

THE PURPOSE OF THE UNDERGRADUATE LABORATORY  
THE APPROACH AT THE OHIO STATE UNIVERSITY

By  
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I. INTRODUCTION

This paper gives the philosophy, objectives, and approach to undergraduate chemical engineering laboratory work at Ohio State University.

The prerequisites of the undergraduate laboratory courses are the lecture-recitation courses in chemistry, mathematics, physics, chemical engineering process principles and graphics, the transport properties, unit operations, chemical engineering thermodynamics, kinetics, economy, and processes. The curriculum in chemical engineering is given in Appendix I of this paper.

The curriculum is five years plus one half quarter between the fourth and fifth year. For the first two years all engineering students follow the curriculum of the Pre-Engineering Division and then petition to be admitted to the Professional Division.

The Philosophy and Objectives of the Chemical Engineering Professional Program

1. What is Chemical Engineering?

Chemical Engineering is the application of the principles of the physical sciences, together with principles of economics and human relations to fields that pertain directly to processes and process equipment in which matter is treated to effect a change in state, energy, content, or composition. These processes may usually be involved into a coordinated series of unit physical operations and chemical processes.

The work of the chemical engineer is concerned primarily with research, development, design, construction, sales, and production or operation of equipment and plants in which these unit operations and processes are applied. Chemistry, physics and mathematics are the underlying sciences of chemical engineering, and economics is its guide in practice.

The six technical fundamentals are: (1) the material balance, (2) the energy balance, (3) static chemical equilibria, (4) kinetics, (5) rates of transfer and transformation of fluids, mass, and energy, and (6) the economic balance.

2. How the Philosophy and Objectives Are Met

The professional program is so designed to meet these objectives as follows:

(1) Maintaining its strong and traditional foundation of the basic science of chemistry. The latter is so interwoven which results in a well-rounded and integrated program. The science of chemistry is not static.

(2) Expansion of the work in mathematics to meet the challenge of the advances and newer techniques in the field of chemical engineering involving fluid, heat and mass transport phenomena, kinetics, and sequences leading to unit operations and optimization of process and plant design; also, all of these integrated with computer work, a tool which is expanding at an exponential rate in the chemical industry.

(3) Increasing the emphasis on the basic fundamentals of chemical engineering science so as to educate and instruct the students so well that they can tackle totally new and different problems.

(4) Integrating mathematics, the basic and engineering sciences, and their applications with laboratory work results in well-rounded graduate chemical engineers. Appreciation of application as a part of the program is necessary, also to realize that theory is only a tool and not an end in itself.

(5) Providing sequences of work in the humanities, social and life sciences develops the whole "Educated Man."

II. THE UNDERGRADUATE LABORATORY COURSES1. Required Courses

- Ch.E. 704 - Chemical Engineering Inspection Trip - 2 credit hours, 1 week taken between the Winter and Spring Quarters, Fourth year. J. H. Koffolt, E. R. Haering.
- Ch.E. 740 - Chemical Engineering Process Control - 3 credit hours, 2 class hours and 4 hours of lab per week, Spring Quarter, fourth year. C. J. Geankoplis, G. Wilcox.
- Ch.E. 741 - Chemical Engineering Operations Laboratory - 8 credit hours, 5 weeks, 6 days per week, 8 hours per day, Summer Quarter, fifth year, J. H. Koffolt, E. R. Haering, G. Wilcox.
- Ch.E. 770 - Chemical Engineering Process Development - 4 credit hours, 12 lab hours per week, Winter Quarter, fifth year. C. E. Dryden, T. E. Corrigan, G. Wilcox, E. R. Haering.
- Ch.E. 772 - Chemical Process Design - 3 credit hours, 9 lab hours per week, Spring Quarter, fifth year. A. Syverson, E. R. Haering, G. Wilcox
- Ch.E. 791 - Special Project Problem Investigations - 5 credit hours, 15 lab hours per week, Spring Quarter, fifth year. The Staff.

