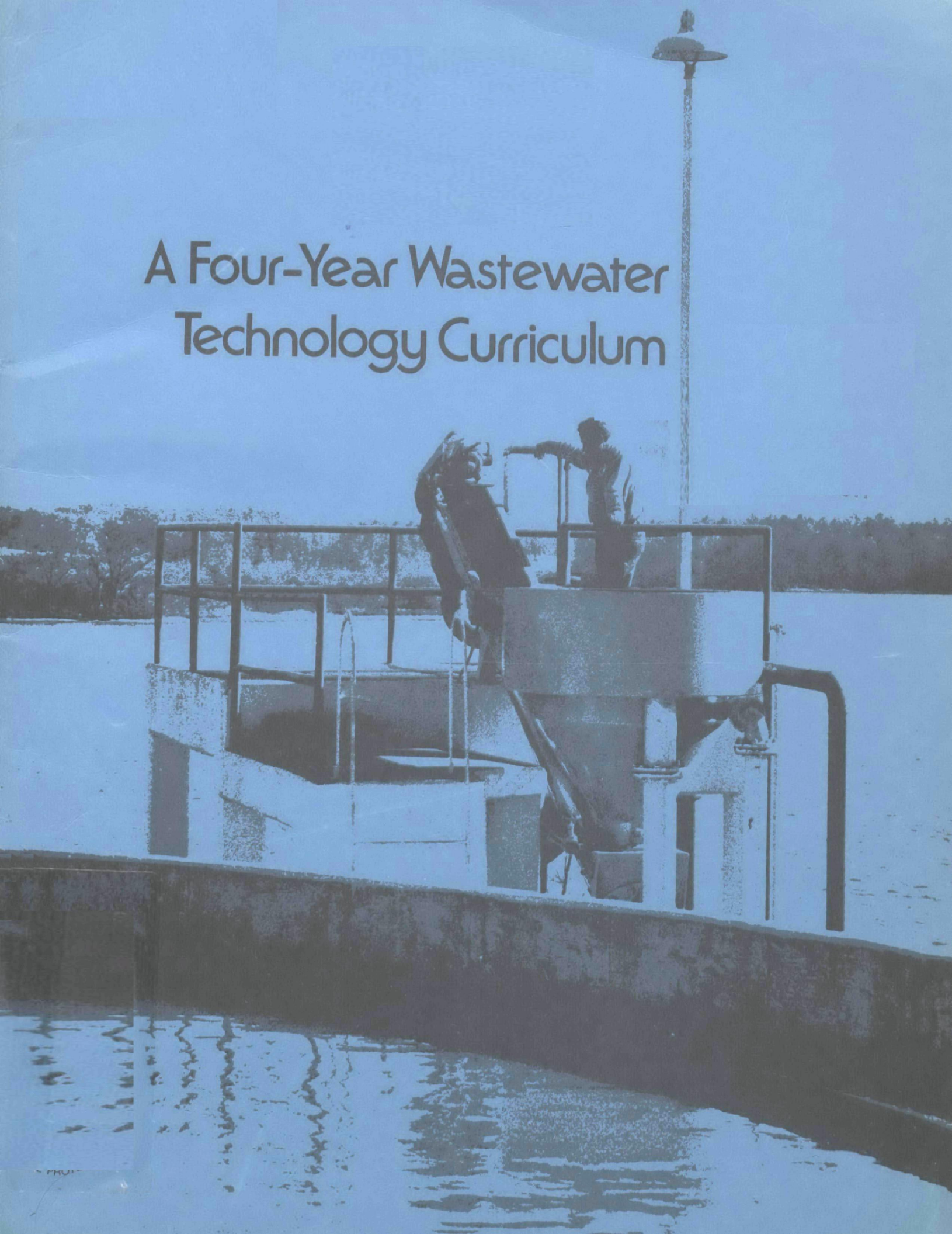
A Four-Year Wastewater Technology Curriculum



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Acknowledgements

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Training Grants Branch
Division of Manpower and Training
Office of Water Program Operations
US Environmental Protection Agency
Washington, DC 20460

Summary

A program is designed for training a four-year wastewater technologist based on the desired on-the-job performance of the program graduate. This graduate might fill positions with regulatory, consulting, industrial, municipal, and manufacturing organizations. The program described could be applied to the development of curricula for a variety of environmental personnel: technicians, scientists, engineers, and other professionals.

Recommendations

1. The proposed program for establishing performance oriented curricula and course descriptions should be evaluated and applied by other curricula efforts in the environmental control field.

2. The proposed curricula and course descriptions should be evaluated as to their effectiveness in producing program graduates who will fill positions in the water quality control field.

3. Performance oriented curricula and course descriptions should be developed for all water quality control personnel.

4. Performance oriented curricula and course descriptions should be developed for continuing education programs for all water quality control personnel.

A Four-Year Wastewater Technology Curriculum

Proposed Qualifications of Program Graduate

The passage of the Water Quality Improvement Act of 1970 (PL 91-224) has provided impetus to prepare trained people who can design, operate and maintain wastewater treatment plants. To accomplish this training it is essential to develop a program which will train technologists who will be equipped to become a member of a productive team upon employment (Table I).

This type of training lends itself well to a curriculum in which the goals of the program, performance objectives and necessary terminal behavior of the graduates are reflected in its design. The purpose of this curriculum, therefore, is to:

1. Design a four-year engineering curriculum in wastewater technology leading to a Bachelor's Degree in engineering technology in which the graduates will be productive immediately upon employment.

2. To develop a goal oriented curriculum in which each course is defined as to its purpose, performance objectives and terminal behavior. In this manner the student will know prior to taking the course what he must accomplish to complete it successfully and what his ability will be upon successful completion.

3. To design a curriculum format which can be developed into a system of modules thereby allowing the instructor to develop, evaluate and use a variety of instructional strategies on a given topic. This approach can be tried, evaluated and revised until maximum achievement is obtained. Various components of the curriculum can then be extracted and used for review, as a short course, or incorporated into a different but applicable situation.

The curriculum as developed here has all these attributes. It clearly defines its goals and the terminal behavior that the graduate will possess. It is designed to produce a technologist who can be employed in many levels being productive immediately upon job entry or with a minimum of retraining. It is a highly flexible system which lends itself to easy evaluation and revision with optimal instruction for the students.

TABLE I

ORGANIZATIONS WHICH MIGHT EMPLOY GRADUATES OF WATER POLLUTION CONTROL TECHNOLOGIST PROGRAM AND HIS EXPECTED ACTIVITY

Place of Employment	Activity
1. Consulting Engineers	Field survey of pollutant sources; stream survey studies; feasibility studies and reports; hydraulic studies; cost estimate studies; financing of construction; operation, maintenance and repairs; installation design including production of plans and specifications of piping layouts, heating and ventilation systems, control systems, and wiring diagrams; earthwork and landscaping computations, bidding and construction specifications; supervision of construction; supervision of operation and maintenance, development of operation manuals; start up of plants, public relations.
2. Government	
a. Federal	Stream surveys; laboratory analyses; plan and specification review; inspection of construction and existing plants; investigation of and reporting on complaints, public relations, assistance to plant operations staff, interpretation and enforcement of laws and regulations.
b. State	Stream surveys; laboratory analyses; plan and specification review; inspection of construction and existing plants; investigation of and reporting on complaints, public relations, assistance to plant operations staff, interpretation and enforcement of laws and regulations.
c. Municipal	Combination of consulting engineering activity and Federal activity depending on size of municipality.
d. Drainage Basin and Commissions	Combination of consulting engineering activity and Federal activity depending on size of municipality.
3. Industry	Responsible charge of design; operation, maintenance and repair of pollution abatement facilities; inplant studies of potential pollution sources and abatement thereof; start-up of equipment; cost studies of construction, operation, maintenance and repairs; evaluation of pretreatment and direct discharge into municipal sewers; public relations; reports to management.

TABLE I
(Continued)

4.	Manufacturer of Process Equipment and Chemicals	Research and development; product manager; application engineering sales; supervision of plant start up; supervision of operation of plants and instruction of plant personnel on proper equipment operation, maintenance and repair; checking installation and operation of new and old equipment.
5.	Equipment Distribution	Research and development; product manager; application engineering sales; supervision of plant start up; supervision of operation of plants and instruction of plant personnel on proper equipment operation, maintenance and repair; checking installation and operation of new and old equipment.
6.	Construction	Take off quantities for bidding; cost estimates; preparation of construction drawings; preparation of construction schedules; supervision of construction and installation of equipment; directing and assigning of work schedules; ordering, scheduling and recording shipment of materials and equipment; start up of plant operation and instruction of plant personnel in operation, maintenance and repair of equipment.

Curriculum and Course Descriptions

A four-year technologist curriculum is shown in Table II. The performance oriented course descriptions are given in Appendix 1 for all of the courses except the humanities courses and electives.

Each course description contains three sections:

1. A brief description of the course purpose and the subject matter to be covered,

2. A series of statements indicating the performance (knowledge and skills) that the trainee will be able to demonstrate upon completion of the course, and

3. A listing of the prerequisites for the course.

These performance oriented course descriptions represent a significant step forward in defining one level in the continuum of talent needed in the water quality control field. This effort did produce a curriculum for technologist training in design, operation and maintenance of wastewater treatment plants. The curriculum, if implemented by the academic community, will produce graduates for employment by consulting engineers, regulatory agencies, municipalities, industry, and others. This graduate will be well qualified to meet the on-the-job requirements without extensive entry training and permit immediate assignment of a large number of tasks without extensive supervision.

Figures 2 through 11 indicate possible flow charts for progressing through the curriculum. Every course is on at least one flow chart and noted by an arrow coming from the bottom of the box when it is a prerequisite for another course. (Figure 1)

When a course may be taken concurrently with another, an arrow is shown entering the side of the box. Any course marked with an asterisk (*) on any flow chart is an appropriate starting point for a trainee. A trainee can enter a flow chart at the course or courses on the first line and progress upward. When he reaches the last course he proceeds to the proper course on the next appropriate flow chart. Eventually he will emerge from the courses as a program graduate. A combined flow chart is shown in Figure 12 for the entire curriculum.

These flow charts not only indicate the various pathways a trainee may progress through a four-year technologist program, but also suggest a variety of pathways that may be utilized for continuing education programs for persons working in the water quality control field. A person desiring knowledge and skills in a limited area could proceed through any one of the stems to the extent desired.

Development of flow charts of this nature assists the developer in verifying the prerequisite knowledge and skills for each course.

Humanities and elective courses could be inserted to the flow charts at suitable points.

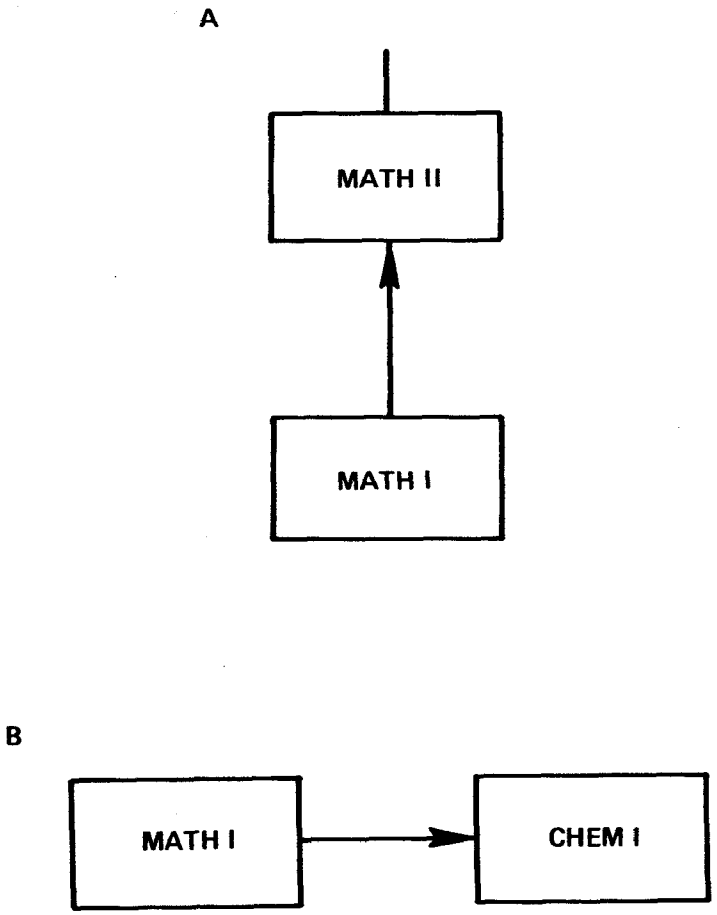


Figure 1. Key for curriculum flow charts.

Future Work

The effort described herein is a significant effort toward solving the manpower requirements of the water quality control field. The approach described here should be applied in analyzing the on-the-job performance required of technicians, technologists, engineers, scientists and other personnel involved not only in the water quality control field but also in other environmental control efforts.

The initial effort in reviewing this report should be to ascertain the need for a wastewater technologist produced by the curriculum. The performance oriented course descriptions should facilitate this type of analysis as well as assist with the evaluation of curriculum development efforts for other technician, technologist and engineering programs.

The curriculum and performance oriented course descriptions need to be refined and evaluated to ascertain that they do produce a program graduate that can meet the initial job performance requirements of the employer. Where required, the curriculum and course descriptions must be changed to meet these requirements. This could be handled by a joint effort representing both the employers and the educational institutions and including representatives from professional organizations.

One important aspect of any continuation of this effort would be close coordination with similar activities producing curricula and instructional materials that could be utilized directly in or be used to give guidance to the further implementation of this technologist curricula. A number of these efforts have produced performance oriented course descriptions or performance oriented instructional materials that are suitable for use in the curricula described in this report. The following listing represents some of the organizations.

