SUMMARY REPORT

TEACHING OF UNDERGRADUATE MASS TRANSFER

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INTRODUCTION

A preliminary survey was made in 1976 to estimate classroom time allocations to those topics generally referred to as the unit operations. This survey indicated that 1/4 of the total time was devoted to heat transfer, 1/4 to fluid flow, 3/8 to mass transfer and the remaining 1/8 to all other topics. The 1977 survey covered heat transfer and fluid flow. This year's survey deals with mass transfer and the other unit operations.

A three-page questionnaire was sent in May, 1978 to the Chairman of each chemical engineering department in the United States and Canada, together with a cover letter asking that the appropriate faculty member(s) complete and return the questionnaire. A follow-up letter was sent in August to those schools which had not responded. Of the 156 schools contacted, 111 returned completed questionnaires. This is the highest number of responses in the seven years this survey has been conducted.

SI SYSTEM OF UNITS

Both the American Chemical Society and the AIChE require that dimensions in their journals be expressed in SI units. Last year's survey showed that 2/3 of the heat transfer and fluid flow courses employ both English and SI units. 27% use only English units and 5% use only SI units. The question on dimensions in this year's questionnaire was included to discover the relative popularity of these two systems.

The results show a marked preference for the English system in mass transfer problem assignments. In 38% of the schools, the SI system is used in less than 10% of the assignments. Almost 70% of the schools use the English system in at least 75% of the assignments. From another viewpoint, the fact that about 2/3 of the schools use both systems is in close agreement with last year's study.

Percent of Assignments using SI Units	No. of Schools
Less than 10%	42
About 25%	36
About 50%	24
About 75%	8
Over 90%	1
TOTAL	111

TEXTBOOKS

Seventeen textbooks were mentioned in the 192 courses reported by the responding universities. In 11 courses, either no text was used or personal notes by the instructor constituted the text. The texts by McCabe and Smith and by Treybal were used in over half the courses. The six most popular texts were used in 87% of the courses which used texts. The other 11 books were scattered through the remaining 13% of the courses.

Authors (Publication Year)		No. of Courses
McCabe and Smith	(1976)	53
Treybal	(1968)	45
Bird, Stewart and Lightfoot	(1960)	22
Bennett and Myers	(1974)	20
King	(1971)	10
Welty, Wicks and Wilson	(1969)	7
Other texts		24
TOTAL		181

COURSE ORIENTATION

Instructors were asked to judge whether their mass transfer course textbook was oriented toward the unit operations or toward transport theory. It appears that transport theory is less frequently applied to mass transfer than to heat transfer or fluid flow. The transport approach was used in 35% of the heat transfer courses and 30% of the fluid flow courses, but only 17% of the mass transfer courses. The unit operations approach was correspondingly more popular in mass transfer (53%) than in heat transfer (40%) or fluid flow (38%).

Course Orientation	% of Courses
Unit Operations	53%
Transport Theory	17%
Some of both	30%

COURSES AND COURSE LEVEL

The 110 schools responding reported a total of 192 courses devoted wholly or in part to mass transfer. This total excludes courses devoted entirely to laboratory. There were slightly more schools offering two mass transfer courses than one course.

Mass Transfer Courses	No. of Schools
One	43
Two	53
Three	13
Four	1
TOTAL	110

Slightly more mass transfer courses are taught in the junior year than the senior year.

Course Level - Semester Basis	
Sophomore year	4%
Junior, Semester 1	25%
Junior, Semester 2	31%
Senior, Semester 1	30%
Senior, Semester 2	10%

Course Level - Quarter Basis

Sophomore year	0%
Junior, Quarter 1	11%
Junior, Quarter 2	16%
Junior, Quarter 3	27%
Senior, Quarter 1	31%
Senior, Quarter 2	13%
Senior, Quarter 3	2%

COMPUTERS IN MASS TRANSFER COURSES

Design of multicomponent distillation columns is usually done by a computer program rather than by hand calculations. Questions about the access to multicomponent distillation programs and the relative number of assignments requiring computer solutions were placed on the questionnaire. Only 30% of the schools make a multicomponent computer program available to their mass transfer students. About 85% of the schools require 10% or less of the course problem assignments to be solved by the computer.

