THE TEACHING OF UNDERGRADUATE CHEMICAL ENGINEERING THERMODYNAMICS

A Survey Prepared by the
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INTRODUCTION

This survey is the twenty-first in a series on undergraduate chemical engineering courses that began in 1971. Each survey attempts to present the current text materials, course credits, curriculum placement, student enrollments, topical content and special features of one of about ten standard chemical engineering courses. The first cycle began with Mass and Energy Balances in 1971 and ended with Chemical Engineering Electives in 1980. The second cycle began with Mass and Energy Balances in 1981 and ended with Chemical Engineering Electives in 1989. The third cycle began with Mass and Energy Balances in 1990. This 1992 survey on Chemical Engineering Thermodynamics is the third survey of the third cycle.

A three-page questionnaire was mailed to the chairman of each chemical engineering department in the United States and Canada in March, 1992. A follow-up letter was sent in September to those departments which had not replied. Of the 174 departments contacted, 96 replied (55%). There were 106 responses to the 1991 survey on Kinetics/Reactor Design and 136 responses to the 1990 survey on Mass and Energy Balances.

The analysis of the responses is usually presented at the Undergraduate Free Forum at the Annual Meeting of AIChE. A copy of the analysis is mailed to each chemical engineering department submitting a completed questionnaire.

The results from this survey will be compared with the 1982 survey on Chemical Engineering Thermodynamics as appropriate.

I. COURSE MECHANICS

This section of the report summarizes administrative factors. These include student enrollments and the time allocated to the course.

Course Length.

About 19% of the departments responding operate on the quarter system. The quarter lasts just over 10 weeks while the semester is less than 15 weeks long. Both time periods exclude final examinations periods.

COURSE LENGTH
(Quarter Basis)

Length	Departments
9 weeks	1
10 weeks	13
11 weeks	4
Average	10.2 weeks

COURSE LENGTH
(Semester Basis)

Length	Departments
12 weeks	3
13 weeks	8
14 weeks	22
15 weeks	30
16 weeks	13
Average	14.6 weeks

Number of Courses

Many departments report two courses in thermodynamics. The first course is often a core course taken by chemical, mechanical and other engineers. The second course is then for chemical engineers only. Other departments report just one course in thermodynamics. In this survey, 46% of the departments reported two courses. However, some replies probably reported only the Chemical Engineering Thermodynamics course, particularly if the core course is taught outside of the chemical engineering department.

NUMBER OF COURSES

Courses	Departments
1	52
2	44

Course Level.

The Chemical Engineering Thermodynamics course is usually taught at the junior level. When two courses are reported, they are usually taught in the first and second semesters of the junior year, respectively. An alternative is to teach the courses in the second sophomore semester and the first junior semester. In 1982, 49% of the first courses were taught in the first junior semester and 54% of the second courses were taught in the second junior semester.

COURSE LEVEL
(Single Course, Semester Basis)

Semester	Courses
Sophomore, Semester 2	4
Junior, Semester 1	22
Junior, Semester 2	12
Senior, Semester 1	2

(Single Course, Quarter Basis)

Quarter	Courses
Junior, Quarter 1	2
Junior, Quarter 2	6

COURSE LEVEL
(Two Courses, Semester Basis)

Semester	Course #1	Course #2
Sophomore, Semester 1	7 (10)	
Sophomore, Semester 2	4 (14)	2 (8)
Junior, Semester 1	22 (37)	13 (13)
Junior, Semester 2	12 (10)	18 (31)
Senior, Semester 1	2 (4)	1 (5)

(1982 results in parentheses)

(Two Courses, Quarter Basis)

Quarter	Course #1	Course #2
Sophomore, Quarter 3	5	
Junior, Quarter 1	1	2
Junior, Quarter 2	10	4
Junior, Quarter 3		5
Senior, Quarter 1		1

Class Sessions.

In 76% of the departments, thermodynamics meets for three hours lecture per week. No laboratory experience was reported.

LECTURE HOURS PER WEEK
(Based on 50-minute periods)

Hours	Departments
2	12
3	71
4	11
Average	2.99

Class Sections and Enrollment.

78% of the departments offer one section of Chemical Engineering Thermodynamics annually. 16% offer two sections. Two-thirds of the sections have enrollments of 30 students or less. The average enrollment per section is 45.