Project BIOTECH (Dr. John Olive)
American Institute of Biological Sciences
3900 Wisconsin Avenue NW
Washington, DC 20016
(202) 244-5581

Project CIVTEC (Dr. Kent Sharples)
State Board for Technical and Comprehensive Education
1429 Senate Street
Columbia, SC 29201
(803) 758-3171

Standard Field Operation Procedures (Mr. Harold Jeter, Director)
Water Program Operations
Manpower Development Staff
National Training Center, EPA
Cincinnati, OH 45268
(513) 684-8223

TECH Physics Project (Philip DiLavore, Project Coordinator)
American Institute of Physics
Indiana State University
Terre Haute, IN 47804
(812) 232-6311 Ext 5355

Wastewater Technician Training (CEWT) (Bernard Lukco)
Manpower Training Branch
Office of Water Program Operations
Environmental Protection Agency
Washington, DC 20460
(703) 557-7363

Preprofessional Individually Paced Instruction (PIPI) (Dr. Kenneth A. McCollom, Associate Dean)
College of Engineering
Oklahoma State University
Stillwater, OK 74074
(405) 372-6211 Ext 7551

Wastewater Plant Operating Procedures
(Carl Schwing, Director)
Charles County Community College
LaPlata, MD 20646
(301) 934-2251

More detail on what is available from these organizations is given in Appendix VI.

Based on the effort in this report and associated activities in the educational and professional community the following future work is suggested for consideration by EPA:

1. Convene a group of employers, educators and professional representatives to review this report and suggest to EPA the priorities and procedures for carrying out further work on the application of performance oriented curricula development in the environmental control field.

2. Evaluate the position the graduate described in this program has in respect to the need for environmental specialists in the future.

3. Allocate resources toward the development of performance oriented curricula and instructional programs as described in this report.

4. Use this method advocated for future sources and programs.

Appendices

Appendix 1

COURSE DESCRIPTIONS

TABLE II

FOUR-YEAR WASTEWATER TECHNOLOGY CURRICULUM

YEAR	SEMESTER	COURSE	TITLE	CREDITS
I	I	Chemistry I	General Chemistry	4
		Biology I	The Science of Life	3
		Math I	College Algebra	3
		Social Science I*		3
		English I	Fundamental Composition and Rhetoric	3
		Environmental Control I	Introduction to Environmental Control	1
				17
I	II	Chemistry II	Quantitative and Qualitative Chemistry	4
		Biology II	Biological Systems of Microorganisms	3
		Math II	Trigonometry	3
		Social Science II*		3
		Drafting I	Fundamental Drafting	3
		Environmental Control II	Water Quality Control Methods	2
				18
SUMMER I		Summer Work I	Wastewater Treatment Plant Operations	3
			FIRST YEAR TOTAL	38
II	I	Physics I	Fundamental Physics	3
		English II	Advanced Composition and Rhetoric	3
		Math III	Metronics	3
		Humanities I*		3
		Drafting II	Advanced Drafting	3
		Operations I	Collection System Maintenance	1
				16
II	II	Physics II	Fundamentals of Electricity	3
		Math IV	Analytical Geometry	3
		Humanities II*		3
		Mechanics I	Statics	3
		Surveying I	Fundamental Surveying	3
		Operations II	Collection System Construction	3
				17
SUMMER II		Summer Work II	Regulatory Agency Enforcement	3
			SECOND YEAR TOTAL	36
			SUM TWO YEARS	74

*These courses to be selected to meet requirements of the institution implementing this curriculum.

TABLE II
(Continued)

YEAR	SEMESTER			CREDITS
III	I	English III	Business English and Report Writing	3
		Math V	Computer Science	3
		Economics I	Fundamental Ecomics	3
		Mechanics II	Strength of Material	3
		Chemistry III	Sanitary Chemistry	4
				16
III	II	Economics II	Accounting and Management	3
		Design I	Structures	3
		Surveying II	Advanced Surveying	3
		Hydraulics	Fluid Flow	3
		Biology III	Sanitary Microbiology	4
				16
SUMMER	III	Summer Work III	Consulting Engineering Design Firm	3
			THIRD YEAR TOTAL	35
			SUM THREE YEARS	109
IV	I	Government Systems I	Governmental Interactions	3
		Construction	Construction Methods	3
		Design II	Wastewater Treatment Plant Design I	6
		Technical Elective*		3
				15
IV	II	Government Systems II	Public Financing	3
		Design III	Wastewater Treatment Plant Design II	6
		Operations III	Wastewater Treatment Facility Operational Evaluation	3
		Technical Elective*		3
				15
			FOURTH YEAR TOTAL	30
			SUM FOUR YEARS	139

*These courses to be selected to meet requirements of the institution implementing this curriculum.

CHEMISTRY I

General Chemistry

The purpose of this course is to assist the student in learning the fundamental principles of chemistry and their applications; the application of scientific methodology; the nature of matter, the atomic model, chemical bonds; principles of stoichiometry and types of chemical reactions. He will also study solutions and colloids; changes of state; principles of chemical kinetics, chemical equilibria, and electrochemistry; and basic organic chemistry nomenclature. The laboratory exercises will demonstrate the above and allow the student to identify and use common laboratory equipment.

When you complete this course, you should be able to:

1. Describe in essay form scientific methodology and demonstrate the application of the principle.
2. Describe the difference between metals and nonmetals
3. Describe, using the periodic table, the term periodicity.
4. Draw Bohr diagrams.
5. Describe in essay form the nature of ionic compounds and, using the periodic table, predict ionic charge, sizes of sets of ions, and electronegatives for the listed elements.
6. Identify simple chemical compounds with given symbols or names.
7. Identify the oxidation state of each element in a chemical formula.
8. Balance chemical equations.
9. Identify from a list, elements most likely to form covalent bonds.
10. Describe the kinetic molecular theory.
11. Describe in essay form, using the concept of entropy, the differences in solids, liquids, and gases.
12. Differentiate between polar and nonpolar bonds.
13. Describe the nature of hydrogen bonding.
14. Describe the solution of a solid or liquid in water including the effect of temperature and type of bonding in the solid or liquid.
15. Describe how ions are formed in solutions from both electrovalent and polar covalent compounds.
16. Select from a list of acids and bases the strongest acid or base.
17. Make calculations using
    a. Specific heat
    b. Heat of fusion
    c. Heat of vaporization
    d. Atomic weights
    e. Molecular weights
    f. Avagadro's number
    g. Mole ratios
    h. Emperical formulas
    i. Ionization potentials
    j. Degrees Kelvin
    k. Graham's Law of gaseous diffusion
    l. Equivalent weights

18. Calculate theoretical yield, percent yield, emperical formula, percent by weight or volume, mole fraction, molarity, molality, and normality.

19. Will be able to use bunsen burner, thermometer, measuring and volumetric glassware, balances, desiccators, cathode ray tube, and pH meter.

20. Demonstrate the laboratory technique for bending, cutting, and fire polishing glass; determing density of a substance; separating solids from liquids, gases from liquids, and liquids from liquids; and determing the molecular weight of a volatile liquid.

Before beginning this course, you should have the prerequisites of:

1. Use of exponential numbers.
2. Use of significant figures.
3. Conversion between English and Metric systems.
4. Concurrent registration in Math I.

BIOLOGY I

The Science of Life

The purpose of this course is to assist the student in learning the relationship of biology with other sciences; the origin, development, and cellular basis of life; basic bio-chemical-physical processes of life and the ecological function and relationships of organisms.

When you complete this course, you should be able to:

1. Describe in essay form using diagrams the interrelationships of biology with other sciences which use observation and experimentation. List what you consider to be the most closely aligned science to biology and explain your reasoning.

2. Using Pasteur's work on spontaneous generation and Darwin's writing on "The Origin of Species by Means of Natural Selection," contrast the theories of special creation, Genesis Book I, and organic evolution. Also, state some possible reasons for the fossil records incompleteness and the importance of Mendalian Genetics and Watson-Crick's later work on the double helix on inheritance, mutation, and evolution.

3. Using diagrams and charts, describe the role of the nucleus in the function of the cell and the role of the cell in the functioning of the organism.

4. Draw a diagram of the oxygen, hydrogen, carbon, and nitrogen atom. Show how the electrons transfer from hydrogen ions to join with oxygen ions to form water.

5. In the process of photosynthesis, inorganic compounds and water are joined to form the organic compound $C_6H_{12}O_6$ in green plants using the energy of sunlight. Show by ion transfer and a flow diagram how this reaction takes place and what are the end products. Be sure to include the reactions in both the light phase and dark phase of photosynthesis.

6. Compare (using diagrams) the gross structure of a terrestrial ecosystem (a forest) and an open fresh water ecosystem. Include the location and function of abiotic substances, producers, microconsumers, macroconsumers, and decomposers.

7. Using a pyramid of numbers, graphically represent a 10 percent yield from the producer (1000 lbs. of green algae) to the ultimate consumer in a pyramid of 5 organisms. Compare this pyramid with one in which there is

only one consumer but a 0.01 percent yield. Use as your base 1000 lbs. of algae. How does this affect the availability of food on growing populations (primarily man)?

Before beginning this course, you should have the prerequisites of:

1. High school chemistry or concurrent registration in Chemistry I.

MATH I

College Algebra

The purpose of this course is to assist the student in learning the fundamentals of algebra that will aid him in the solution of algebraic expressions involving polynominals, interest problems and the use of logarithmic terms.

When you complete this course, you should be able to:

1. Given an algebraic expression, evaluate the expression by using simplification and evaluation.
2. Determine the solution of a given equation by:
   a. The substitution method.
   b. The addition or subtraction method.
3. Add, subtract, multiply, and divide polynomials.
4. Determine the square of a monomial.
5. Using the graphing technique, determine the solution to algebraic expressions or equations.
6. Given an algebraic expression, use factorization to simplify the expression.
7. Determine the product of given binomials.
8. Given a quadratic equation, solve by any method.
9. Multiply, divide, add, subtract, and change to lowest equivalent terms any given fractions.
10. Using the laws of exponents, convert numbers from decimal form to exponential form or from exponential form to decimal form.
11. Simplify, combine (add or subtract), multiply, rationalize, and divide radicals.
12. Determine the solution of a literal equation.
13. Using the principles involving interest rates, time, and money, determine the unknown when given the two other quantities.
14. Using the method of perfect squares, factor a given expression, e.g., factor $(y^4 - 16)$.
15. Given a logarithm to a given base, determine the unique number corresponding to the logarithm.
16. Determine the number corresponding to a given logarithm by the use of log tables, the characteristic, and mantissa.
17. Given a number either in scientific notation convert to decimal form, or vice versa.

Before beginning this course, you should have the prerequisites of:

1. High school algebra (or its equivalent).

ENGLISH I

Fundamental Composition and Rehtoric

The purpose of this course is to assist the student in learning the basic concepts of the English language and how to apply these concepts in utilizing the language for clear and meaningful communications such as letter and report writing.

When you complete this course, you should be able to:

1. Given a part of speech such as verb, describe its use in sentences and provide an appropriate example sentence using that part of speech.

2. Define the following and give an example of each in a sentence:

   a. Phrase

   b. Clause

3. Describe and give examples in sentences of the different types of clauses and phrases.

4. Classify the structure of a sentence such as simple, compound, complex, and compound-complex.

5. Given a list of sentences, identify the errors based on the following rules of grammar and mechanics, and correct the error. (A list will be given.)

6. Given a series of sentences, correct for punctuation and spelling.

7. Spell correctly and words given orally or written wrong.

8. Use the dictionary to:

   a. Find definitions.

   b. Determine correct spelling of words.

   c. Determine correct capitalization of words.

   d. Determine the correct pronunciation of words.

   e. Determine the correct usage of the right word in a sentence.

9. Given a series of sentences:

   a. Cross out any word or phrase not used in accordance with standard English. Insert the standard English equivalent.

   b. Strike out each word used inappropriately and insert the correct or exact word.

   c. Bracket needless words and revise the wording.

10. Using the procedures for good English, write a theme or essay on a topic of your choice.

Before beginning this course, you should have the prerequisites of:

1. High school English.

ENVIRONMENTAL CONTROL I

Introduction To Environmental Control

The purpose of this course is to assist the student in learning the application of scientific and engineering methods to the solution of environmental problems throughout history, the effect of waste disposal practices on man and the environment, modern methods of protecting man and the environment from wastes, procedures for

setting environmental protection criteria, and laws for protecting the environment.

When you complete this course, you should be able to:

1. Describe by charts and/or essay the characteristics of wastes that have a detrimental effect on man or his environment.

2. Describe by the use of bio-geochemical cycles how man's disposal practices have had a detrimental effect on man or the environment.

3. Describe by diagram and/or essay the scientific and engineering methods used by man throughout history to solve environmental problems.

4. Describe by diagrams and essay modern methods of protecting man and the environment from man's wastes.

5. Describe by flow charts and essay procedures for setting environmental criteria and laws to protect man and the environment.

Before beginning this course, you should have the prerequisites of:

1. High school chemistry and biology, or

2. Concurrent registration in Chemistry I and Biology I.

CHEMISTRY II

Quantitative and Qualitative Chemistry

The purpose of this course is to assist the student in learning the methods of systematically separating, identifying, and quantitatively determining inorganic substances; the use of the basic analytical tools and operations of qualitative and quantitative analytical processes; the calculations used in quantitative analysis, the types and sources of errors found and the treatment of data. Include the calculations involved in acid-base precipitation and redox reactions. The laboratory exercises will demonstrate the above and aid the student in becoming familiar with volumetric and gravimetric methods of quantitative analysis and spectrometric, electrometric, and chromatographic techniques.

When you complete this course, you should be able to:

1. Describe in essay form and perform procedures for the following:

   a. Sampling of gases, liquids, and solids

   b. Drying using ovens, burners, furnaces, desiccators, evaporation

   c. Ignition

   d. Weighing

   e. Precipitation

   f. Solution

   g. Titrations

   h. Preparing standard solutions

   i. Extraction

   j. Adsorption chromatography determination

   k. Gas chromatography determination

   l. Ion exchange determination

   m. Complexometric titrating

   n. Spectrophotometer determination

   o. Ultraviolet absorption determination

   p. Infrared absorption determination

q. Photometric titrations

r. Potentiometric determination

s. Conductometric determination

t. Colorometric determination

u. Polarographic determination

2. Perform the calculations for the procedures in (1) above.

Before beginning this course, you should have the prerequisites of:

1. Chemistry I
2. Biology I
3. Math I

BIOLOGY II

Biological Systems of Microorganisms

The purpose of this course is to assist the student in learning the metabolic pathways, and photosynthetic, chemosynthetic systems of bacteria, algae, fungi, and protozoans. The microbes commonly found in fresh water, wastewater and treatment systems will be studied. The student will be introduced to basic field sampling and identification techniques.

