SUMMARY REPORT

TEACHING OF UNDERGRADUATE FLUID FLOW AND HEAT TRANSFER

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INTRODUCTION

The 1986 survey examines the teaching of undergraduate Fluid Flow and Heat Transfer. A questionnaire was sent in April, 1986 to the chairmen of 172 chemical engineering departments in the [redacted] that appropriate faculty members complete and return the questionnaire. A follow-up letter was sent in late August to those departments which had not responded.

Replies were received from 110 departments. This compares with 110 replies to last year's survey on Process Dynamics and Control and 92 replies to the 1977 survey on Fluid Flow and Heat Transfer.

The questionnaire consisted of three sheets. The first two [redacted] fluid flow. The third requested an estimate of time allotments to subject areas for heat transfer and for fluid flow. The replies to the questionnaires are analyzed in this report and are compared, when appropriate, to replies to the 1977 survey.

ANALYSIS OF REPLIES

COURSE LEVEL

Table 1 lists the number of courses of each classification taught in each semester and quarter of the sophomore, junior an senior years. The fluid flow course is usually taught before t heat transfer course. 85% of the fluid flow courses are taught in the second semester or third quarter of the sophomore year o the first quarter or first semester of the junior year. Heat transfer follows in the semester or quarter after fluid flow. 90% of the heat transfer courses are given in the two junior ye semesters or the first or second quarters of the junior year.

TABLE 1

COURSE LEVELS

Semester Basis	Fluid Flow			Heat Transfer			Combined		
	UF	TF	DF	UH	TH	DH	UC	TC	DC
Sophomore, Sem 1	1							1	1
Sophomore, Sem 2	7	7	4				1	3	2
Junior, Sem 1	14	15	6	9	9	4	7	5	6
Junior, Sem 2	3		2	8	11	6	4	3	1
Senior, Sem 1		1		2			1	3	
Senior, Sem 2				1	1			1	

Quarter Basis	Fluid Flow			Heat Transfer		
	UF	TF	DF	UH	TH	DH
Sophomore, Qtr 3	3	1	3			
Junior, Qtr 1	2	8	1	1	2	2
Junior, Qtr 2		3		3	4	1
Junior, Qtr 3		1		2	1	
Senior, Qtr 1		1				

Table 2 compares the course placements of 1977 and 1986. It appears that the fluid flow course has been shifted to an earlier semester. The percent of courses in the senior year has decreased by 15 percentage points while the percent of courses in the sophomore year has increased by 14 percentage points. The predominent position for fluid flow remains in the first semester of the junior year.

The heat transfer course has been shifted slightly in both directions. Compared with 1977, there are fewer courses in the first semester of both the junior and the senior year and more courses in the second semester of the junior year. Courses in the first semester has decreased 14 percentage points while the second semester junior year has increased by 17 percentage points.

TABLE 2

COURSE LEVELS

Semester Basis	Fluid Flow	Heat Transfer	Combined
Sophomore Year	32% (18%)	0% (3%)	21%
Junior, Semester 1	58% (56%)	43% (53%)	46%
Junior, Semester 2	8% (15%)	49% (32%)	21%
Senior Year	2% (11%)	8% (12%)	12%

Quarter Basis	Fluid Flow	Heat Transfer
Sophomre Year	29% (7%)	0% (0%)
Junior, Quarter 1	46% (46%)	31% (33%)
Junior, Quarter 2	13% (12%)	50% (39%)
[illegible]	[illegible]	[illegible]

[illegible]

[illegible] distribution of class enrollments for [illegible]

TABLE 3

It appears that SI usage is greater in heat transfer than in fluid flow. Just over half the computational effort is carried out in SI dimensions.

TEXTBOOK SELECTION

A total of 28 textbooks were mentioned 186 times in the questionnaires. The five texts listed below account for 67% of all the citations. Of the remaining 23 texts, 9 were cited once, 5 were cited twice and 4 were cited thrice.