2. Elective Laboratory Courses

- Ch.E. 693 - Problems in Chemical Engineering Operations - 2 to 6 credit hours, (course may be repeated), 6 to 18 lab hours per week, all quarters, fifth year. J. H. Koffolt, E. R. Haering, G. Wilcox.
- Ch.E. 763 - Applied Electrochemistry - 3 credit hours, 2 lectures and 4 hours of lab per week, Autumn Quarter, fourth or fifth year. A. Syverson, E.R. Haering.
- Ch.E. 766 - Nuclear Chemical Engineering - 4 credit hours, 3 class hours and 3 hours of lab per week, Spring Quarter, fifth year. C. E. Dryden.

3. Elective Laboratory Courses in Petroleum Engineering

Petroleum Engineering is administered by the Chemical Engineering Department. The curriculum and degree will be dropped effective the end of the Summer Quarter, August 24, 1962. However, by electives a student may take a program in petroleum production. This is also true of Nuclear Chemical Engineering. In both programs, the student receives a B.Ch.E. degree as he completes the Chemical Engineering curriculum. The elective courses in Petroleum Engineering laboratory are:

- P.E. 713 - Drilling Fluids - 3 credit hours, 1 class hour, and 6 hours of laboratory per week, Winter Quarter, fourth year. H. C. Slider, K. Shepherd.
- P.E. 723 - Physical Analysis of Petroleum Reservoirs - 2 credit hours, 1 class hour and 4 hours of laboratory per week, Winter Quarter, fifth year. H. C. Slider, K. Shepherd.
- P.E. 736 - Reservoir Engineering - Fluid Flow - 3 credit hours, 2 class hours, 3 laboratory hours per week, Winter Quarter, fifth year. H. C. Slider.

These courses with the exception of the courses in Petroleum Engineering will be discussed in detail in the paper.

III. THE SAFETY PROGRAM OF THE DEPARTMENT OF CHEMICAL ENGINEERING

Safety consciousness in Chemical Engineering laboratory work at Ohio State goes back to 1906 when Dr. James R. Withrow, the first Chairman of the Department took charge. In 1946, when the College of Engineering adopted the five-year program, a lecture-recitation course in Safety was put into the curriculum. We received many bouquets concerning the introduction of this course in our curriculum. The comments of the students were good, bad, and indifferent. It was quite common to hear a group of students say "We will now be safety conscious for the next fifty minutes."

It was the unanimous opinion of the staff that, although the objectives of such a course was ideologic and altruistic, in the final analysis it preached but did not practice safety. It produced various grades of safety-minded chemical engineering students from "A" to "D" grade. As a result, this course was dropped from the curriculum in 1952. In its place, safety was integrated in all courses possible, and especially in the laboratory courses. Safety is practiced at all times in the unit operations, instrumentation, process development, project problem, and the nuclear laboratory courses.

### 1. Organization of the Safety Program in the Chemical Engineering Laboratories

The students are given their first intensive work in safety the first day of the Chemical Engineering operations laboratory which is given during the Summer Quarter between the fourth and fifth years. By emphasizing safety and maintaining good safety practices from the very beginning of the laboratory work, the student as well as staff members will be so instilled with the sense of "Safety Consciousness" that it will carry over into their laboratory courses at the University and eventually into industry.

The safety program may be best described by giving a few details.

#### FIRST DAY OF UNIT OPERATIONS LABORATORY - MONDAY, JUNE 18, 1962

- 8:00 a.m. - Class Organization and details of the Unit Operations course.  
 9:00 a.m. - Safety in the Chemical Engineering Laboratories. The Safety Manual.  
 to Each student is given a copy of the safety manual, a pair of safety  
 11:00 a.m. glasses and a hard hat. The latter is returned at the end of the  
 course. The safety glasses are charged to the student. Those stu-  
 dents who already wear glasses may obtain prescription safety glasses  
 from our Department of Optometry at a reduced price.

The Safety Manual covers many items concerning safe practices in the laboratory, handling chemicals, toxicity, gas masks, ladders, organization of the safety committee, etc. The following are some of the details contained in the Safety Manual.