When you complete this course, you should be able to:

1. Explain the differences (using diagrams) between eucaryotic and procaryotic cells.
2. Given five different agar slant cultures of bacteria, be able to transfer these bacteria to the proper culture media and maintain the cultures free of contamination for a period of 8 weeks.
3. Describe the chemical production of nutrients by autotrophic bacteria which utilize CO_2 as their exclusive source of carbon. Use formulas and flow charts.
4. List ten heterotrophic microbes, the nutrients which they utilize the manner in which they obtain these nutrients, and the waste products which result from their metabolism.
5. Differentiate between the mode of entry of forty disease causing microbes in man. Include food poisoning, water borne infections, air borne infections, and animal or plant contact diseases.
6. Obtain samples from a fresh water stream, the air, wastewater system, and the treated water from a wastewater treatment plant. Identify (according to given classifications) and count in the appropriate units (numbers per unit volume) the microbes in the sample.

Before beginning this course, you should have the prerequisites of:

1. Biology I

MATH II

Trigonometry

The purpose of this course is to assist the student in learning the function and basic properties of acute and oblique angles and triangles and to name and order the fundamental relations of trigonometric functions. The student will become familiar with the law of sines and cosines in the solution of unknown elements, solve acute and oblique triangles to determine unknowns, areas, altitudes, or parts as required.

When you complete this course, you should be able to:

1. Identify and name the sides of a triangle.
2. Name and define the six terms used in trigonometry to express the ratios between sides
3. Define vectors differentiating between length, direction, and sense.
4. When given an angle:
   a. Construct the desired angle.
   b. Drop a perpendicular from the end point to the side adjacent.
   c. Measure a convenient even distance on the hypotenuse.
   d. Measure the side opposite and find the sine ratio.
   e. Calculate the sine.
5. When given the value of a function:
   a. Draw a horizontal line
   b. Erect a perpendicular at the end of the line
   c. Measure the distance on the perpendicular
   d. Swing a 1 inch arc from the end point of the perpendicular
   e. Draw a hypotenuse through the end point and the intersecting point
   f. Measure the acute angle formed with the horizontal line
6. Explain the procedure for reading table of natural trigonometric functions, interpolate these tables and round off linear dimensions to three places.
7. Define equilateral triangle and find the sides of the equilateral triangles.
8. Define isosceles triangle and compute the sides and angles of these triangles.
9. Solve oblique triangles by drawing perpendiculars and using the law of sines and law of cosines to simplify the solution.
10. Graph the trigonometric functions of $y = a \sin x$ and $y = a \cos x$.

Before beginning this course, you should have the prerequisites of:

1. Math I

DRAFTING I

Fundamental Drafting

The purpose of this course is to assist the student in learning the basic methods of transferring objects or structures such as shapes and dimensions from the actual working conditions they are located in, to the drawing board. The student will produce simple pencil and paper drawings using neat lettering techniques and transferring measurements to drawings of different scale. He will also learn to prepare tracings.

When you complete this course, you should be able to:

1. Draw a simple pencil and paper drawing of an object or simple structure presented.
2. Given three complete views of an object, draw the object.

3. Using the lettering techniques for engineering, letter the alphabet on a sheet of paper with guidelines for at least four times.

4. Draw the following pictorial views given an object or structure:

   a. Isometric

   b. Perspective (ground) (above)

   c. Oblique

5. Given a drawing, measure the lengths on the drawing and translate such information to other drawings of different scale.

6. Given several detail drawings, combine drawings with appropriate dimensions and notes and prepare tracings for the combined drawings.

Before beginning this course, you should have the prerequisites of:

1. Math I

2. Concurrent registration in Math II

ENVIRONMENTAL CONTROL II

Water Quality Control Methods

The purpose of this course is to assist the student in learning the unit operations and processes in treating water and wastewater and how these accomplish the desired degree of treatment. Methods for evaluating the performance of a treatment plant, and the role of private and governmental organizations in the planning, design, financing, operation and regulation of treatment facilities will also be studied.

When you complete this course, you should be able to:

1. Describe by diagram and essay the common unit operations and processes required for given raw water and wastewater characteristics.

2. Describe by diagram and essay how a unit operation or process accomplishes the removal or alteration of a particular constituent.

3. Describe by flow charts and essay procedures for evaluating the performance of treatment plants.

4. Visually identify a treatment unit by name and verbally describe its function.

5. Describe by flow chart and essay the function of city, county, state, and Federal regulatory agencies.

6. Describe by flow chart and essay the functions of consulting firms; and municipal, industrial, and commission operators of treatment facilities.

Before beginning this course, you should have the prerequisites of:

1. Environmental Control I

2. Concurrent registration in Chemistry II

SUMMER WORK I

Wastewater Treatment Plant Operations

The purpose of this course is to assist the student in learning the normal operational procedures for a wastewater plant and to actually perform the procedures. He will learn to recognize emergency conditions of the waste stream and the cause for these conditions; to carry out the routine preventive maintenance procedures; and to recognize when corrective maintenance procedures are required. He will also learn the safety features that must be considered

in all of the above operations, and how to prepare daily and monthly reports pertaining to the plant's operation.

When you complete this course, you should be able to: (The following objectives apply to the wastewater process units on the list below.)

Collection

Prechlorination

Screening and Grinding

Grit Removal

Primary Sedimentation

Trickling Filtration

Aeration

Secondary Sedimentation

Pond Stabilization

Thickening

First State Digestion

Second Stage Digestion

Sludge Conditioning

Postchlorination

Sludge Dewatering

Solids Disposal

Effluent Disposal

Flow Measurement

Electric Power

Gas Power

1. Describe orally and perform the procedure to follow to assure proper functioning of each of the process units. For each unit include:

   a. Frequency of performance

   b. Conditions to look for

   c. Actions to take

2. Describe orally the procedure to follow to assure proper functioning of each process unit under emergency conditions, i.e. color of influent bright red, floating solids on surface of secondary settling tank. For each unit include:

   a. How to identify the emergency condition

   b. The probable reason(s) for the occurence of the condition

   c. The action to take

3. Describe orally and perform the procedure to follow to assure proper preventive maintenance of each of the process units. For each unit include:

   a. Reference materials to be used (manual, chart, nomograph, diagram, etc.)

   b. Frequency of performance

   c. Conditions to look for

   d. Actions to take

4. Describe orally the procedure to follow for repair of each component of each process unit when it is not operating properly. For each component include:

   a. Reference material to be used (manual, chart, nomograph, diagram, etc.)

   b. Conditions to look for

   c. Actions to take

   d. The probable reason(s) for the occurrence of the condition

5. Describe orally and perform the procedure to follow for taking samples at any point in the plant. For each sample include:

   a. Frequency of sampling

   b. Container to be used

   c. Actions to take

   d. Data to record

6. Describe orally and perform the procedure for any of the procedures performed under 1 through 5 above that relate directly to employee safety. For each procedure include:

   a. Why the procedure is necessary

   b. How the procedure protects the employee

   c. Actions to take

7. Describe orally, for any process unit or series of units in the plant, an alternate process unit or series of units that will accomplish comparable treatment.

8. Fill out forms (tables, charts, narrative) for preparing daily and monthly operating reports for each unit process or series of unit processes.

Before beginning this course, you should have the prerequisites of:

1. Chemistry II
2. Biology II
3. English I
4. Environmental Control II
5. Drafting I

PHYSICS I

Fundamental Physics

The purpose of this course is to assist the student in learning the relationship of physics with other sciences, the structure and properties of matter, the theory and mechanics of energy, and the nature of sound, light, electricity, and atomic energy.

When you complete this course, you should be able to:

1. Describe in essay form using diagrams the interrelationships of physics to the other sciences and the contributions and problems that the impact of physics has had upon the other sciences and society.

2. Describe the structure and properties of the three states of matter and their relationship to temperature and pressure. Use the appropriate mathematical formulas to illustrate Boyles' Law, Charles' Law, the flow equation, and Bernoullis' Principle.

3. Explain how the mercury barometer, aneroid barometer, altimeter, the lift pump, the force pump, the siphon, and the Bourdon gage function.

4. Describe Newton's three laws of motion: inertia, acceleration, action and reaction. Give example to illustrate each using f = ma where appropriate.

5. Describe the relationship between force, work, and energy. Include in this discussion potential and kinetic energy.

6. Given a steel I beam which weights 600 lbs. and spans a distance of 30 ft. supported at each end by girders, find the reaction forces in the supporting girders--the beam supports a 2200 lb. punch press 5 ft. from the right end and 24,000 lbs. lathe 10 ft. from the left end.

7. Musical sounds are characterized by their pitch, loudness, and quality. Describe, using illustrative diagrams, how these characters are determined.

8. List four ways in which light waves differ from sound waves and four ways in which they are similar to sound waves.

9. Define inverse-square law using the formula $\frac{\varepsilon^1}{\varepsilon^2} = \frac{d_2^2}{d_1^2}$.

10. Given an electric motor operating at 100 percent efficiency and from a 440 volt line which is used to hoist automobiles with a winch that operates the hoist that is 60 percent efficient:

    a. What is the horsepower necessary to raise the car weighing 4000 lbs. a distance of 30 ft. in 70 seconds?

    b. What is the power converted to kilowatts?

    c. What current will the motor draw from the line while operating the hoist?

11. Define: alpha particle, beta particle, and gamma ray.

12. What is the energy equivalent of a proton (assuming all the mass is converted to energy) in:

    a. Ergs

    b. Electron volts

Before beginning this course, you should have the prerequisites of:

1. Chemistry I

2. Math II

ENGLISH II

Advanced Composition and Rhetoric

The purpose of this course is to assist the student in learning the finer points of writing proper English and incorporating the fundamentals of English into a well written theme or research paper. The student will also learn to critique research reports, technical papers, short stories, and novels.

When you complete this course, you should be able to:

1. Develop an outline for a reading selection on pollution problems.

2. Write a critical essay of a book dealing with the problems of pollution.

3. Use the card catalogue to locate books on wastewater treatment and abstracts to locate papers on wastewater treatment problems.

4. Write a research paper on a given topic.

5. Show a reading comprehension level of 80 percent or better on five selected articles on wastewater treatment.

Before beginning this course, you should have the prerequisites of:

1. English I

MATH III

Metronics

The purpose of this course is to assist the student in learning the relationship of the elements of mathematics, drafting, and surveying as they relate to measuring, scaling, computing, gaging, and estimating.

When you complete this course, you should be able to:

1. Calculate the area of a regular or irregular figure.
2. Describe how you would use the following in surveying and area calculation:
   a. Geometry
   b. Parallel lines
   c. Polygons
   d. Angles
3. Determine volumes by the use of the principles of solid mensuration.
4. Define the following:
   a. Prismoidal formula
   b. Rules of solid mensuration
   c. Averages
   d. Medians
   e. Modes
   f. Dispersion
   g. Deviation
   h. Statistical methods
5. Given an object, measure it with metric and engineering scales.
6. Using the following techniques or instruments make the required measurement with accuracy (± 2%):
   a. Tape
   b. Weighing technique
   c. Gaging technique
   d. Sampling technique
7. Given a map, perform the following:
   a. Identify map symbols and make legible sketches of desired parts such as steep slopes, populated areas, roads, etc.
   b. Use scales, elementary surveying, and note keeping techniques in reading map and drawing sketches

Before beginning this course, you should have the prerequisites of:

1. Math II
2. Drafting II

DRAFTING II

Advanced Drafting

The purpose of this course is to assist the student in learning the preparation of construction plans including profile, cross-sections, projections, and required views of objects. The study will also include aspects of plotting field notes, plotting property lines and computing dimensions as well as taking quantities from construction drawings to put into tabular form.

When you complete this course, you should be able to:

1. Prepare construction plans for profiles, cross-sections, projections, and required views of objects by:
   a. Tracing
   b. Lettering
   c. Drawing
2. Plot the following:
   a. Field notes as prepared by surveyor
   b. Property line of lots, streets, etc. from deeds
3. Given a set of drawings, compute the dimensions and convert to a different scale if necessary.
4. Letter and prepare drawings and tracings with pen and ink.
5. Given construction drawings, take off quantities from drawings and present information in tabular form for estimating costs.

Before beginning this course, you should have the prerequisites of:

1. Drafting I

OPERATIONS I

Collection System Maintenance

The purpose of this course is to assist the student in learning the normal operational procedures for a collection system and to perform the procedures. He will learn to: recognize emergency conditions of the waste stream and the cause for these conditions; to carry out routine preventive maintenance procedures; to recognize when corrective maintenance procedures are required and describe orally the procedure to make the repair. He will also learn to describe orally the safety features that must be considered in all of the above operations and prepare daily and monthly reports pertaining to the collection system's operation.

When you complete this course, you should be able to:

1. Identify by name the types of sewers in a collection system.
2. Identify by name and functional description the components found in a collection system.
3. Describe in essay form with charts and figures the following information concerning wastewater:
   a. Source (domestic, commercial, industrial, infiltration, runoff)
   b. Characteristics (physical, chemical, biological, quantity)
   c. Variations with time (hour, day, week, season)
4. Describe in essay form with charts and figures the methods for population prediction.
5. Describe in essay form with charts and tables the materials to be used in collection system construction.
   a. Reference material (manuals, charts, specifications, etc.)
   b. Pipe material
   c. Pipe size
6. Describe orally and perform the procedure to follow to assure proper functioning of each component of a collection system. For each component include:

a. Frequency of performance

b. Conditions to look for

c. Actions to take

7. Describe orally the procedure to follow to assure proper functioning of each component of the collection system under emergency conditions, i.e., gasoline in sewer, flooded manhole, etc. For each component include:

   a. How to identify the emergency condition

   b. The probable reason(s) for the occurrence of the condition

   c. The action to be taken

8. Describe orally and perform the procedure to follow to assure proper preventive maintenance of each of the components of the collection system. For each component include:

   a. Reference material to be used (manual, chart, nomograph, diagram, etc.)

   b. Frequency of performance

   c. Conditions to look for

   d. Actions to take

9. Describe orally the procedure to follow for repair of each component of the collection system when it is not operating properly. For each component include:

   a. Reference material to be used (manual, chart, nomograph, diagram, etc.)

   b. Conditions to look for

   c. Actions to be taken

   d. The probable reason(s) for the occurrence of the condition

10. Describe in essay form or orally the procedure to follow for any of the procedures in 6 through 9 above that relate directly to employee safety. For each procedure include:

    a. Why the procedure is necessary

    b. How the procedure protects the employee

    c. Actions to be taken

11. Demonstrate by simulated exercise (role playing) the supervision of maintenance personnel conducting the procedures in 6 through 10 above.

