membership: 185

Publications: *Report of Proceedings,* annually.

INSTITUTE OF ENVIRONMENTAL SCIENCES, 34 South Main Street, Mt. Prospect, Ill. 60057.

History: Merger of Institute of Environmental Engineers and Society of Environmental Engineers in April 1959 resulted in Institute of Environmental Sciences.

Purpose: To provide means whereby environmental sciences can be explained, discussed, and debated, and thus aid the technological advances of this hemisphere.

Total membership: 1,900

Publications: *Journal of Environmental Sciences*, bimonthly; *Proceedings*, annually.

INSTITUTE OF SANITATION MANAGEMENT, 55 West 42d Street, New York, N.Y. 10036.

History: Organized October 1957; incorporated in New York, through merger of three former associations.

Purpose: To maintain and improve the standards of industrial sanitation—including building maintenance; to promote industrial sanitation as a managed function in its application to work environment; to foster and engage in research and educational activities; to disseminate information pertaining to methods and costs.

Total membership: 1,600

Publications: *Annual Conference Highlights*, annually; various technical bulletins, periodically.

NATIONAL ASSOCIATION OF SANITARIANS, University of Denver, Denver, Colo. 80203.

History: Organized as California Association of Sanitarians 1930; name changed to present title June 25, 1937; incorporated November 5, 1937. Has 37 sections, 14 standing committees, and 25 project committees.

Purpose: To provide specific services in the field of environmental sanitation for official and voluntary agencies, and other people concerned; to uphold and increase standards of the sanitation profession; to search continually for truths, and disseminate findings; to strive for knowledge, and to be fully informed of developments in the field of public health; to cooperate fully with allied public health agencies.

Total membership: 4,700

Publications: *Journal of Environmental Health*, bimonthly.

NATIONAL RIVERS AND HARBORS CONGRESS, 1028 Connecticut Avenue, NW., Washington, D.C. 20036.

History: Founded in October 1901 at Johns Hopkins University, Baltimore, Md.; recognized and incorporated under the nonprofit laws of the District of Columbia in January 1932.

Purpose: To collect and prepare all obtainable data regarding the improvement, development, and uses of the rivers, harbors, and waterways of the United States and other countries.

Total membership: 7,500

Publications: *The Monthly Reporter*.

WATER POLLUTION CONTROL FEDERATION, 3900 Wisconsin Avenue, Washington, D.C. 20016.

History: Organized October 1928 as Federation of Sewage Works Association; incorporated as a nonprofit organization February 1941; name changed to present title January 1, 1960.

Purpose: To promote the advancement of fundamental and practical knowledge of all aspects of water pollution control by dissemination of technical knowledge through publications of the organization, and by promotion of good public relationships and sound regulations aimed toward water pollution control.

Total membership: 13,000

Publications: *Journal*, monthly; *Highlights*, monthly; special series of *Technical Manuals of Practice*, intermittent.

APPENDIX B

Student-Locker Inventory
Sanitary Chemistry and Biology Laboratory

Items	*Quantity*
Beaker, 100 ml	1
Beaker, 250 ml	1
Beaker, 400 ml	1
Beaker, 600 ml	1
Bottles, dropping	3
Bottles, reagent, 250 ml	3
Bottle, wash, plastic	1
Brush, burette	1
Brush, test tube	1
Burette, 25 ml	1
Burner, Bunsen	1
Clamp, pinchcock	1
Clamp, test tube	1
Clamp, utility	1
Cylinder, graduated, 10 ml	1
Cylinder, graduated, 25 ml	1
Cylinder, graduated, 100 ml	1
Cylinder, graduated, 200 ml	1
Dishes, evaporating, 200 ml	2
File, triangular	1
Flasks, Erlenmeyer, 125 ml	3
Flasks, Erlenmeyer, 250 ml	3
Funnel, Buchner	1
Funnel, filtering	1
Funnel, 65 mm	1
Guage, wire	1
Inoculating needle	1
Pipettes, 1 ml	5
Pipettes, 10 ml	5
Pipette box	1
Spatulas	2
Support, funnel	1
Support, ring	1
Support, test tube	1
Tong, crucible	1
Watch glasses	2
Estimated Total Cost	$55 to $65

APPENDIX C

Student-Locker Inventory
Biology and Microbiology Laboratory

Items	*Quantity*
Beakers, 100 ml	2
Beakers, 250 ml	2
Beakers, 400 ml	2
Bottles, dilution	6
Bottles, dropping	6
Bottles, wash	2
Brush, test tube	1
Burette, 25 ml	1
Burner, Bunsen	1
Clamp, burette	1
Clamp, test tube	1
Cylinders, graduated, 10 ml	2
Cylinders, graduated, 100 ml	2
Cylinders, graduated, 25 ml	2
Flasks, Erlenmeyer, 125 ml	2
Flasks, Erlenmeyer, 250 ml	2
Forceps	1
Funnel, 65 mm	1
Inoculating needle	1
Micro-cover glasses	50
Micro slides, hanging drop	25
Micro slides, standard	50
Microscope slide box	1
Pipettes, 1 ml	5
Pipettes, 5 ml	5
Pipettes, 10 ml	5
Rings, 4″	2
Support, burette	1
Support, funnel	1
Spatulas	2
Test tubes	25
Watch glasses	2
Estimated Total Cost	$60 to $70

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