1. Safety glasses shall be worn in all laboratories and shops that are in operation.
  2. Hard hats shall be worn in the Unit Operations Laboratory when this laboratory is in operation.
  3. Under no circumstances shall Bermuda shorts be worn while working in a laboratory.
  4. If you receive an injury, no matter how slight, report it at once to your instructor, and if he is not available, to the Departmental office. There will always be someone available to get you to the University Health Center or to the hospital, if necessary.
  5. Do not work after hours unless you have a permit from the office of Special Services. This requires that a card requesting such a permit be granted by the Chairman of the Department. Working after 5:00 p.m. on Saturdays and all day Sunday is prohibited except in case of an emergency. Working after hours in laboratories and shops is prohibited unless someone else is present within calling distance.
  6. Housekeeping - Good housekeeping shall be maintained at all times. Quoting from item Unit Operations Laboratory Course Organization 15-k-Duties of Squad Foreman, good housekeeping shall be maintained at all times. This is the most important duty of the squad foreman. He will detail members of his squad to assure (by use of mop, broom, hose, and other "diver" means) that untidy working conditions such as precipitates from filter presses, oil from steam pumps on evaporator, dust from the crushers and grinders, and water and solvents on the floor from laboratory problems in distillation, heat transfer, evaporation, fluid flow, furnacing, liquid-liquid extraction, humidification, and electrolysis during the course of experimental work is cleaned up at all times. Untidy working conditions during the course of an experimental test run WILL NOT BE TOLERATED. Spillage must be cleaned up at once. Infraction of this rule will result in stopping all work until the "mess" is cleaned up. In many cases it will result in starting the particular "test run" over again. It is the responsibility of the rotating squad foreman to assign members of his squad to maintain good housekeeping conditions at all times. As most of the experimental work requires from 6 to 16 hours of time, he should plan his schedule so that every member of his squad is responsible for good housekeeping and knows how to handle the "mop" and "broom". The rotating foreman shall not handle the mop or broom. The rotating foreman is the "boss man". He does not work, he supervises."
- 11:00 a.m. - The class is organized in squads of four each. This organization is  
 to kept for the duration of the course. Each squad under the supervision  
 3:00 p.m. of an instructor spends one hour each on the items given below.

1. Inspection of Laboratories; location of all emergency utility controls, various types of fire extinguishers, gas masks, fire blankets, stretcher, master valves for gas, air, water and steam.
2. Gas Masks and Respirators - A short lecture is given on these items, their construction, and where they are to be used. Each student is required to try the various types, and test them for leaks, in order to familiarize themselves with the method and adjustment and use of the masks and respirators.
3. Explosion Meter - A brief lecture is given on explosive limits, what to do in case of spillage of inflammable solvents, and the principle of construction and operation of the various types of explosion meters and other detecting devices. Each student is then required to operate these instruments with synthetic explosive mixtures (in a quantity which will not cause damage).

3:00 p.m. - Fire Prevention and Demonstration - The Fire Marshall of the University explains the construction and use of various types of fire fighting equipment, the various classes of fires and the types of extinguishers to be used. This is covered in detail in the Safety Manual issued to the students.

to  
4:30 p.m.

The class then adjourns to a vacant lot on the University property where the various classes of fire are demonstrated. The use of the right and wrong types of extinguishers are demonstrated. Each student then operates the various types of extinguishers so that he will be familiar with their operation.

## 2. The Departmental Safety Committees

There are three safety committees in the Department: (1) a General Safety Committee consisting of senior staff members which formulates and establishes Departmental policy on all safety and potential hazards. This committee reviews the reports of the Departmental safety committee who make bi-weekly inspections of all laboratories and makes recommendations of action to be taken. Appendix II, Form I, of this paper gives the form of the report used in the inspection of the laboratories; (2) Divisional Safety Committee consisting of senior staff members who are responsible for housekeeping, and safety in the various laboratories; and (3) Departmental Safety Committee consisting of a senior staff member as Chairman and graduate students who make the bi-weekly inspection of all laboratories. The roster of these committees are given in Appendix II, memoranda numbers 631 and 632. Appendix II, Form #2 gives the form for accident, fire, explosion and damage to equipment report.