Percent of Assignments Requiring Computer Solution	No. of Schools
0%	33
1-10%	59
11-50%	15
TOTAL	107

Access to Multicomponent Distillation Program	No. of Schools
Yes	31
No	78
TOTAL	109

COURSE ADMINISTRATION

Five questions were asked regarding the conduct and content of the course.

1. Do you require students to turn in assigned problems?

Reply	% of Schools
Most of the time	92%*
Sometimes	5%
Rarely	2%
Never	1%

* 9% wrote in "All of the time".

2. Do you use articles from the chemical engineering literature in your course?

Reply	% of Schools
Yes	52%
No	48%

3. How is your course time apportioned?

Activity	Average of Replies
Lecture	59%
Problem solving	26%
Questions and answers	15%

4. Do your quizzes emphasize theory or applications?

Quiz Emphasis	% of Schools
Mainly theory	5%
Mainly application problems	50%
About evenly split between theory and application	45%

5. What methods do you present for design of distillation columns?

Method	% of Schools*
Ponchon-Savarit	85%
McCabe-Thiele	81%
Thiele-Geddes	33%
Other multicomponent methods	19%

* Most schools teach several methods

The replies to these questions show the emphasis placed on mass transfer as a practice-oriented subject. A number of instructors indicated use of the chemical engineering literature as sources of problem assignments and sources of data on new developments such as tower packing. At least half the schools teach a multicomponent distillation method in the undergraduate mass transfer course, although only 1/3 of the schools have access to an appropriate computer program in this area.

COURSE STRUCTURE

About two dozen topics were selected from textbooks recently used in mass transfer and unit operations. Instructors were asked to show the number of class sessions spent on each of these topics. Each school spent an average of 53 sessions on these topics. A 40-session course plan assumes a 15-week course meeting three times a week, with 5 sessions for quizzes. Thus, the replies indicate about 1 1/3 courses devoted to mass transfer. While a number of schools devoted two or more courses to mass transfer, few of these second and third courses were devoted exclusively to mass transfer. This is especially true for transport-oriented courses, where one course covers mass, heat and momentum transfer.

MASS TRANSFER

TOPIC TIME ALLOCATIONS

Molecular Diffusion	5.5	
Gases		2.8
Liquids		2.0
Solids		0.7
Mass Transfer Coefficients	6.0	
Laminar Flow		2.0
Turbulent Flow		2.0
Local/Overall		2.0
Equilibrium Stage Operations	7.5	
Principles		4.0
Equipment		2.2
Heat and Mass Transfer		1.3
Humidification	2.4	2.4
Gas Absorption	6.9	
Single Component, Isothermal		4.9
Multicomponent		0.9
Non-isothermal		1.1
Distillation	12.3	
Differential		1.7
Multistage		6.9
Multicomponent		2.9
Azeotropic		0.8
Liquid Extraction	6.2	
Equipment		0.9
Equilibria		1.2
Single Stage		1.1
Multistage		2.6
Multicomponent		0.4
Other Unit Operations	3.6	
Adsorption		0.38
Ion Exchange		0.13
Drying		1.21
Leaching		1.07
Crystallization		0.21
Membrane Separations		0.18
Filtration		0.43
Other Topics	2.5	
TOTAL	52.9 hours	

REPLIES TO QUESTIONNAIRES

The replies to the Mass Transfer questionnaires received from each school are summarized on the following pages. The following form is used:

NAME OF UNIVERSITY

TX:	Authors of text(s). Complete listings are given in the bibliography. (Year/Semester/Class hours - lab hours) Jr/S2/3-0 indicates a course with 3 hours classroom, 0 hours lab given in the second semester of the junior year.
ORIENTATION:	Unit operations or transport theory.
SI PROBLEMS:	Percent of problem assignments requiring SI units.
TEXT COMMENTS:	Comments on how the text could be improved.
DIFFICULT TOPICS:	What subject areas seem most difficult for the students to grasp.

UNIVERSITY OF AKRON

TX: 1. McCabe & Smith (Sr/3/3)
2. Bird, Steward & Lightfoot (Jr/3/0)

ORIENTATION: Unit Op.
SI PROBLEMS: About 1/4
DIFFICULT TOPICS: Design of packed towers and associated theory.