NUMBER OF SECTIONS
(1991-92)

Sections	Departments
1	74
2	15
3	3
4+	3

COURSE ENROLLMENT
(1991-92)

Enrollment	Courses
1 - 10	4
11 - 20	24
21 - 30	36
31 - 40	20
41 - 50	15
51 - 60	16
61 - 80	12
81 - 100	6
100+	14
Average	45

Graduate Assistants

Only four departments used graduate teaching assistants in the thermodynamics course. In each case the TA's gave less than 30% of the lectures.

II. BACKGROUND

This section examines the technical background of students enrolled in Chemical Engineering Thermodynamics.

Prerequisites.

The position of Chemical Engineering Thermodynamics in the first or second semester of the junior year is reflected in the courses students have taken during their freshman and sophomore years. Mass and Energy Balances has been completed by almost 90% of the students in thermodynamics. About half the students have completed Differential Equations, Physical Chemistry and Organic Chemistry and at least two semesters of Calculus.

PREVIOUS COURSES

Course	Departments
Mass and Energy Balances	84
Differential Equations	45
Physical Chemistry	45
Organic Chemistry	44
Thermodynamics	20
Fluid Mechanics	19
Heat Transfer	13
Calculus	
One semester	21
Two semesters	18
Three semesters	31
Other	10

III. COURSE CONTENT

This section deals with several aspects of the course content. These include textbook selection, problem solving, dimensions and design content.

Textbook.

In almost every survey conducted over the past 20 years, one textbook is used in a significant majority of the courses. This survey was no exception. The text by Smith and Van Ness was used in 90 courses (68%). Sandler's text was used in 30 courses (22%). Six other texts were used in 12 courses.

TEXTBOOKS

Smith, J. M. and Van Ness, H. C.: Introduction to Chemical Engineering Thermodynamics. 4th ed., McGraw-Hill, New York, 1987.

Sandler. S. I.: Chemical and Engineering Thermodynamics,, Prentice-Hall, Englewood Cliffs, 1990.

TEXTBOOK SELECTION

Author(s)	Courses
Smith & Van Ness	90
Sandler	30
6 other texts	12

DIFFICULT CONCEPTS

Entropy
Activity Coefficients
Solution Thermodynamics
Fugacity
Partial Molar Quantities

Computer Use.

Four questions on the questionnaire dealt with the use of computers in thermodynamics courses.

What computer languages/programs do students use in this course?

	Departments
FORTRAN	58
Basic	30
Lotus	15
Pascal	4
Other	40

Two thirds of the departments require their students to use the computer in their homework assignments. Three quarters use the computer in 30% or less of the assignments. In 74% of the departments, 30% or less of the students own a PC.

Do you require students to use the computer in their homework assignments?

	Departments
Yes	63
No	33

What percent of assignments were done with the computer?

Percent	Departments
0	17
10	35
20	21
30	18
40+	4

What percent of the students own a PC?

Percent	Departments
0	34
10	14
20	14
30	12
40	6
50+	20

The English system is more widely used than the SI system in solving problems. Many departments (75%) would like to use the SI system over 50% of the time.

What percent of the problems you assign <u>are</u> solved in the SI system?

Percent	Departments
<30	8
40	3
50	24
60-70	11
80	24
90	8
100	18

What percent of the problems <u>would you like to see</u> solved in the SI system?

Percent	Departments
<30	10
40	2
50	31
60-70	6
80	19
90	6
100	52

How many major tests do you give in this course?

Number	Departments
1	7
2	26
3	34
4	24
5	4

Do you cover reaction equilibria in this course?

	Departments
Yes	52
No	44

Do you use self-paced instruction in this course?

	Departments
Yes	4
No	89

Do you use a process simulation computer program (such as PRO/II) in this course?

	Departments
Yes	14
No	81

Do you assign a project lasting one month or longer in this course?

	Departments
Yes	12
No	83

ENGINEERING REGISTRATION

Most states require two 8-hour written exams plus experience for a professional engineer's license. The questionnaire sought to determine how many chemical engineering seniors take the first exam, the EIT exam. About half the replies presented data on both the number of B.S. chemnical engineering graduates in 1991-92 and the number taking the exam. Five departments **require** seniors to take the exam. The questionnaire also sought two reasons why seniors should take the EIT exam and two reasons why they should not take the EIT exam.