## IV. THE DETAILS OF UNDERGRADUATE LABORATORY COURSES IN CHEMICAL ENGINEERING

### Ch.E. 704 - Chemical Engineering Inspection Trip

All undergraduate students in Chemical Engineering are required to take one week-long inspection trip between the Winter and Spring Quarters, preferably in the fourth year.

These trips are intended to give to the chemical engineering student some practical knowledge of the magnitude of modern chemical engineering industrial operations from a selected variety of examples, and to give a practical opportunity for acquaintance with the different branches of the profession of chemical engineering in the proper perspective, and to furnish training in observation, report writing, and discussion.

The plants visited alternate from year to year. The southern trip which is given in the odd-numbered years include the following cities and plants:

Cincinnati, Ohio	- Procter and Gamble Company
Belle, West Virginia	- E.I. duPont de Nemours and Company Industrial and Biochemicals Department
South Charleston, W. Va.	- Union Carbide Chemicals Company and Union Carbide Olefins Company
Parkersburg, W. Va.	- E.I. duPont de Nemours and Company, Polychemicals Department
Willow Island, W. Va.	- American Cyanamid Company, Organic Chemicals Division
Pittsburgh, Pennsylvania	- United States Steel Corporation
Kebuta, Pennsylvania	- Koppers Company, Chemical Division

The northern trip which is given in the even-numbered years include the following cities and plants:

Barberton, Ohio	- Pittsburgh Plate Glass Company, Chemical Division
Akron, Ohio	- Goodyear Tire and Rubber Company
Painesville, Ohio	- Industrial Rayon Company
Avon Lake, Ohio	- The B. F. Goodrich Chemical Company
Toledo, Ohio	- The Standard Oil Company (Ohio)
Midland, Michigan	- Dow Chemical Company
	- Dow Corning Corporation
Detroit, Michigan	- The Ford Motor Company
	- Parke-Davis Company
Wyandotte, Michigan	- Penn-Salt Company, Industrial Chemicals Division

One or two plants are visited per day.

These trips are highly organized. Safety is emphasized; all members of the party are equipped with safety goggles and safety hard hats.

In Ch.E. 761-Chemical Engineering Processes include three or four plant inspection trips in the vicinity of Columbus such as the City of Columbus Water Works; Mead Corporation in Chillicothe; Owens-Corning Fiberglas in Neward, Ohio; Pure Oil Company, Heath Refinery in Newark, Ohio; American Zinc Oxide Company, Columbus; and Capital City Products in Columbus, Ohio.

## 2. Chemical Process Control

by

C. J. Geankoplis

Ch.E. 740 - Chemical Process Control, 2 class and 4 laboratory hours per week.  
Prerequisite Ch.E. 720 - Chemical Engineering Operations.

This course is concerned with the study of the principles employed in the measurement and control of the physical and chemical variables of chemical process, applications to control of chemical processes, and applications concerned with the process dynamics of chemical process and equipment.

The course is open to 4th year chemical engineering students who have had the standard chemical engineering course in transport processes (heat, mass, and momentum transfer) and in unit operations applications. Differential equations and partial differential equations mathematics courses are also prerequisites.

The following is a general outline of the lecture section of the course which meets for 2 lectures a week for 10 weeks:

1. Introduction
  - A. Survey of Need for Automation
  - B. Concepts of Closed Loops, Feedback
2. Physical Measurements
  - A. Temperature
    - a. Theory
    - b. Hardware
  - B. Pressure
    - a. Theory
    - b. Hardware
  - C. Flow
    - a. Theory
    - b. Hardware
  - D. Level, Miscellaneous
    - a. Theory
    - b. Hardware