UNIVERSITY OF ALABAMA

TX: 1. Treybal (Jr/3/0)
2. Treybal (Jr/3/0)

ORIENTATION: Unit Op.
SI PROBLEMS: Less than 10%
TEXT COMMENTS: Cover less material with more examples and explanations. Most texts are good reference books but not very good for instruction.
DIFFICULT TOPICS: Heat effects in gas absorption.

UNIVERSITY OF ARIZONA

TX: 1. McCabe & Smith (Jr/3/0)

ORIENTATION: Unit Op.
SI PROBLEMS: About 1/2
TEXT COMMENTS: Make material simpler to understand.
DIFFICULT TOPICS: Diffusion theory.

UNIVERSITY OF ARKANSAS

TX: 1. Treybal or McCabe & Smith (Jr/3/0)
2. Smith (Sr/3/0)

ORIENTATION: Unit Op.
SI PROBLEMS: About 1/4
TEXT COMMENTS: Simple exercise problems are needed prior to the more difficult comprehensive problems at the end of the chapters.
DIFFICULT TOPICS: Diffusion, Gas Absorption.

AUBURN UNIVERSITY

TX: 1. McCabe & Smith (Sr/4/0)
2. McCabe & Smith (Jr/4/0)

ORIENTATION: Unit Op.
SI PROBLEMS: Less than 10%

UNIVERSITY OF CALIFORNIA-BERKELEY

TX: 1. Sherwood, Pigford & Wilke (Jr/4/0)
2. King (Jr/3/0)

ORIENTATION: Both
SI PROBLEMS: About 1/2
TEXT COMMENTS: More emphasis on solving design and operating problems in mass transfer controlled separations
DIFFICULT TOPICS: Extraction using ternary diagrams; Simultaneous mass and heat transfer.

UNIVERSITY OF CALIFORNIA-DAVIS

TX: 1. Bird, Stewart & Lightfoot (Sr/3/0)
2. Treybal (Sr/3/0)

ORIENTATION: Both
SI PROBLEMS: Less than 10%
TEXT COMMENTS: Better correlation between transport phenomena and applications.
DIFFICULT TOPICS: Diffusion theory.

UNIVERSITY OF CALIFORNIA-LOS ANGELES

TX: 1. Edwards, Denny & Mills, "Transfer Processes" (Jr/4/0)
2. McCabe & Smith (Sr/4/0)

ORIENTATION: 1. Transport; 2. Unit Op.
SI PROBLEMS: About 3/4
DIFFICULT TOPICS: Bulk flow term in Fick's Law.

UNIVERSITY OF CALIFORNIA-SANTA BARBARA

TX: 1. Bennett & Myers (Jr/3/0)
2. Bennett & Myers (Jr/3/0)

ORIENTATION: Both
SI PROBLEMS: About 1/2
TEXT COMMENTS: More theoretical discussion of transport phenomena is needed.
DIFFICULT TOPICS: Simultaneous heat, mass and momentum transport.

CALIFORNIA INSTITUTE OF TECHNOLOGY

TX: 1. Bird, Stewart & Lightfoot (Jr/3/0)

ORIENTATION: Both
SI PROBLEMS: About 1/2

CITY UNIVERSITY OF NEW YORK

TX: 1. Bird, Stewart & Lightfoot (Jr/3/0)
2. Foust (Sr/3/0)

ORIENTATION: 1. Transport; 2. Unit Op.
SI PROBLEMS: Less than 10%
DIFFICULT TOPICS: Application of the equations of change and multi-component systems by picking boundary conditions.

CLARKSON COLLEGE OF TECHNOLOGY

TX: 1. Treybal (So/3/0)
2. Treybal (Sr/3/0E)

ORIENTATION: Unit Op.
SI PROBLEMS: Less than 10%
TEXT COMMENTS: Use SI units.
DIFFICULT TOPICS: Diffusion theory.

CLEMSON UNIVERSITY

TX: 1. Littlejohn: Notes on Distillation & Extraction (So/3/3)
2. McCabe & Smith (Jr/3/0)

ORIENTATION: Unit Op.
SI PROBLEMS: About 1/4
TEXT COMMENTS: Extend section on humidification (cooling tower design) in McCabe & Smith.
DIFFICULT TOPICS: Diffusion theory.