Before beginning this course, you should have the prerequisites of:

1. Summer Work I
2. Environmental Control II
3. Biology II
4. Concurrent Registration in Drafting II

PHYSICS II

Fundamentals of Electricity

The purpose of this course is to assist the student in learning the fundamentals of electricity and magnetisms with emphasis on direct and alternating current circuits, meter instrumentation, and the measurement of electrical quantities, motors and generators, and the elements of electronics.

When you complete this course, you should be able to:

1. Describe Eqing's theory of Magnetism and the Electron Theory of Magnetism.

2. Describe why when a magnet is suspended the ends turn towards the north and south pole.

3. Define volts, joules, coulombs, and dyne.

4. Describe in terms of the electron theory, using appropriate formulas and diagrams, why a small neutral pith ball suspended by a silk thread when brought near a negatively charged sphere is first attracted to the sphere until contact is made and then repelled.

5. Compare the differences between series circuits and parallel circuits.

6. Describe, using diagrams, how an ammeter and a voltmeter are connected in a circuit.

7. Define: watt-hour, kilowatt-hour, electrolyte.

8. Find the cost of operating, for an 8 hour day, a bank of 40 incandescent lamps (connected in parallel) using the following information:

   a. Each lamp has a resistance of 240 ohms when hot

   b. The lamps are connected to a 120 volt power line

   c. 6.5 cents per kilowatt-hour is the charge

9. List three applications where direct current is preferred to alternating current and why it is preferred.

10. State Ohm's Law so that it is applicable to AC circuits.

11. Differentiate between AC and DC and explain how an AC generator can be modified to produce direct current.

Before beginning this course, you should have the prerequisites of:

1. Physics I

MATH IV

Analytical Geometry

The purpose of this course is to assist the student in learning the concepts that will enable him to visualize two and three dimensional lines, curves, and planes applicable to the tasks of drafting, take off, surveying, plan and map reading, and design. The study will include locating points from equations, findings locus of points which define surfaces, and generating surfaces of revolution which form various solids.

When you complete this course, you should be able to:

1. Graph the function of $y = f(x) - 2x^3 - 8x^2 - 11$.

2. Locate the points having the coordinates given below:

   a. (2,5)

   b. $(4,\sqrt{3})$

   c. (-2,6)

   d. $(-\sqrt{2},3)$

   e. (8,-3)

   f. (7,-4)

   g. (-3,-5)

   h. (-6,-2)

   i. (0,5)

j. (-5/2,0)

k. (0,0)

l. (11/2,-2/3)

3. Name the four common methods of solving systems of simultaneous equations.

4. Solve a given system of equations by any of the four common methods.

5. Graphically solve a word problem given all the needed information.

6. Solve a given system of simultaneous linear equations by determinants.

7. Given an equation, outline the graph.

8. Given an equation, describe in detail the symmetry of the curve.

9. Given an equation, determine the asymptates, if any, and also any excluded region.

10. Using the composition-of-ordinates techniques, sketch the curves given.

11. Given a list of equations, perform the indicated operations:

    a. Sketch the curves using the method of translation of axes

    b. Write the basic equation in each case

12. Given a system of equations, solve algebraically for all values of x and y.

Before beginning this course, you should have the prerequisites of:

1. Math III

MECHANICS I

Statics

The purpose of this course is to assist the student in learning the principles of mechanics and their applications. This will involve the study of equilibrium of coplanar force systems, noncoplanar force systems, centroids and moments of inerta, and friction.

When you complete this course, you should be able to:

1. Given the name of one of the six force systems, describe the characteristics of the system and also how to determine the resultants of several forces that may act within the system.

2. Using the principle of moments, compute the moments, the moments of object, and then determine any unknown moment of the object.

3. Draw the free-body diagram of a given object being sure to include all angles, forces, and moments and be able to use the diagram to solve for any unknown angles, forces or moments by the methods of equilibrium of that system.

4. Given the type surface (such as dry or lubricated), determine whether the friction force is dependent or not on properties such as velocity, type material, and temperature by using the laws of friction.

5. Draw the friction force diagram completely of any of the following and solve for any unknown with the aid of any of the friction force equations:

    a. Block on plane

b. Belt and pulley

c. Rolling object

6. Given any size and shape area, determine the following:

a. Centroid

b. Moment of inertia

c. Radius of gyration

Before beginning this course you should have the prerequisites of:

1. Math IV

SURVEYING I

Fundamental Surveying

The purpose of this course is to assist the student in learning the basic techniques of surveying and the importance of accurate note taking, minimal error, equipment adjustment and maintenance, and basic map reading.

When you complete this course, you should be able to:

1. Measure horizontal distances using a steel tape and related equipment with an error no greater than 0.012 ft. for the first measurement.

2. Demonstrate using the instruments and diagrams how to adjust a transit and a dumpy level.

3. Demonstrate using the instruments and diagrams the proper care and maintenance of the transit, range pole, tape and dumpy level.

4. Run a level network, using a level and related equipment and keep proper field notes.

5. Given a geodetic topographic survey map (U. S. geodetic survey) determine (describe your methods) the location; the approximate area covered in square miles; the ten highest points; the ten lowest points; true North; direction of stream flow; and the location of the steepest angle of rise.

Before beginning this course, you should have the prerequisites of:

1. Drafting II

OPERATIONS II

Collection System Construction

The purpose of this course is to assist the student in learning the construction and major repair procedures for a collection system, to actually perform the procedures and direct others to perform the procedures. He will be able to describe orally the safety features that must be used in all of the above operations, demonstrate these safety procedures, and direct others in the use of these procedures. He will prepare daily and monthly reports pertaining to the collection system's construction.

When you complete this course, you should be able to:

1. Describe in essay form the organization and administration of collection system projects including:

a. Phases of project development

b. Organizations or persons involved in project prosecution and their roles

c. Rules and regulations pertaining to sewer design and use

In addition the student will demonstrate his competence in the above by solving simulated problems (role playing).

2. Describe in essay form and actually conduct surveys for the preliminary design, design, and construction of a collection system.

3. Design collection systems using the calculations, nomographs, tables, and figures necessary to meet local construction standards. Also consider:

   a. Gravity loads on sewers

   b. Superimposed loads

   c. Strength of conduit

   d. Safety factors

   e. Shoring requirements

   f. Corrosion requirements

4. Describe orally the meaning of symbols, diagrams, representations, etc. on plans and specifications of collection systems.

5. Describe in essay form and orally the methods used to construct collection systems. This should include.

   a. Trenching methods

   b. Trenching equipment

   c. Trench shoring

   d. Pipe placing

   e. Pipe laying equipment

   g. Backfilling

   h. Surface restoration

   i. Tunneling

   j. Crossing of pipelines, electrical conduits, railroads, highways.

   k. Surveying techniques

   l. Pumping stations

   m. Force mains

6. Demonstrate by simulated exercises (role playing) the supervision of laborers, equipment operators, surveyors in conducting the construction procedures in (5) above.

7. Complete forms, records, time sheets, work orders, accident reports pertaining to collection system.

8. Receives information and work orders from superior and translates these into directions to persons working under him.

Before beginning this course, you should have the prerequisites of:

1. Operations I

2. Concurrent registration in Surveying I

SUMMER WORK II

Regulatory Agency Enforcement

The purpose of this course is to assist the student in learning the application of local, state, and Federal regulations and laws to water quality control problems; techniques for determining the need for sampling surveys and the analyses to be conducted and the procedures to follow. Procedures for evaluating treatment plant performance and its compliance with standards and for evaluating plant and specification for wastewater treatment plants; and procedures for evaluating environmental impact statements will also be studied.

When you complete this course, you should be able to:

1. Describe in essay form and demonstrate the procedure for evaluating the appropriate local, state, or Federal regulation applicable to a water quality control problem. The procedure should include:
   a. How to select appropriate regulation(s)
   b. How to select appropriate data relating to problem
   c. Interpretation of regulation in relation to data
   d. Control action dictated by regulation
2. Describe in essay form and demonstrate the procedure for sampling surveys. The procedure should include:
   a. Criteria for:
      (1) Determining need for survey
      (2) Samples to be taken
      (3) Analyses to be made
   b. Sampling locations
   c. Sampling frequency
   d. Sampling schedule
   e. Data analysis and evaluation
3. Describe in essay form and demonstrate the procedures for evaluating treatment plant performance. The procedure should include:
   a. Reference materials (standards, regulations, specifications, etc.)
   b. Samples to be taken
      (1) Location
      (2) Type
      (3) Frequency
   c. Analyses to be performed
   d. Calculations to be performed
   e. Graphs and tables to be prepared
   f. Interpretations to be made
   g. Control Actions to be made
4. Describe in essay form and demonstrate the procedures for plan evaluation and environmental impact statement evaluation. The procedure should include:
   a. Reference material (standards, regulations, specifications, etc.)
   b. Calculations
   c. Evaluation procedures
   d. Forms and charts to be completed
   e. Actions to be taken

Before beginning this course, you should have the prerequisites of:

1. Summer Work I
2. Operations II

ENGLISH III

Business English and Report Writing

The purpose of this course is to assist the student in learning the principles and application of business and technical writing.

When you complete this course, you should be able to:

1. Write general and specific types of business communications including order

letters, inquiries and replies, intra-office memos, recommendations, and general business correspondence.

2. Examine and interpret data from: a technical paper, a report, a research paper, a case history, and a project proposal.

3. Write a report, project proposal, and case history.

4. Describe the methods for planning, organizing, writing, and summarizing a report.

5. Distinguish between connotations and euphemisms.

Before beginning this course, you should have the prerequisites of:

1. English II

MATH V

Computer Science

The purpose of this course is to assist the student in learning to program a computer for engineering and scientific applications and to acquaint the student with leading types of digital computers and their peripheral equipment.

When you complete this course, you should be able to:

1. Identify five common digital electronic computers and their accompanying equipment.

2. Design, using graphs, diagrams, and numerical computations, a generalized computer program.

3. Write a program on coding sheets, including read and print statements and punch this program into punch cards with a resulting source program deck.

4. Complete the further steps necessary for reading the program into the computer. This includes the Fortran compiler program, the source program deck, the object program, and the data cards.

5. Use Fortran processor to successfully run numerical computations such as interpolations, solutions of equations and nonnumerical computations including searching, sorting, data-handling, and simulation.

Before beginning this course, you should have the prerequisites of:

1. Math I

ECONOMICS I

Fundamental Economics

The purpose of this course is to assist the student in learning the fundamental economic problems of the American economy and an understanding of the nature and interrelationships of such groups as consumers, business, government, and financial institutions.

When you complete this course, you should be able to:

1. Discuss the evolution of the American economic system and the nature and method of economics.

2. Explain and relate the two statements: "Society's material wants are virtually unlimited" while "economic resources are limited or scarce." Use diagrams illustrating the production possibilities curve; unemployment and the

production possibilities curve; and economic growth and the production possibilities curve.

3. Given the underlying philosophy, institutional characteristics and method of solving economic problems for capitalism, democratic socialism, communism.

4. Discuss the problems involved in increasing a full employment--full production economy's stock of capital goods.

5. Define demand and explain the law of demand, why a demand curve slopes downward and what are the determinants of demand.

6. Distinguish, using diagrams, between social goods and private goods; private reserves and cost; and social revenues and cost, giving illustrations of each.

7. Explain the implications that personal distribution of income have for the size and composition of the economies total input and for resource allocation.

8. Describe the mechanics of the Federal personal income tax and corporate income taxes.

9. Explain the law of demand through the income and substitution effects, using a price increase as a point of departure for this discussion.

10. Distinguish between fixed and variable costs and give examples of each.

11. Explain why the greater use of sales taxes, as opposed to income or property tax, is recommended as a corrective for social imbalance.

Before beginning this course, you should have the prerequisites of:

None.

MECHANICS II

Strength Of Material

The purpose of this course is to assist the student in learning the basic concepts of the physical properties and limitations of materials and mechanical equipment specified for wastewater systems and to analyze causes of failure, rapid wear, and abnormal maintenance costs.

When you complete this course, you should be able to:

1. Define the following terms:

   a. Stress

   b. Strain

   c. Torsion

   d. Ductility

   e. Hardness

   f. Impact

   g. Endurance limit

   h. Creep rate

   i. Elasticity

   j. Modules of elasticity

   k. Resilience

   l. Toughness

   m. Moment of inertia

2. Given a structure, its dimensions, characteristics, and loading determine the following:

a. Unit shearing stress

b. Average unit bearing stress

c. Maximum average unit stress

d. Average unit compressive stress

e. Unit tensile stress

f. Unit elongation

g. Total elongation

3. Determine the combined stress and maximum deflection of a given structure with information given such as dimension, type material, characteristics of material, and other needed information.

4. Describe how you would determine the following characteristics of an impact loading and what information is needed to determine them:

   a. Maximum deflection

   b. Maximum stress (bending)

   c. Maximum torsional shearing stress

   d. Total angle of twist due to impact of load

5. Explain or describe in detail what effect on the strength of a given material certain conditions have such as repeated loading, temperature, and atmospheric conditions.

Before beginning this course, you should have the prerequisites of:

1. Mechanics I

2. Math V

CHEMISTRY III

Sanitary Chemistry

The purpose of this course is to assist the student in learning those aspects of chemistry which are pertinent to water quality control practice and to lay a groundwork in the area of specialized quantitative analysis that will serve the student as a basis in all phases of water quality control.

When you complete this course, you should be able to:

1. Perform in an actual situation the indicated analyses for: settleable matter, volatile solids, suspended solids, pH, dissolved oxygen, biochemical oxygen demand, chlorine, temperature, and coliforms.

2. Describe or demonstrate, when applicable and possible, the safety procedures to be followed when doing the analysis listed in one above. Include how these procedures protect the employee.