3. Process Dynamics and Unsteady-State
  - A. Steady-State Transfer
  - B. Process Dynamics
    - a. First Order Processes and Instruments, Time Constants
    - b. Other Order Processes and Instruments
    - c. Dynamic Response to Step, Ramp, Etc. Functions
    - d. Multiple Systems and Overall Responses
4. Control Theory
  - A. Types of Theory
    - a. Proportional
    - b. Reset
    - c. Derivative
  - B. Hardware
5. Integration of Systems in Closed Loops
  - A. Theory of Analog Computer
  - B. Solution of Complete Closed Loop Systems
6. Specific Control Systems
  - A. Chemical Processes
  - B. Nuclear Processes

The following is an outline of the various laboratory experiments performed by the students. The basic philosophy and objectives are to perform a lab experiment illustrating the theory discussed in the lectures during the same week:

- Exp. 1. Study of Pressure Measuring Devices and Statistics of Replications in Experimental Measurements.
- Exp. 2. Study of Pressure Measuring Devices and Statistics of Accuracy of Measurements.
- Exp. 3. Dynamic Response and Process Dynamics in Temperature Controlled Systems.
- Exp. 4. Flow and Liquid Level Measuring Devices
- Exp. 5. Control Instruments and Optimum Control Settings in Process Dynamics
- Exp. 6. Applications of Control to Distillation Tower and Dryer
- Exp. 7. Study of Control and Process Dynamics of a Heat Transfer Process by Simulation with an Analog Computer.
- Exp. 8. Study of Control and Process Dynamics of a Batch-Stirred Reactor with Heat Generation by Simulation with an Analog Computer.

In all of the above experiments the students are divided into groups of 2 or 3 for each set of equipment. The philosophy here is that in small groups each student is able to actually get his own data. Each student analyzes his own experimental data in a short written report. The laboratory is coordinated very closely with the lecture to give maximum learning efficiency and incentives to the students. Usually one instructor for every 12 students is used in the lab to provide maximum teaching effectiveness. It has been found that utilizing concrete examples in the lab to illustrate theories discussed in the lecture provides good incentives and stimulation for the students.

### 3. CHEMICAL ENGINEERING OPERATIONS LABORATORY

#### A. Catalogue Description.

Ch.E. 741 - Chemical Engineering Operations Laboratory. Summer Quarter between fourth and fifth years. Laboratory 8 to 5, Monday to Saturday inclusive or 48 hours per week. First Term of Quarter or 5 weeks. Prerequisites Ch.E. 720 and 740.

The fundamental laboratory course in the chemical engineering or unit operations. Laboratory investigation of the operating characteristics and efficiency of chemical engineering equipment as distillation, drying, absorption, evaporation, filtration, humidification, liquid-liquid extraction, etc.

#### B. Objectives of the Course

The work of this course is so designed to attain the following objectives:

a. To develop a sense of safety consciousness to one's fellow workers, to one's self, to equipment, and one's institution or company. A University laboratory should be as safe as an industrial plant or laboratory.

b. As a corollary to "a." above, to teach good chemical engineering house-keeping. A clean laboratory is a safe laboratory.

- c. To develop initiative, resourcefulness, and responsibility.
- d. To teach organization of an experimental program and the steps necessary to carry it to a successful conclusion.
- e. To coordinate the hands with the mind.
- f. To develop a mechanical and engineering sense of the construction and maintenance of chemical engineering equipment.
- g. To develop judgment in interpreting and correlating data, and from these to be able to draw logical conclusions and reasonable recommendations.
- h. To crystallize the theory and calculations involved in the theoretical and problem work in the courses in chemical process principles, the phenomena of fluid, heat and mass transport, thermodynamics, and the unit operations.
- i. To develop a better understanding of the potentialities and the limitations of the engineering sciences, mathematics, and other sciences.
- j. To demonstrate that to carry a problem to a successful completion requires team work and full-hearted cooperation.
- k. To teach the principles and organization of professional report writing with emphasis on clarity and technical data presentation.
- l. To provide an opportunity for student leadership and evaluation of the potentialities and limitations of squad members.
- m. To give a foundation for the capstone courses in the fifth year such as Chemical Engineering Economy, Process Development, and Design.