Authors	Citations	Percentage
McCabe, Smith, Harriott	39	21%
Bird, Stewart, Lightfoot	30	16%
[illegible]		
Geankoplis	16	9%
Welty, Wicks, Wilson	15	8%
Others	63	34%

The textbook usage was also analyzed for class approach and course subject matter. The distibution for the Unit Operations approach is shown below:

McCabe	17	10	9
Bird		1	
Bennett	1		2
Geankoplis	3	4	2
Welty			
Holman		4	
Others	5	7	

For courses using the transport approach, the following distribution was found:

	TF	TH	TC
McCabe			1
Bird	10	8	8
Bennett	5	1	2

In courses using both approaches, the distribution is:

	DF	DH	DC
McCabe	2		
Bird	2	1	
Bennett	5	4	3
Geankoplis	2		4
Welty	1	1	
Holman		4	
Others	5	3	2

COURSE STRUCTURE

Approximately two dozen topics were selected from textbooks frequently used in heat transfer and fluid flow courses. Instructors were asked to show the number of class sessions spent on the respective topics and to other topics. The results were added and normalized to a 40-session course plan. This is equivalent to a 15-week course meeting three times a week, with 5 sessions for quizzes. Replies to this section of the questionnaire were received on 94% of the heat transfer responses and 94% of the fluid flow responses. The Topic Time Allocations are given on the following pages.

Comparison of the 1986 and 1987 time allocations shows few

FLUID FLOW

TIME ALLOCATIONS
(Sessions of 50 Minutes Each)

	1986		1977	
Properties/Definitions		1.9		1.8
Viscosity; Mass, Force Units	1.9		1.8	
Fluid Statics		3.0		3.0
Manometers	1.1		1.3	
Buoyancy, Flotation	0.9		0.6	
Plane Surfaces	0.6		0.8	
Curved Surfaces	0.4		0.3	
Flow Equations		8.0		7.6
Continuity	2.1		2.3	
Bernoulli	2.8		2.7	
Conservation of Momentum	3.0		2.6	
Incompressible Flow		11.7		11.8
Laminar/Turbulent Flow	3.4		3.8	
Friction Factors	2.3		2.0	
Equivalent Length of Fittings	1.2		1.0	
Boundary Layer, Velocity Distribution	2.6		2.5	
Piping Systems	2.3		2.5	
Compressible Flow		2.2		2.3
Isothermal	0.7		0.8	
Isentropic	0.6		0.7	
Non-isothermal	0.5		0.5	
Sonic Velocity	0.4		0.3	
Ideal Fluid Flow	1.1	1.1	1.6	1.6
Dimensional Analysis	1.9	1.9	2.0	2.0
Non-Newtonian Fluids	1.6	1.6	1.0	1.0
Fluid Measurement		2.9		2.8
Orifice, Venturi	1.7		1.9	
Pitot tube, others	1.2		0.9	
Fluid Machinery		2.2		2.2
Pumps	1.6		1.8	
Turbines	0.6		0.4	
Other Topics	3.5	3.5	3.9	3.9
	[illegible]	[illegible]	[illegible]	[illegible]

HEAT TRANSFER

	1986		1977	
Dimensional Analysis	1.6	1.6	1.6	1.6
Steady State Conduction in				
[illegible]				
Plane Systems	2.3		2.2	
Radial Systems	1.9		1.8	
Heat Source Systems	1.3		1.2	
Fins	1.6		1.4	
Steady State Conduction in				
[illegible]				
Relaxation	0.6		0.6	
Unsteady State Conduction		3.0		2.6
Lumped Heat Capacity	1.4		1.4	
Heisler Charts	1.2		0.8	
Schmidt Plot	0.4		0.4	
Boundary Layer Theory	2.2	2.2	1.8	1.8
[illegible]				
Pipes/tubes	2.7		3.0	
Cylinders/spheres	1.4		1.4	
Tube banks	1.3		1.0	
Natural Convection Correlations		3.0		3.3
Flat Plates	1.1		1.2	
[illegible]				

BIBLIOGRAPHY

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McCabe, Smith and Harriott, "Unit Operations in Chemical Engineering", 3rd ed., McGraw-Hill, 1976.