3. Name and describe the available reference materials which are pertinent to the listed analyses.

Before beginning this course, you should have the prerequisites of:

1. Physics II

2. Summer Work II

3. Biology II

4. Chemistry II

ECONOMICS II

Accounting and Management

The purpose of this course is to assist the student in learning the uniform system of accounting endorsed by the National Association of Regulatory Commissions for investor owned utilities, American Society of Civil Engineers, Water Pollution Control Federation and the American Water Works Association as well as general accounting and managerial practices.

When you complete this course, you should be able to:

1. Identify the accounting guidelines of the regulatory and professional societies.

2. Describe the uniform system of accounting as recognized by the regulatory and professional societies and develop cost estimates, budgets, billings, rate charges, capital expenditures and maintenance as operation cost.

3. Prepare estimates for feasibility reports, planning, financing, construction, maintenance and operation of wastewater collection and treatment systems.

4. Identify legal, administrative and other costs necessary in determing the probable cost of a project.

Before beginning this course, you should have the prerequisites of:

1. Economics I

DESIGN I

Structures

The purpose of this course is to assist the student in learning the aspects of structural design so that he can determine the type design and material to use for given loadings. The study will include analysis of loadings on walls, footings, beams, and other structures while using design specification handbooks, tables, graphs, and building codes in determining the correct design for good engineering work.

When you complete this course, you should be able to:

1. Define the following:

   a. Laterial support

   b. Shear

   c. Buckling

   d. Flexure formula

   e. Effective length

   f. Factor of safety

2. List at least 4 advantages and 2 disadvantages of using steel as a structural material.

3. Given the loading, allowable stress, length, and other characteristics, select the member (such as select a WF shape) that is needed using the AISC or other design specifications.

4. Given a certain beam, with dimensions, reinforced with a certain number of sized bars, concrete strength, tensile strength, yield point of steel, and

stress strain curves, determine the stresses caused by a certain bending moment.

5. Given the length, load, characteristics of concrete and steel, design the beam including the spacing, size and number of steel bars.

6. Given the proper information, design a beam by:

   a. Ultimate strength design

   b. Working stress design

7. Design one-way slab given the proper information and using U.S.D. methods following the provisions of the ACI code.

8. List the steps in designing:

   a. Shoring

   b. Walls

   c. Beams

   d. Footings

9. Given a truss and the loadings on the truss, determine any unknown force component in any member of the truss.

Before beginning this course, you should have the prerequisites of:

1. Mechanics II

SURVEYING II

Advanced Surveying

The purpose of this course is to assist the student in learning the techniques of surveying so that he can perform successfully the duties of any member of a surveying team both in the field and in the office.

When you complete this course, you should be able to:

1. Demonstrate how to operate a transit and level.

2. Demonstrate how to determine and compute, sketches and computations, elementary triangulation and traverses.

3. Demonstrate the proper techniques for surveying and computing property lines and topographic surveys.

4. Demonstrate the proper techniques for carrying out a construction survey, including setting a predetermined angle, marking elevations, batter boards, double centering, bucking over a hill, right angle offset leveling, and random traverse.

5. Demonstrate the proper techniques for determining rights-of-way and property descriptions.

Before beginning this course, you should have the prerequisites of:

1. Surveying I

2. Math V

HYDRAULICS

Fluid Flow

The purpose of this course is to assist the student in learning the basic concepts of the flow of water and wastewater through pipes and channels, the use of pumps, and the effect of pressure exerted by water in a constructive or destructive fashion.

When you complete this course, you should be able to:

1. Using the hydraulic-elements graphs determine the size and slope of a gravity sewer given the type material of pipe, type fluid, and the quantity of flow.

2. Given the quantity of flow, type of flow, and type of pipe material, determine the sizes of pump suction and discharge piping.

3. Describe the method of compiling pipe loss data and plotting the system curves.

4. Determine the head that a flow be delivered against if the desired pump flow is 200 gpm and the pump characteristics are given on a pump characteristic curve.

5. Given the physical dimensions of a channel and the velocity of flow desired, compute the carrying capacity.

6. Using the weir formulas for a given shape weir, and data such as length, discharge, weir factor, and water height behind the weir, determine the height of the weir.

7. Determine the size of a given shaped weir, using any weir formula, given the head and discharge.

8. Given the instrument formula for measurement and the data obtained from observation, determine the size of the measuring device.

9. Given the head and discharge, compute the length of a certain shaped weir, using the appropriate weir formula.

Before beginning this course, you should have the prerequisites of:

1. Math III

2. Physics II

BIOLOGY III

Sanitary Microbiology

The purpose of this course is to assist the student in learning to identify and classify the microbiological plants and animals in the various stages of treatment works. The student will be able to calculate oxygen depletion; reaeration and oxygen sag; describe, explain, and compare microbiological properties of trickling filter, activated sludge, digestion, stabilization lagoons and determine the cause and effect of biological, chemical, and physical parameters of wastewater units on the environment.

When you complete this course, you should be able to:

1. Describe the three environmental factors which are important in activated sludge systems.

2. Describe the theory of operation of:

   a. Trickling filters

   b. Activated sludge

   c. Stabilization lagoons

   d. Digestion

3. Using the equation for oxygen sag, determine the oxygen sag of a free flowing river or theoretical situation.

4. Determine the effects of industrial waste from a local industry on the water supply of the community. Include estimates of strength and volume of waste, periods of flow, and the composition of the waste.

5. Sample and identify microbes from the following:

   a. Trickling filters

   b. Activated sludge

   c. Stabilization lagoons

Before beginning this course, you should have the prerequisites of:

1. Biology II
2. Summer Work II
3. Chemistry III

SUMMER WORK III

Consulting Engineering Design Firm

The purpose of this course is to assist the student in learning the procedure for determining the appropriate process unit(s) for treating a wastewater to meet given criteria; for developing flow charts to treat wastewater of given characteristics; for selecting process equipment to meet treatment requirements; for determining if proposed treatment schemes meet regulatory requirements; and the procedures for dealing with clients in the design of a wastewater facility.

When you complete this course, you should be able to:

1. Demonstrate the procedure to determine the appropriate process unit applicable for a given criteria. The procedure should include:

   a. Reference materials (standards, regulations, design manuals, computer programs)

   b. Calculations

   c. Interpretation

2. Draw flow charts to treat wastewaters of given characteristics. The flow charts should include:

   a. Name of process unit

   b. Direction of flow

   c. Recycling arrangements

   d. Probable reductions in wastewater characters in each unit process.

3. Design process units for given treatment requirements. The design procedure should include:

   a. Reference materials (design manuals, equipment manufactures manuals, tables, charts, computer programs, etc.)

   b. Calculations

   c. Sizing requirements

   d. Placement requirements

   e. Operation and maintenance requirements

   f. Cost requirements

   g. Reliability requirements

   h. Standby requirements

4. The procedure to determine if proposed treatment schemes meet regulatory requirements. The procedure should include:

   a. Reference materials (standards, regulations, design manuals, equipment manufactures manuals, computers, tables, charts, programs, etc.).

   b. Calculations

   c. Comparisons

d. Criteria for acceptance or rejection

5. The procedure for dealing with clients in the design of wastewater facilities. The procedure should include:

   a. Required background on client

      (1) Financial status

      (2) Legal status

      (3) Technical competance

   b. Information needed for meetings

      (1) Technical

      (2) Financial

      (3) Public relations

   c. Conduct of meetings

   d. Follow up of meetings

Before beginning this course, you should have the prerequisites of:

1. Summer Work II
2. Economics II
3. English III
4. Hydraulics
5. Design I
6. Biology III

GOVERNMENT SYSTEMS I

Government Interactions

The purpose of this course is to assist the student in learning the local state and Federal agencies involved in planning regulating and enforcing environmental requirements and performance on national, state or local levels.

When you complete this course, you should be able to:

1. Draw organizational charts illustrating the relationship of the Federal, state, and local governmental agencies and describe the function of each government unit, using as your starting point the Executive Branch of the Federal Government. Include the following types of organizations:

   a. Public utility

   b. Private utility

   c. Commission management

   d. City administration

   e. County administration

   f. Council of governments

   g. State administration

2. Describe the Water Quality Control Act of 1972 (Public Law 660), the agencies initiated due to this act, the responsibilities delegated, the amount of funding, the ramifications on government, industry and the public, and its effect on local and state laws.

3. Describe the procedures you would follow in applying for a permit to construct and operate a pollution abatement facility and name the specific office the permit request would be sent to.

4. Describe the role of the Judicial Branch under the Water Quality Control Act of 1972. Also cite five Judicial decisions which have had a major affect on the environmental programs and the public.

Before beginning this course, you should have the prerequisites of:

None

CONSTRUCTION

Construction Methods

The purpose of this course is to assist the student in learning the procedures to follow in the inspection of materials and construction; verifying that construction is done in accordance with plans and specifications and that building codes are met. The student also will learn to take specimens and make analyses of constructing materials; gather data and make calculations for cost estimates, ordering materials, and scheduling of work.

When you complete this course, you should be able to: [For selected combinations of process units (i.e. primary plant, trickling filter, activated sludge, advanced waste treatment, etc.)]

1. Perform the procedures for determining if construction materials meet specifications. The following materials should be included:
   a. Earth
   b. Concrete
   c. Steel
   d. Wood
   e. Paint and other protective coatings
   f. Plastic
   g. Aggregate
   h. Pipe
   i. Mechanical equipment
   j. Electrical equipment
   k. Control equipment
2. Perform the procedures for determining if construction has been done according to plans, specifications, and codes. The following procedures should be included:
   a. Excavation
   b. Dewatering
   c. Form construction
   d. Placing concrete, block, brick
   e. Placing reinforcing
   f. Welding, brazing, bolting, riveting
   g. Installation of
      (1) Mechanical equipment
      (2) Electrical equipment
      (3) Control equipment
   h. Painting
   i. Landscaping
   j. Paving
   k. Heating and ventilation
   l. Lighting
3. Perform the sampling procedures and analyses for materials. This should include:
   a. Construction materials
   b. Earth Compaction
   c. Concrete
   d. Asphalt

4. Select appropriate data and using calculations, tables, figures, and computer programming techniques generator information required for.

    a. Cost estimates

    b. Ordering material

    c. Scheduling work

Before beginning this course, you should have the prerequisites of:

1. Summer Work III
2. Concurrent registration in Design II
3. Surveying II

DESIGN II

Wastewater Treatment Plant Design I

The purpose of this course is to assist the student in learning the methods of selecting the appropriate unit process(es) to treat a given waste to meet known criteria. The procedures for developing flow charts to treat wastewater of given characteristics and the procedures for selecting process equipment to meet treatment requirements will also be studied.

When you complete this course, you should be able to: (For each process unit and selected combinations.)

1. Select the appropriate process unit (see Appendix A) applicable for a given criteria. The selection procedure will include:

    a. Reference materials (standards, regulations, design manuals, computer programs)

    b. Calculations

    c. Drawings

2. Draw flow charts to treat wastewaters of given characteristics. The flow charts should include:

    a. Name of process unit

    b. Direction of flow

    c. Recycling arrangments

    d. Probable reductions in wastewater characteristics in each process unit

3. Design process units for given treatment requirements. The design procedure should include:

    a. Reference materials (design manuals, equipment manufactures manuals, tables, charts, computer programs, etc.).

    b. Calculations

    c. Sizing requirements

    d. Placement requirements

    e. Operation and maintenance requirements

    f. Cost requirements

    g. Reliability requirements

    h. Standby requirements

Before beginning this course, you should have the prerequisites of:

1. Design I
2. Summer Work III
3. Concurrent registration in Construction

GOVERNMENT SYSTEMS II

Public Financing

The purpose of this course is to assist the student in learning the sources of funds for financing water pollution control projects including planning, programming, and financing aspects.

When you complete this course, you should be able to:

1. Describe in essay form the sources of funds for water pollution control projects. Include the following sources:
   a. Private
   b. Local agencies
   c. State agencies
   d. Federal agencies
   e. Bonds
2. Describe in essay form, using diagrams and flow charts the procedure for obtaining funds for financing water pollution control projects for the following phases of a project:
   a. Planning
   b. Preliminary design
   c. Final design
   d. Construction
   e. Operation
   f. Research
   g. Demonstration

Before beginning this course, you should have the prerequisites of:

1. Government Systems I
2. Economics II

DESIGN III

Wastewater Treatment Plant Design II

The purpose of this course is to assist the student in learning the methods of design of wastewater treatment plants utilizing computer methods, evaluating treatment schemes to meet regulatory requirements, and make cost estimates of treatment alternatives.

When you complete this course, you should be able to: [For selected combinations of process units (i.e. primary plant, trickling filter, activated sludge, advanced waste treatment, etc.)]

1. Design process units for given treatment requirements. The design procedure should include:
   a. Reference materials (design manuals, equipment manufactures manuals, tables, charts, computer programs, etc.)
   b. Calculations
   c. Sizing requirements
   d. Placement requirements
   e. Operation and maintenance requirements
   f. Cost requirements
   g. Reliability requirements
   h. Standby requirements
2. The procedure to determine if proposed treatment schemes meet regulatory requirements. The procedure should include:

a. Reference materials (standards, regulations, design manuals, equipment manufactures manuals, computers, tables, charts, programs, etc.)

b. Calculations

c. Comparisons

d. Criteria for acceptance or rejection

3. Make calculations for cost of construction, operation and maintenance of wastewater treatment plants.

Before beginning this course, you should have the prerequisites of:

1. Design II

OPERATIONS III

Wastewater Treatment Facility Operational Evaluation

The purpose of this course is to assist the student in learning the procedures for recognizing operational problems and the control actions to be taken to correct the problem. He will base solutions on standards, plant operational capabilities, cost and public relations.

When you complete this course, you should be able to: [For selected combinations of process units (i.e. primary plant, trickling filter, activated sludge, advanced waste treatment, etc.)]

1. Recognize operational problems, either simulated or in an actual plant situation. The problems should include:

   a. Flow

   b. Characteristics of wastewater or effluent from any unit process(es)

   c. Power

   d. Safety

   e. Public relations

   f. Personnel

   g. Political

   h. Financial

   i. Planning

   j. Disaster

   k. Professional development

   l. Staffing

   m. Training

2. Suggest alternative solutions to operational problems (listed under 1 above) and actually (simulated or in reality) carry out the required action.