### C. Organization of the Courses

- a. Laboratory Squads or Groups: The class is broken up into groups of 4 or 5 each. In arranging the groups, thought is given to balancing the men according to their scholastic records. Each group is under the supervision of a squad foreman. Foremanship is rotated among the members of the squad and each man usually is foreman for at least three problems.
- b. Squad Foreman: Squad foremanship involves responsibility. It is a challenge to one's ability of leadership. The characteristics and abilities shown by a good foreman are (1) to organize, (2) initiative and resourcefulness, (3) to supervise without doing all of the work himself, (4) to obtain the cooperation of his group and coordinate the experiment with the instructor in charge, (5) to improvise when necessary, (6) to carry a problem in the laboratory through to a successful conclusion, and (7) to supervise the writing of the written report.
- c. Duties of the Squad Foreman: (1) to ascertain from the schedule of problems the exact time for working on a particular problem in the laboratory, (2) to study the instructions, (3) to review the underlying theory and equipment so as to be the "expert" on the problem, (4) to arrange for a meeting of his squad several days before taking the preliminary quiz on the problem, (5) to assume leadership, emphasize the pertinent points of the problem, especially the principles of the operation of the equipment, and to make sure that the objectives of a problem are met.
- d. Organization of the Problem: At a squad conference the complete details for running the experiment are outlined. Each problem is not the clean-out type but requires thought and judgment. At this conference the group under the supervision of the foreman decides what measurements are to be taken to meet the objectives of the problem and the final requirements of the report, the calculations that must be made and what charts are to be submitted, the duties of the observers, and finally the clean-up program. All of these items must be entered in a bound notebook and not on loose sheets of paper.  
 After this conference, the group reports to the instructor in charge of the problem for a preliminary quiz and approval of the plan of attack. At this conference with the instructor, the data that must be taken and the plan of attack are finalized. Before beginning the experimental work, the final data sheets are drawn up in the laboratory notebook. Approval to proceed with an experiment requires that the data sheet be complete with the units specified.
- e. Laboratory Schedules: Most of the problems are of such a length that they require at least 6 hours of laboratory time. In cases where the test run is more than 6 hours, two groups work on the problem. The schedule is so arranged so that at least 3 persons are on duty at all times. The day following a laboratory run the groups work as a team in making the calcu-

lations and preparing the final report under the supervision of the foremen. The report submitted is a group report. After the submission of the report, a comprehensive written examination covering theory, calculations, and other items is taken by members of the squad.

- f. Evaluation of the Students: The squad foreman is responsible for an unbiased confidential report of each squad member. This includes a report on the following: Cooperation and team work, technical ability, initiative, manual skill, attitude, energy (includes "gold bricking", independent thinking, and how much detailed supervision was required).

In most cases the foremen's reports are good, and in few cases the evaluations are taken "cum salis granis."

The instructors in the course also submit a rating sheet of each member of the squads. The form is given in Appendix III of this paper. These ratings are discussed at weekly staff meetings. At the end of the term, a compilation is made of these reports. The Chairman of the Department then discusses these reports with the student at the beginning of the Autumn Quarter, Fifth Year. The students, as a whole, welcome the comments. Most of the students try to correct their weak points; in a few cases, some think that everybody is out of step except them.

- g. Requirements of the Course: Each squad is required to complete the work listed below. Each problem is weighted depending upon the time required to complete the problem.

Problem No.	Description	Points
1Z	Chemical Engineering Safety	8
1M	Shop Work, Maintenance and Repair of Equipment, and the Use of Tools.	8
2M	Final Clean Up	4
1T	Gas Chromatography, Spectrophotometry, ASTM Analysis	12
1E	Triple Effect Evaporator	20
1K	Humidification, Water Cooling, and Dehumidification	16
4B	Performance Characteristics of 3-Plate, 18-inch diameter Glass Wall Distillation Column.	16
5B	Continuous Distillation, 35-Plate, 8-inch diameter Column	20
1N	Absorption, 3" x 36" Glass Wall Rasching Ring Tower	16
1P	Constant Pressure Batch Filtration	8
3P	Continuous Vacuum Filtration	8
1S	Liquid-Liquid Extraction, 6-inch diameter Spray Column, 6 feet high.	10
2S	Liquid-Liquid Extraction, 2-inch Pulse Column	8
1D	Drying	16
1AH	Heat Transfer and Fluid Flow, Heating and Cooling in Single, Double, and Four Pass Multi-Tube Heat Exchangers	16
2K	Performance Characteristics of a Croll-Reynold's Four-Stage Evactor and "Chillvactor"	16
7H	Heat Transfer, Multi-Tube Condenser	16
2M	Final Clean Up at the End of the Quarter	4