Bennett and Myers, "Momentum, Heat and Mass Transfer", 2nd ed., McGraw-Hill, 1974.

Robert S. Brodkey, "The Phenomena of Fluid Motions", Addison-Wesley, 1967.

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[illegible] "Process Fluid Mecahnics", Prentiss Hall, 1980.

[illegible]

INSTRUCTOR ____________________ UNIVERSITY ____________________

PART I

COURSE NO.	COURSE TITLE	Year/Semester
1.	____________________	________
2.	____________________	________
3.	____________________	________

COURSE NO.	TEXT (Author, Title)	1985-86		
1.	____________________	________	________	________
2.	____________________	________	________	________
3.	____________________	________	________	________

1. Weeks per quarter/semester ________

2. Do you use any films, videotapes or demonstrations in the classroom? If so, please elaborate.

3. How do you incorporate design into these courses?

UNIVERSITY ____________________________

1. [illegible]

[illegible]

English) dimensions? Express to the nearest 10%.

[illegible]

2. Is this text also the principal text for another course? If [illegible]

[illegible]

3. Would you classify the text as unit operations oriented (eg. McCabe and Smith) or transport phenomena oriented (eg. Bird, Stewart and Lightfoot)?

4. Are the heat transfer/fluid flow courses for chemical engineers only, or can other engineering students enroll?

5. Does your department offer a chemical engineering laboratory course with credit separate from the Heat Transfer or Fluid Flow lecture courses? If so,

a) How many courses [illegible]

[illegible]

The following pages summarize replies to three questions on the questionnaire.

1. What films or other visual aides are used in the classroom? (FILMS)

2. How do you incorporate design within the curriculum? (DESIGN)

3. What topics do students seem to have particular difficulty with? (DIFFICULT TOPICS)

NEW YORK POLYTECHNIC UNIVERSITY-BROOKLYN

PENNSYLVANIA STATE UNIVERSITY

ROSE-HULMAN INSTITUTE OF TECHNOLOGY

A & M UNIVERSITY

DESIGNS: Problems (heat exchanger, pump).

DIFFICULT TOPICS: Non-Newtonian properties.

TEXAS TECH UNIVERSITY

DESIGNS: Pump design, heat exchanger design.

DIFFICULT TOPICS: Navier-Stokes, tensor analysis, flow assumptions, derivations of differential equations from model.

UNIVERSITY OF TEXAS/AUSTIN

DESIGNS: Piping & heat exchanger arrays optimization.

UNIVERSITY OF TOLEDO

DESIGNS: Open-ended problems.

DIFFICULT TOPICS: Shear stress, momentum transfer.

DIFFICULT TOPICS: Meaning of momentum transport relative to heat and mass.

TULANE UNIVERSITY

DIFFICULT TOPICS: Flow net works, combined conduction and convection or radiation trial and error problems.

UNIVERSITY OF VIRGINIA

DESIGNS: Problem sessions.

DIFFICULT TOPICS: Notion that correlations are not perfect and that real world measurements don't have 8-10 significant figures.

UNIVERSITY OF WASHINGTON

FILMS: Fluid Mechanics (3)

DESIGNS: Problems.

DIFFICULT TOPICS: Radiation and turbulence.

UNIVERSITY OF WATERLOO

FILMS: Fluid flow.

DESIGNS: Assignments.

DIFFICULT TOPICS: Thermal radiation

UNIVERSITY OF WEST VIRGINIA TECH

FILMS: Fluid Flow Phenomena

DESIGNS: Project, small design

WEST VIRGINIA UNIVERSITY

FILMS: Slides on heat exchangers, filmstrips (MIT).

DESIGNS: Project, design assignments.

WESTERN ONTARIO UNIVERSITY