Before beginning this course, you should have the prerequisites of:

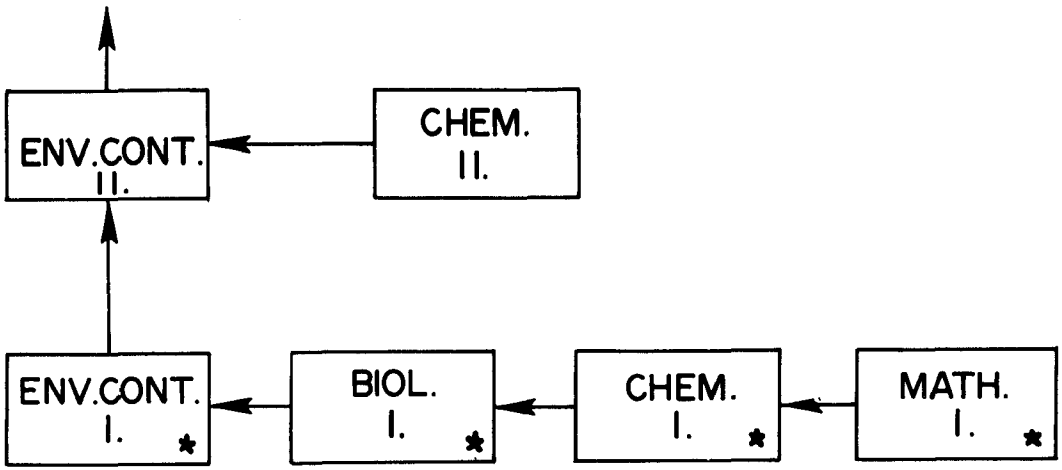
1. Operations II

2. Summer Work III

3. Design III

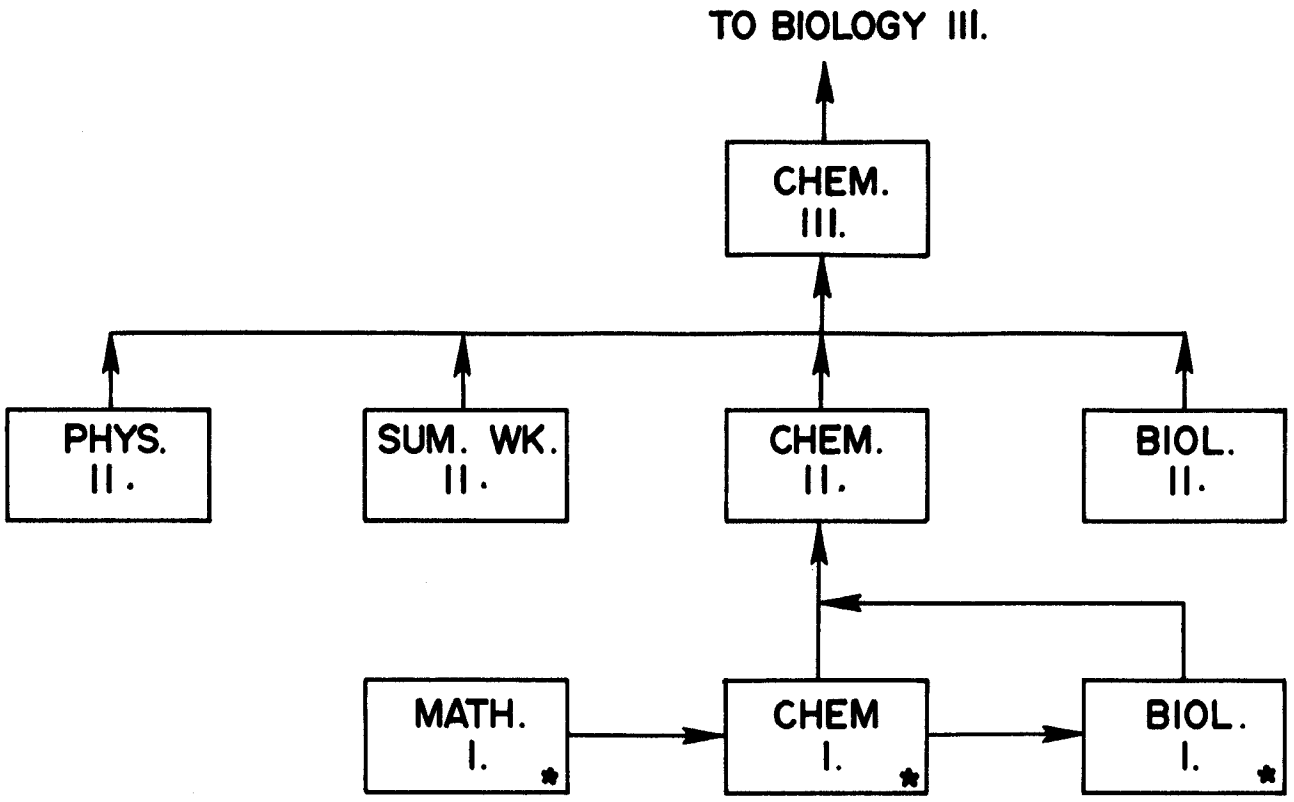
4. Government Systems II

FIGURE 2. COURSES IN THE ENVIRONMENTAL CONTROL SEQUENCE.



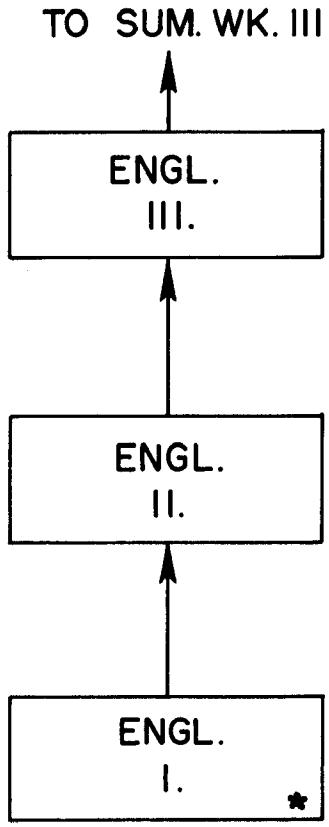
*Possible starting point for trainee.

FIGURE 3. COURSES IN THE CHEMISTRY SEQUENCE



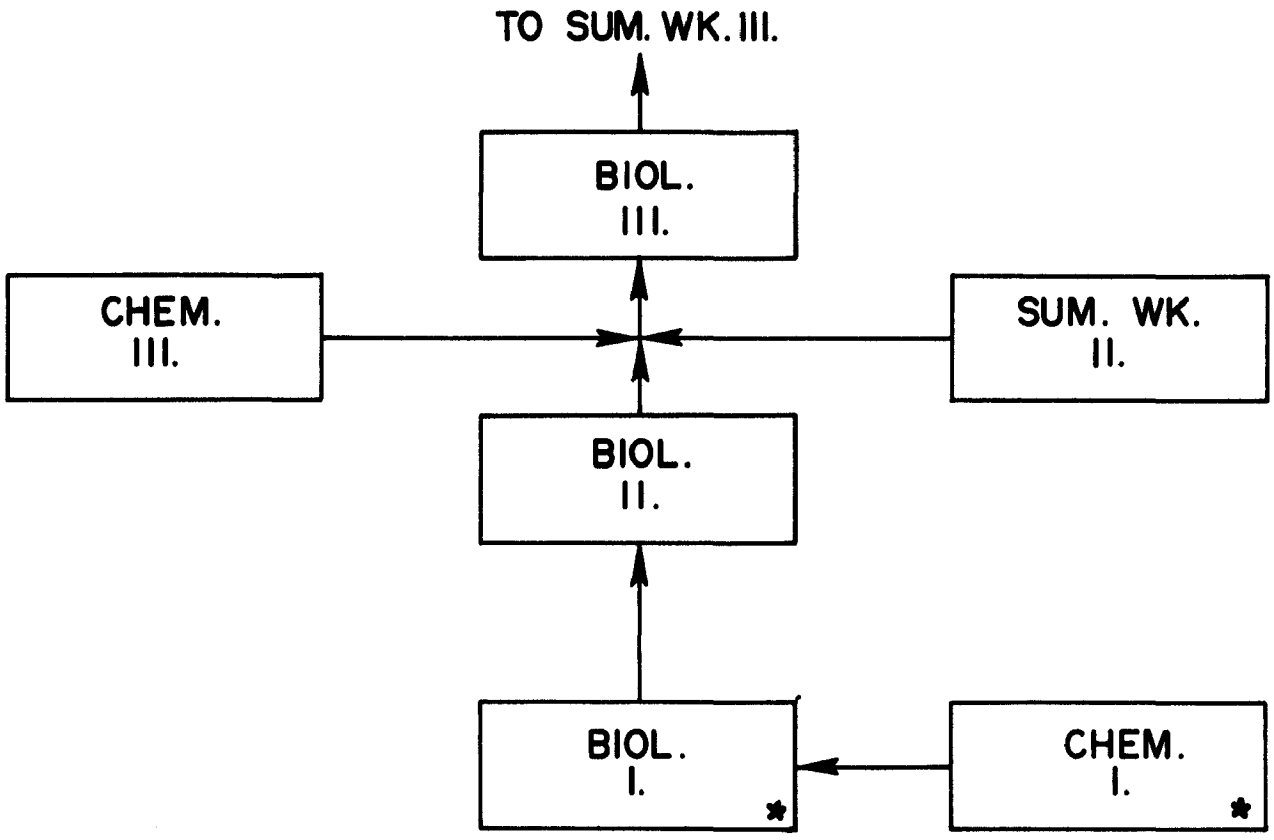
*Possible starting point for trainee.

FIGURE 4. COURSES IN THE ENGLISH SEQUENCE



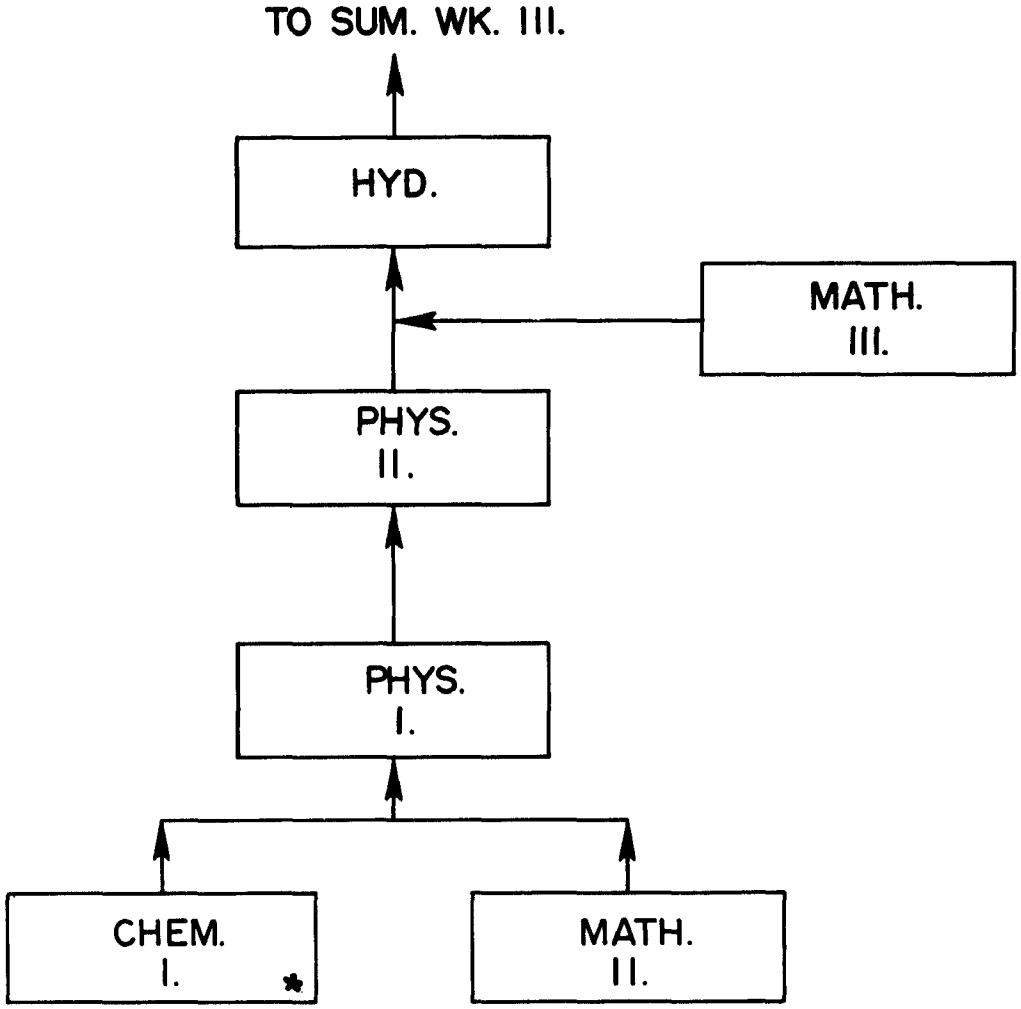
*Possible starting point for trainee.

FIGURE 5. COURSES IN THE BIOLOGY SEQUENCE.