- h. The Unit Operations Laboratory: In the Appendix are photographs of students dismantling and moving equipment from the old building and erecting it in the new building. Estimates were obtained from several companies concerning the cost of doing this. The lowest estimate was \$100,000. We used this money to purchase new research equipment and gave the Class of 1960, \$200,000 worth of experience. This work was done during the last two weeks of the first term of the Summer Quarter. This monumental task was done without a single accident. We believe that this type of work, if not carried to extremes, is an integral part of the training of the Chemical Engineer.

4 CHEMICAL ENGINEERING PROCESS DEVELOPMENT AND DESIGN COURSES

by  
Charles E. Dryden

The courses of this group are summarized in the following table.

TABLE 1

Quarter and Year, Course Number and Title	Credit Hours	Lecture Hrs/Wk	Laboratory Hrs/Wk
<b>A. FALL QUARTER - 5TH YEAR</b>			
Ch.E. 760 - Chem. Engr. Economy	3	2	2 (computation)
Ch.E. 761 - Chem. Engr. Processes	3	2	2 (25% on plant trips)
<b>B. WINTER QUARTER - 5TH YEAR</b>			
Ch.E. 770 - Chem. Engr. Process Development	4	-	12 (50% experimental)
Ch.E. 790 - AIChE Student Contest Problem and Systems Analysis	2	2 after 30 day period	100 hrs over 30 day period
<b>C. SPRING QUARTER - 5TH YEAR</b>			
Ch.E. 772 - Chem. Engr. Process Design	3	1	6
Engr. Draw. 755 - Plant Design	3	1	6
Ch.E. 791 - Special Project Problems Investigations	5	-	15 (0-90% experimental)

Chemical Engineering Process Development and Design Courses

A major portion of the fifth year of the undergraduate B.S. degree program in chemical engineering is devoted to courses which utilize a great deal of previous knowledge. The case study method is used and students are confronted with situations never seen or studied before. They are required to solve problems on a professional basis. This philosophy is in accordance with the Grinter report (1) which stated on page 15: "The capacity to design includes more than mere technical competence. It involves a willingness to attack a situation never seen or studied before and for which data are often incomplete; it also includes an acceptance of full responsibility for solving the problem on a professional basis."

The course sequence in the fifth year to accomplish the above aims is shown in Table 1.

During the Fall Quarter, Chemical Engineering Economy, Ch.E. 760, is taught concurrently with a comprehensive survey of the chemical process industries, Ch.E. 761. The laboratory work in Chemical Engineering Economy consists of several economic analysis problems, whereas in technology about 25% of laboratory time is spent in plant visits and the balance in library research and reporting.

In the Winter Quarter, the process development course, Ch.E. 770, is taught on an informal basis with the students given a typical chemical process study. The sequence includes library research, laboratory and pilot plant experimentation, preliminary process design and economic analysis. Several methods are used, depending on the type of problems and size of class. The students work in groups of 3-5 on one of several related processes or as an entire group on one problem. In the latter case, an industrial research and development group is simulated with assignments rotated periodically throughout the quarter. The latter method develops management and communications skills as well as technical specialization since it is impossible for each student in a large group to follow completely the work of others in an over-all coordinated project.

"Report on Evaluation of Engineering Education," Am. Soc. for Engineering Education, L. E. Grinter, Committee Chairman, issued June 15, 1955.

Individual solution of the AIChE Student Contest Problem, Ch.E. 790, plus lectures on use of computers in optimization studies round out the Winter Quarter design sequence.