EIT EXAMINATION

	Number
EIT students	549
Total students	1344
Percent 40.8 %	

Reasons for taking the EIT

Material is still fresh in mind.
PE will be needed in the near future.
Good professional credential.

Reasons for not taking the EIT

Too time consuming in the senior year.
Too expensive; regular tuition is high enough.
Needed only for consulting.

The questionnaire also asked about current faculty registration. Some states now require faculty who teach engineering or engineering design to be registered PE's.

FACULTY REGISTRATION (PE)

	number
PE faculty	214
Total faculty	727
Percent	29.4 %

Two previous surveys provided limited data on registration. A 1982 survey showed that 33.5 % of chemical engineering seniors take the EIT exam. A 1985 survey showed that 33.2 % of chemical engineering faculty are registered PE's

QUESTIONNAIRE ON THE TEACHING OF UNDERGRADUATE CHEMICAL ENGINEERING THERMODYNAMICS

VERSITY_____ INSTRUCTOR_____

rse No. TEXT (AUTHOR, TITLE) (Circle chapters covered)

1. _____
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

2. _____
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

What are the two main strengths of each textbook above?

What are the two main weaknesses of each textbook above?

Is your school on the semester or the quarter system?
(Circle one:) Semester Quarter

How many weeks of class (excluding final exams) are there in your semester/quarter? _____ weeks.

	Course No. 1	Course No. 2
In which year do most students take this course (Jr., Sr.)?		
In which semester/quarter) do most students take this course (1,2,3)?		
How many sections of the course were offered in 1991-92?		
What was the total student enrollment in all sections taught in 1991-92?		

OVER

9. Please identify the prerequisite courses for ChE Thermodynamics course. Indicate the number semesters/quarters of each course required.

Mass & Energy Balances	_____	_____
Organic Chemistry	_____	_____
Physical Chemistry	_____	_____
Calculus	_____	_____
Differential Equations	_____	_____
Heat Transfer	_____	_____
Fluid Flow	_____	_____
Thermodynamics (core)	_____	_____
Other	_____	_____

10. How many hours lecture are scheduled each week (based on 50 minute periods)? _____ _____

11. Did graduate teaching assistants present any lectures in this course? (yes/no) _____ _____

12. If yes to question 11, about what per cent of the lectures did TA's give? _____ _____

13. What computer programs/languages (Fortran, Basic, Lotus, etc.) do students use in this course?

14. Do you require students to use the computer in their homework assignments (Yes/No)? _____ _____

15. About what percent (to the nearest 10%) of assignments were done with the computer? _____ _____

16. About what percent (to the nearest 10%) of the students own a PC? _____ _____

17. About what percent (to the nearest 10%) of the problems you assign are solved in the SI system of dimensions? _____ _____

18. About what percent (to the nearest 10%) of the problems would you like to see solved in the SI system? _____ _____

19. Do you assign a project lasting one month or longer in this course (Yes/No)? _____ _____

OVER

20. Do you cover reaction equilibria in this course? (yes/no) _____ _____

21. Does the course use formal self-paced instruction? _____ _____

22. Do you use a process simulation program (such as PROCESS) in this course? (yes/no) _____ _____

23. What concepts are particularly difficult for the student to grasp?

24. What explanations of these concepts have you found particlarly effective?

14

25. What additional topics would you like to see included in a reactor design textbook?

26. How many major tests (excluding the final exam) do you given in this course? _____ _____

27. Please describe any classroom demonstrations you have found useful.

OVER

SURVEY ON THE

FUNDAMENTALS OF ENGINEERING EXAMINATION

Most states require two 8-hour written examinations plus experience for a professional engineer's license. The first test, the FE or EIT exam, is can be taken during the senior year. The second, the PE exam, usually can be taken only after the engineering experience has been obtained. The following questions refer to the EIT examination.

1. How many B.S. degrees in chemical engineering were awarded in 1991-92 (August 15, 1991 to August 15, 1992)? _____

2. Of those receiving degrees, how many took the EIT exam? _____

3. Does your department require taking the EIT exam as a condition of graduation? _____

4. Please give two reasons why a senior should take the EIT examination.

5. Please give two reasons why a senior should not take the EIT examination.

Some states now require P. E. registration for engineering faculty.

6. How many faculty in your department are registered PE's? (number):_____ out of (total no.)_____

7. What difficulties do you perceive such a law will present for the academic community?