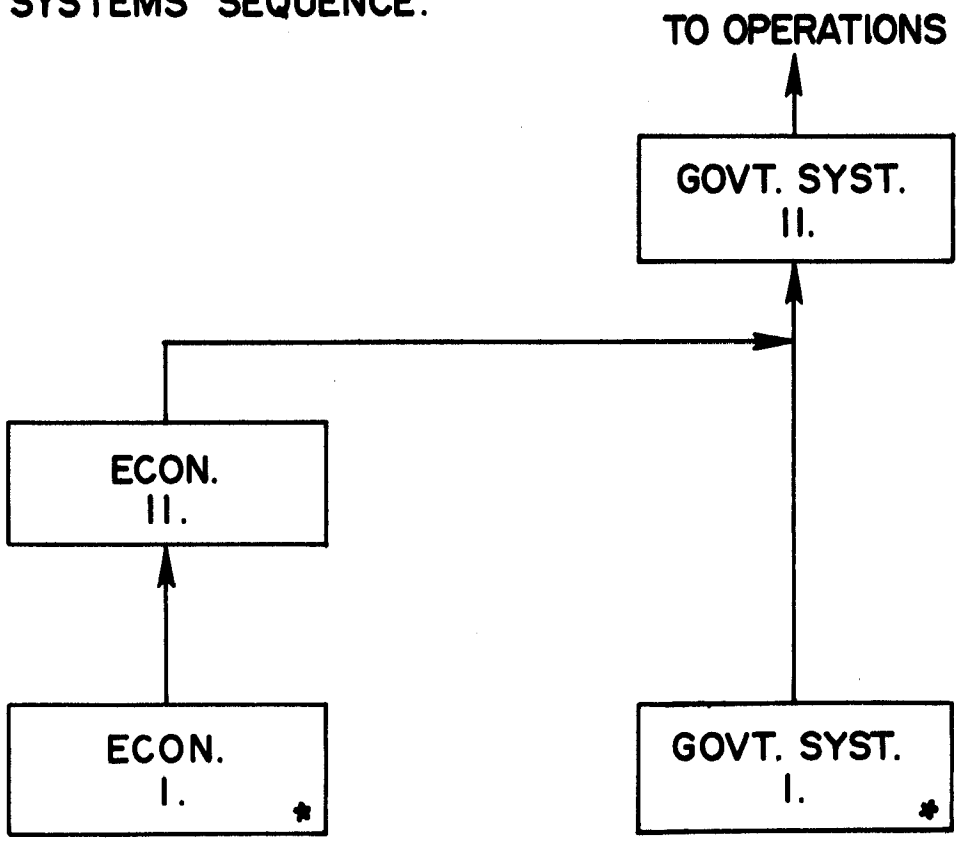
*Possible starting point for trainee.

FIGURE 6 · COURSES IN THE PHYSICS SEQUENCE.



*Possible starting point for trainee.

FIGURE 7. COURSES IN THE ECONOMICS AND GOVERNMENT SYSTEMS SEQUENCE.



*Possible starting point for trainee.

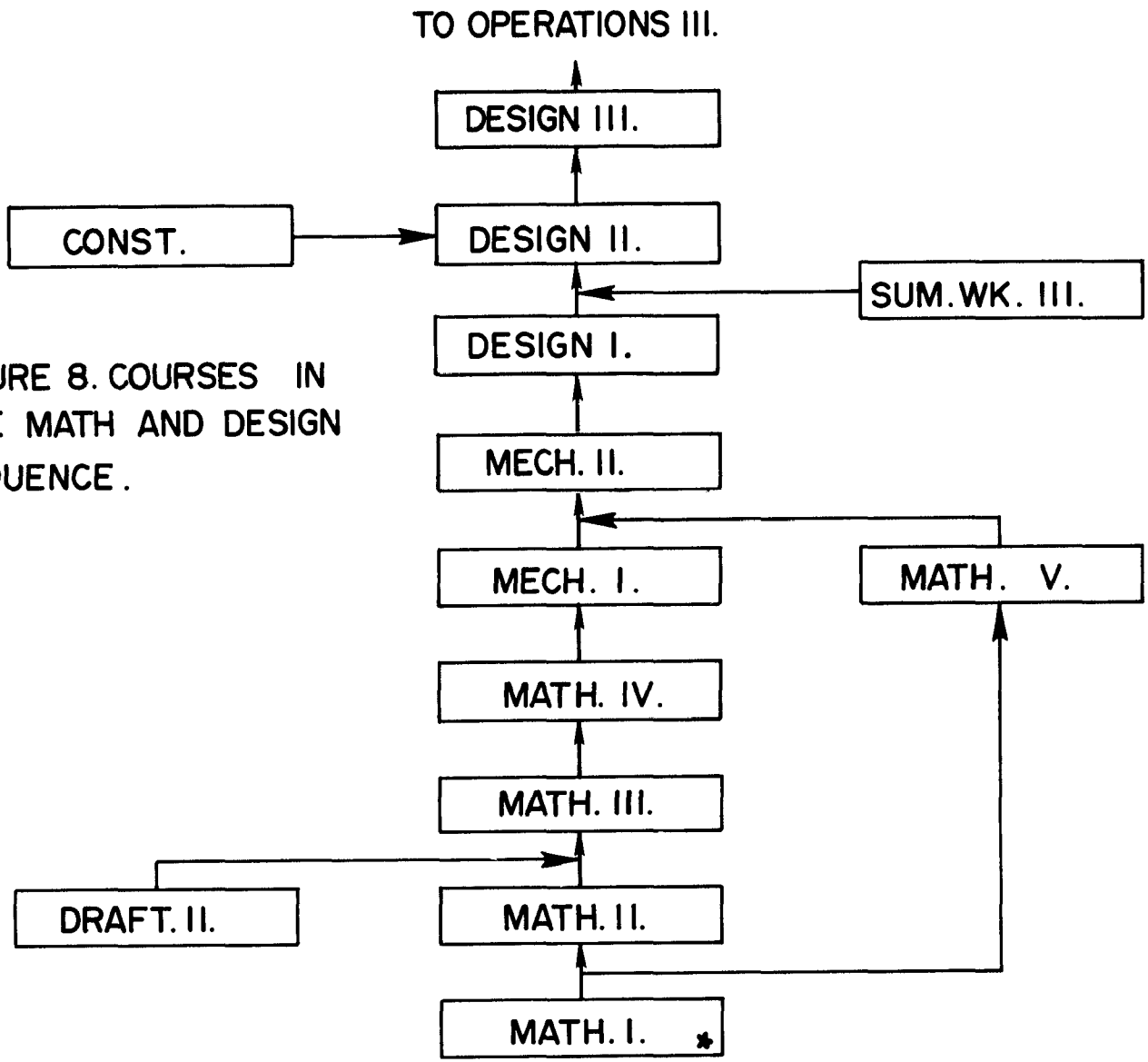
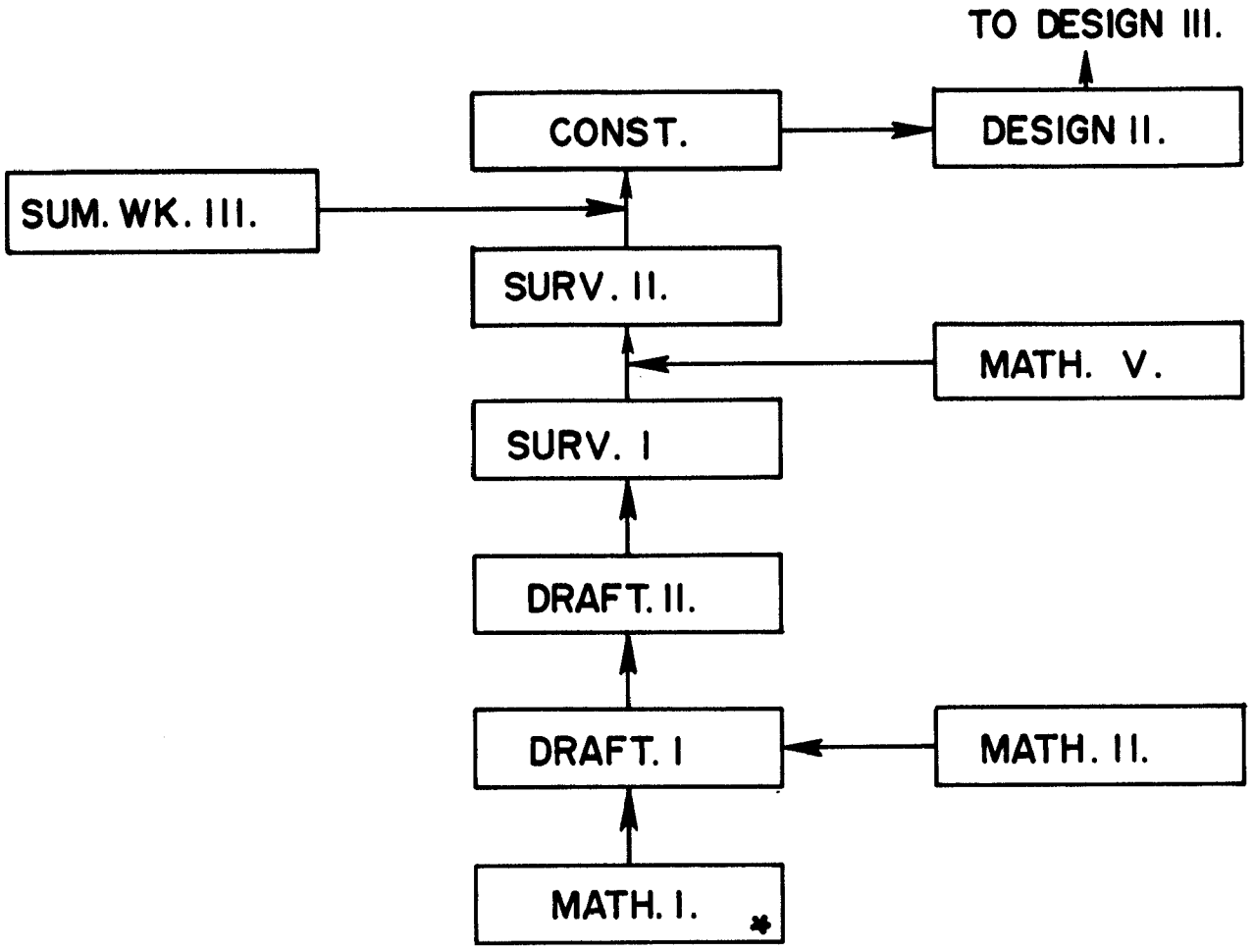


FIGURE 8. COURSES IN THE MATH AND DESIGN SEQUENCE.

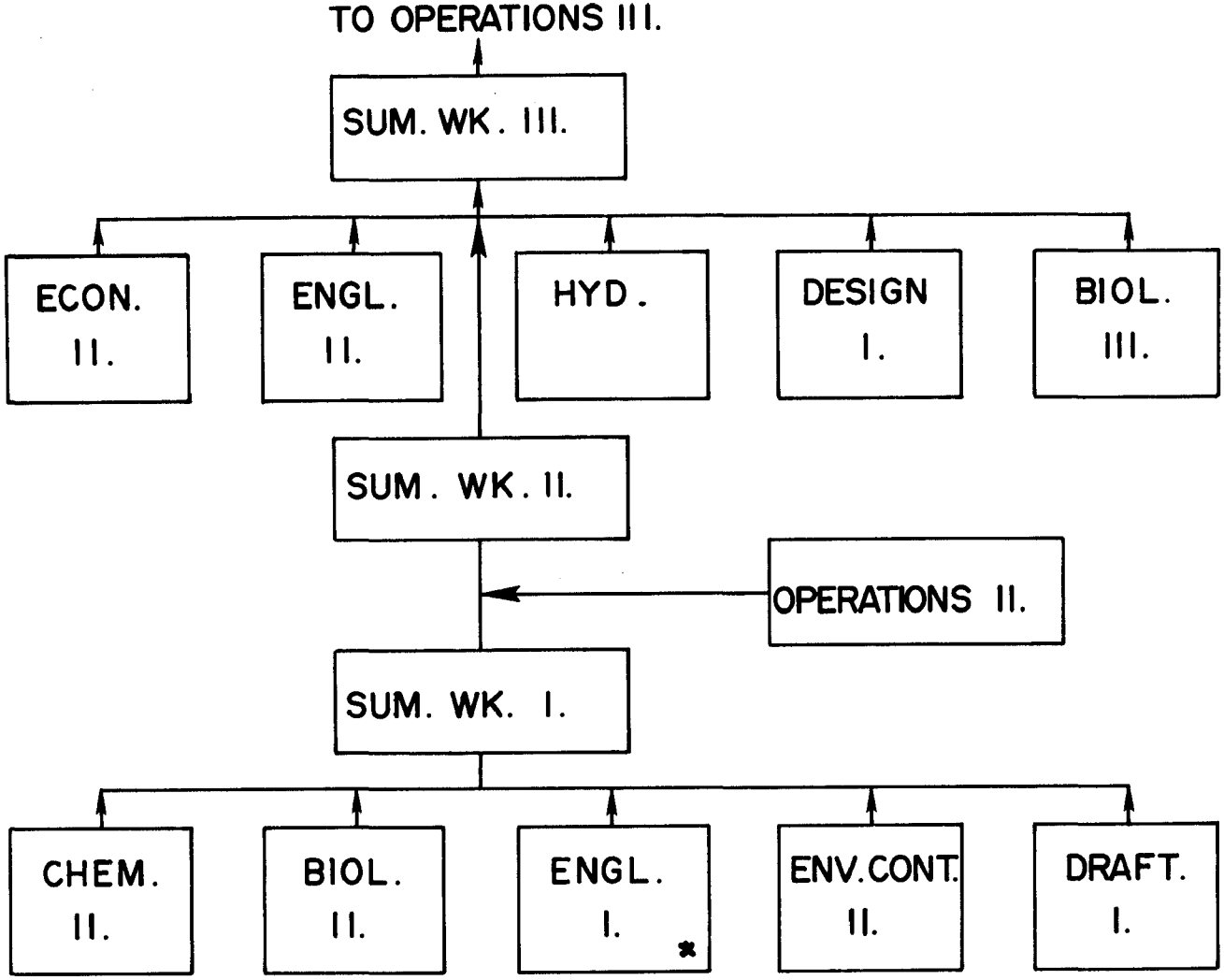
*Possible starting point for trainee.

FIGURE 9. COURSES IN THE DRAFTING, SURVEYING AND CONSTRUCTION SEQUENCE.