The Spring Quarter completes the sequence with a process design course, Ch.E. 772, on a new problem. Emphasis is placed upon using basic chemical engineering principles of thermodynamics, reaction kinetics, heat and mass transfer, the unit operations, etc. for optimization studies of a process design. Digital and analog computers are used as an aid to the solution of a relatively complex problem involving basic engineering concepts and economics.\*

The plant design course, Engineering Drawing 755, again using another new problem, covers plant layout and auxiliaries design.

### 5. SPECIAL PROJECT PROBLEM INVESTIGATIONS

The special project problem is usually conducted as an individual assignment to the student by one of the professors. The scope varies widely and may run from a design project with little experimental work to the opposite extreme. The criterion in each case is to have the student solve some challenging problem.

#### THE ELECTIVE COURSES IN CHEMICAL ENGINEERING

##### NUCLEAR CHEMICAL ENGINEERING COURSES

by

Charles E. Dryden

The nuclear engineering degree is not granted at OSU. Instead, a program or option can be taken in nuclear science and engineering with a major degree granted in the Departments of Physics, Chemistry, Chemical Engineering, or Mechanical Engineering.

In chemical engineering, a 3-course minimum sequence is available to seniors and graduate students.

<u>Course No.</u>	<u>Title</u>	<u>Cr. Hrs.</u>	<u>Lecture Hrs/Wk</u>	<u>Lab. Hrs/Wk</u>
Physics 602	Modern Physics	5	5	-
Chem.Engr. 765	Introduction to Nuclear Engineering	3	3	-
Chem.Engr. 766	Nuclear Chemical Engineering	4	3	3-5

The introductory nuclear engineering course, Ch.E. 765, covers reactor theory, health physics, and shielding. The following quarter, Ch.E. 766 is devoted to fuel cycles, isotopes, radiation chemistry, and waste disposal. The laboratory given in this quarter illustrates the elective material in both Chem. Engr. 765 and 766. A list of typical experiments shows the breadth of coverage.

1. Nuclear Radiation Detection
2. Isotope Dilution Assay Methods
3. Flux Distribution and Buckling in the Subcritical Reactor
4. Critical Reactor Experiment A
5. Critical Reactor Experiment B
6. Pulse Feed Extractor
7. Fluidized Bed Calciner
8. Gamma Radiation Experiment

If a student, particularly a graduate student, wants further work, he may take advanced level courses available in several departments.

#### APPLIED ELECTROCHEMISTRY

by

Aldrich Syverson

Chemical Engineering 763, Applied Electrochemistry, is a lecture-laboratory course and is an elective in the curriculum. This laboratory meets for 4 hours

\* This paragraph was written by Aldrich Syverson.

per week and is operated in conjunction with the theory and 2 hours of lecture per week for a total of 3 credit hours. The objectives of the laboratory program are: (1) to acquaint the student with instruments and methods of measurement for electrochemical phenomena; (2) to provide a better understanding and appreciation for the basic thermodynamic principles underlying electrochemical cells; and (3) to provide an opportunity for individual effort in the planning and execution of a minor research problem in some field of electrochemistry.

The major portion of the laboratory effort is devoted to the research problem. Students may work individually or in groups of two or three. The specific problem may be originated by the student or selected from a list of general topics. The plan of attack must be originated by the student with the approval of the teaching staff. Literature search, planning and execution of the program and a final comprehensive report are the essential requirements. Each student or group meets with a staff member at least once each week to review progress and formulate plans for the coming week. Where groups are involved, responsibility for the program is rotated so that each member serves as director for a week. Weekly progress reports are submitted. Typical problems which have been investigated are: a polarographic method for cyanide ion analysis, hydrogen-oxygen fuel cell, kinetics of reactions of acid on metals, and electro-organic reduction process.

Although the laboratory is scheduled for a particular four-hour period, students are permitted to come in at any time with the instructor's approval. It has turned out that many students have taken advantage of this and have found that this flexibility has permitted them to undertake experimental programs that could not be done in a four hour per week basis. Emphasis is placed on individual responsibility; the better students seem to welcome this opportunity.