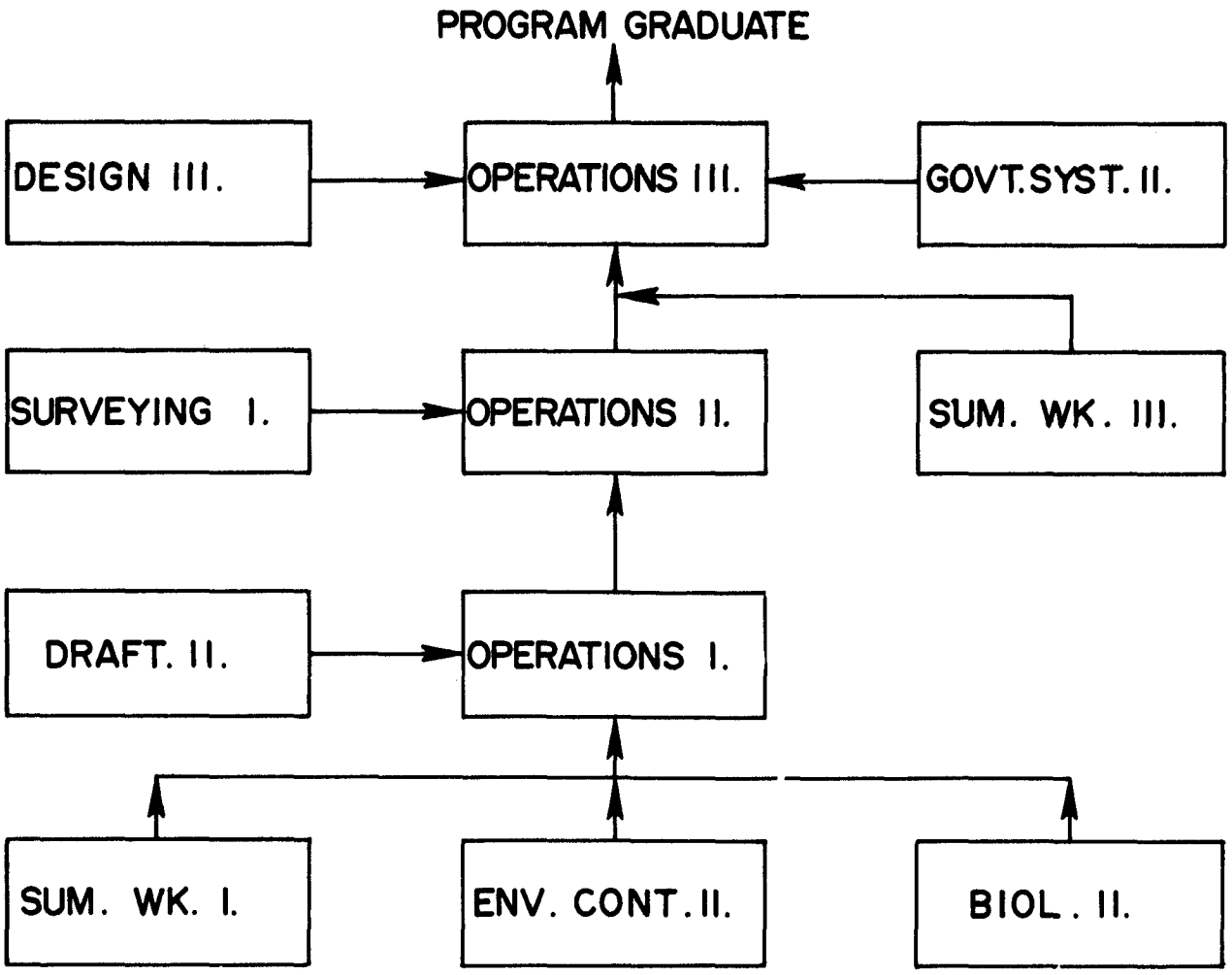
*Possible starting point for trainee.

FIGURE 10. COURSES IN THE SUMMER WORK SEQUENCE



*Possible starting point for trainee.

FIGURE 11. COURSES IN THE OPERATIONS SEQUENCE.



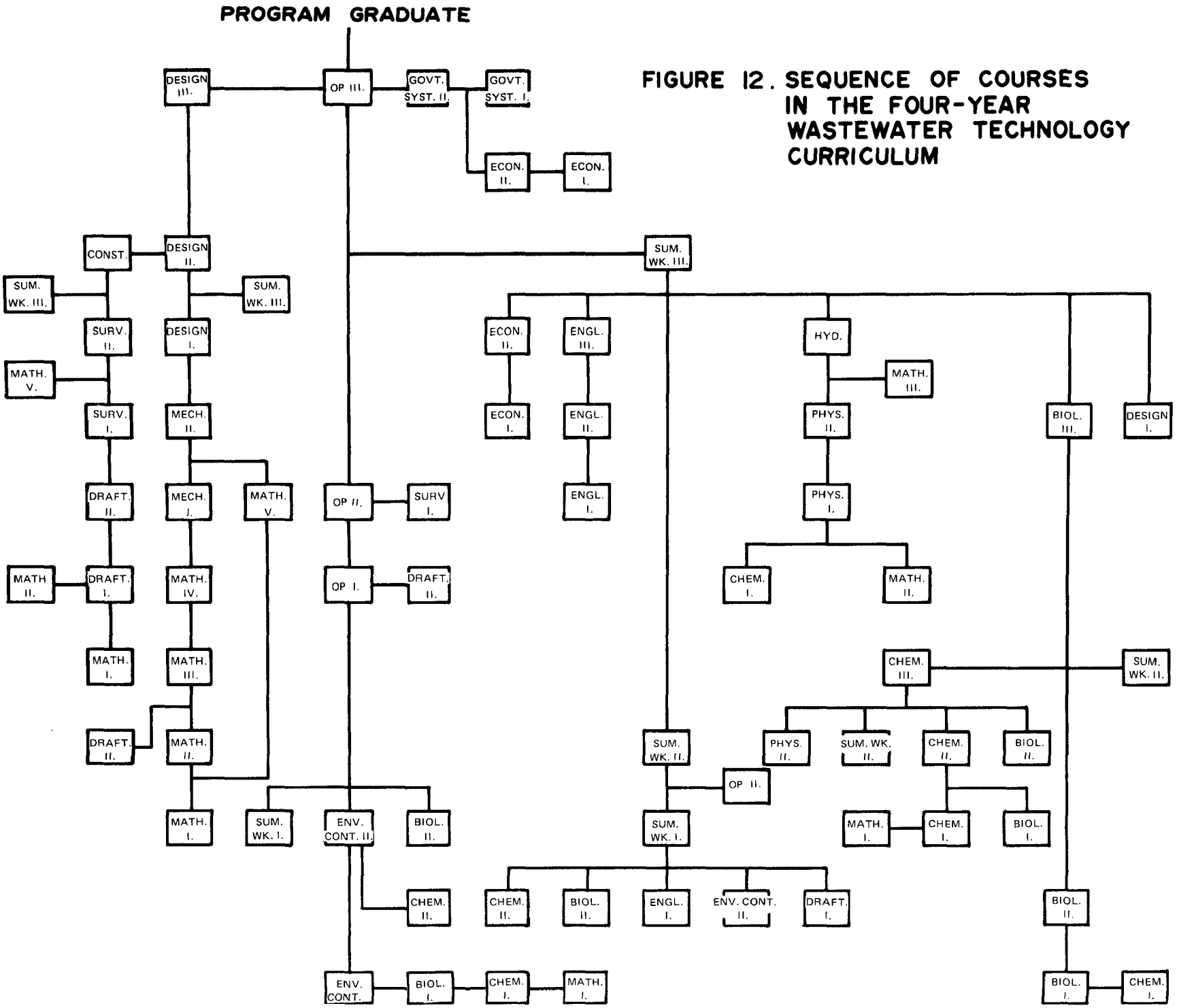


FIGURE 12. SEQUENCE OF COURSES IN THE FOUR-YEAR WASTEWATER TECHNOLOGY CURRICULUM

Appendix 3

CURRICULA AND INSTRUCTIONAL MATERIALS AVAILABLE

TABLE III

MATERIALS UNDER DEVELOPMENT FOR LABORATORY PROCEDURES*

The Microscope Wet Mount
How to Mix Hand Mixing
Use of a Septic Technique in the Tube Transfer of Bacteria
How to Use a Common Laboratory Spectrophotometer
How to Weigh to Less than 0.1 Gram Using a Single-Pan Analytical Balance
How to Use Automatic Pipettors
How to Make Serial Dilutions

*John Olive, Project BIOTECH, American Institute of Biological Sciences, 3900 Wisconsin Avenue NW, Washington, DC, 20016.

TABLE IV

MATERIALS UNDER DEVELOPMENT FOR CIVIL ENGINEERING TECHNOLOGY CURRICULUM*

Contracts and Specifications
Cost Estimating
Hydraulics
Reinforced Concrete Design
Soil Mechanics
Highway Design and Construction
Statics
Strength of Materials
Surveying I
Surveying II
Water and Sewerage Systems

*Kent Sharples, Project CIVTEC, State Board of Technical and Comprehensive Education, 1429 Senate Street, Columbia, SC 29201.

TABLE V

MATERIALS UNDER DEVELOPMENT ON STANDARD FIELD OPERATING PROCEDURES*

Measurement of Flow in an Open Channel by Sharp-Crested Weir and Vertical Staff Gage
Settleable Solids
pH Determination of Wastewater and Wastewater Treatment Plant Effluents
Collecting and Handling of Bacteriological Samples from a Wastewater Treatment Facility
Winkler Determination of Dissolved Oxygen - Azide Modification
Fecal Coliform Test by the Multiple Dilution Tube Method
Total Coliform Test by the Multiple Dilution Tube Method

*Harold Jeter, Director, Standard Field Operating Procedures, Water Program Operations, Manpower Development Staff, National Training Center, EPA, Cincinnati, OH 45268.

TABLE VI

MATERIALS UNDER DEVELOPMENT FOR TECH PHYSICS PROJECT**

* 1. The Analytical Balance (Measurement, errors, and mechanical equilibrium) /0/
* 2. Automobile Collisions (Momentum and energy) /0/
3. THE AUTOMOBILE IGNITION SYSTEM (Electricity and magnetism) /0/
4. THE BINOCULARS (Waves and optics) /6/
* 5. Californium 252 (Nuclear physics) /11,12/
6. The Camera (Optics and photographic measurements) /0/
7. THE CATHODE RAY TUBE (Electric fields and forces) /0/
* 8. The Cloud Chamber (Detection of radiation and phase changes) /0/
* 9. The Electric Eye Control (Modern optics and photometry) /0/
*10. The Electric Fan (Rotational motion) /37/
11. The Gamma-Ray Spectrometer (Gamma rays and matter) /0/
12. THE GEIGER COUNTER (Electrostatics and the detection of radioactivity) /0/
*13. The Guitar (Wave motion and sound) /0/
*14. Hydraulic Devices (Hydraulics and equilibrium) /0/
15. THE INCANDESCENT LAMP (Thermodynamics, current electricity and photometry) /0/
16. THE IONIZATION CHAMBER (Electrostatics and the detection of radioactivity) /0/
*17. Laser Light (Modern optics and quantum mechanics) /0/
*18. The Loudspeaker (Sound) /0/
*19. The Management of Nuclear Data (Measurement and error) /0/
20. The Metal Detector (Electromagnetism) /36/
*21. Meter Movements (Equilibrium and electromagnetism) /0/
*22. Motors and Generators (Energy conservation and electromagnetism) /21/
*23. The Multimeter (Current electricity) /0/
*24. Photo-Detectors (The interaction of light and matter) /15/
25. The Pile Driver (Kinematics, work and energy transformations) /0/
26. THE POWER TRANSISTOR (Heat transfer) /0/
27. THE PRESSURE COOKER (Thermal properties of matter) /0/
28. THE SOLENOID (Magnetism) /0/
29. The Spectrophotometer, Part I (Geometrical and physical optics) /0/
30. THE SPECTROPHOTOMETER, Part II (Light) /29/
*31. The Strip-Chart Recorder (Mechanical oscillations and resonance) /37/
32. THE STROBOSCOPE (Kinematics) /0/
*33. The Thermostatically Controlled Heating System (Heat transfer, heat measurement and thermal properties of matter) /0/

TABLE VI
(Continued)

34. THE TOASTER (Heat and energy transformations) /0/
35. The Torque Wrench (Strains and Torques) /0/
36. The Transformer (Magnetic properties of matter and alternating currents) /0/
37. Device still to be decided. (Linear kinematics and dynamics) /0/
38. The Fluorescent Lamp (Atomic physics) /0/

Titles in ALL CAPITALS are modules which are essentially complete and ready for classroom use.

*Are ready for classroom trials.

/0/ after a title indicates that it required no prerequisite module.

/6/ after a title indicates that module number 6 is prerequisite.

**Philip DiLavore, Project Coordinator, TECH Physics Project, American Institute of Physics, Indiana State University, Terre Haute, IN 47804.

TABLE VII

MATERIALS AVAILABLE FOR WASTEWATER TECHNICIAN CURRICULUM (CEWT)*

Volume II: Curriculum Guidelines, Criteria for the Establishment and Maintenance of Two-Year Post High School Wastewater Technology Training Programs.
Trainee Workbooks, Criteria for the Establishment and Maintenance of Two-Year Post High School Wastewater Technology Training Programs.
Program Implementation Procedures, Criteria for the Establishment and Maintenance of Two Year Post High School Wastewater Technology Training Programs.

*Bernard Lukco, Wastewater Technician Training (CEWT), Manpower Training Branch, Office of Water Program Operations, EPA, Washington, DC 20460.

TABLE VIII

MATERIALS AVAILABLE ON PREPROFESSIONAL INDIVIDUALLY PACED INSTRUCTION (PIPI)*

Communications
General Chemistry
Physics
College Algebra/Trigonometry
Calculus

*Kenneth A. McCollom, Associate Dean, Preprofessional Individually Paced Instruction (PIPI), College of Engineering, Oklahoma State University, Stillwater, OK 74074.

TABLE IX

MATERIALS UNDER DEVELOPMENT FOR WASTEWATER PLANT OPERATING PROCEDURES*

Screening and Grinding
Grit Removal Pump Station
Primary Sedimentation
Activated Sludge (Aeration and Sedimentation)
Trickling Filter
Chemical Treatment
Filtration
Chlorination-Dechlorination
Sludge Thickening
Digestion/Gas Utilization
Sludge Conditioning/Dewatering
Solids Disposal (Land fill, Incineration)
Advanced Wastewater Treatment
Support Unit Operations and System (Flow Measurement, Pumping and Piping, Electric Power)
Laboratory Analysis
Maintenance
Safety
Management/Supervision Training
Administration/Staffing/Personnel
Office Resources Control/Raw Materials/Equipment/Parts

*Carl M. Schwing, Chairman, Pollution Abatement Technology Department, Charles County Community College, La Plata, MD 20646