CLEVELAND STATE UNIVERSITY

TX: 1. Treybal (Jr/4/0)
2. Treybal (Sr/4/0)

ORIENTATION: Both
SI PROBLEMS: About 1/2
TEXT COMMENTS: Include more examples.
DIFFICULT TOPICS: Batch Distillation.

COLORADO SCHOOL OF MINES

TX: 1. Treybal (Jr,Sr/3/0)

ORIENTATION: Both
SI PROBLEMS: About 1/4
DIFFICULT TOPICS: Diffusion

CALIFORNIA STATE POLYTECHNIC UNIVERSITY

TX: 1. Geankoplis (Sr/3/0)
2. McCabe & Smith (Sr/3/0)

ORIENTATION: Both
SI PROBLEMS: About 1/4
TEXT COMMENTS: Case study approach to illustrate concepts.
DIFFICULT TOPICS: Gas absorption HTU/NTU approach.

CARNEGIE-MELLON UNIVERSITY

TX: 1. McCabe & Smith (Jr/3/0)
2. McCabe & Smith; Bird, Stewart & Lightfoot (Jr/3/0)

ORIENTATION: Both
SI PROBLEMS: Less than 10% (since most tables of data are still in English Units)
TEXT COMMENTS: It would be nice to have a first-rate text synthesizing unit operations and transport aspects of mass transfer.
DIFFICULT TOPICS: Liquid Extraction, because of the many types of diagrams used to represent phase equilibria.

CATHOLIC UNIVERSITY

TX: 1. Bennett & Myers (Jr/3/0)
2. Welty, Wicks & Wilson (Jr/3/0)

ORIENTATION: 1. Unit Op.; 2. Transport
SI PROBLEMS: About 1/4
TEXT COMMENTS: Make texts more readable
DIFFICULT TOPICS: Triangular diagrams; Absorption, Basic notation of diffusion.

UNIVERSITY OF CINCINNATI

TX: 1. McCabe & Smith (Sr/4/0)

ORIENTATION: Unit Op.
SI PROBLEMS: Less than 10%
DIFFICULT TOPICS: Diffusion, convective transport.

UNIVERSITY OF COLORADO

TX: 1. Notes (Jr/3/1)

ORIENTATION: Both
SI PROBLEMS: About 3/4
DIFFICULT TOPICS: Continuous contact modeling.

UNIVERSITY OF CONNECTICUT

TX: 1. Bennett & Myers (Jr/3/0)

ORIENTATION: Both
SI PROBLEMS: About 1/2
TEXT COMMENTS: More illustrative problems.

CORNELL UNIVERSITY

TX: 1. McCabe & Smith (Jr/3/2)
2. Smith & VanNess (Jr/3/0)

ORIENTATION: Unit Op.
SI PROBLEMS: Less than 10%
DIFFICULT TOPICS: Multicomponent operations in general.

UNIVERSITY OF DELAWARE

TX: 1. King (Sr/2/0)
2. Bird, Stewart & Lightfoot (Jr/3/0)

ORIENTATION: Both
SI PROBLEMS: Less than 10%
TEXT COMMENTS: Gear text to computer solutions.
DIFFICULT TOPICS: Multicomponent liquid extraction.

DREXEL UNIVERSITY

TX: 1. Bennett & Myers (Jr/3/0)
2. McCabe & Smith (Jr/3/0)

ORIENTATION: 1. Transport; 2. Unit Op.
SI PROBLEMS: Less than 10%
TEXT COMMENTS: Problems in SI units.
DIFFICULT TOPICS: Gas absorption with chemical reaction; Multicomponent distillation.

GROVE CITY COLLEGE

TX: 1. Treybal (Jr/3/0)
2. Treybal (Sr/3/0)

ORIENTATION: Unit Op.
SI PROBLEMS: About 1/4
TEXT COMMENTS: Convert Treybal to MKS units.
DIFFICULT TOPICS: Theoretical mass transfer.

UNIVERSITY OF HOUSTON

TX: 1. None (Jr/3/0)

ORIENTATION: Unit Op.
SI PROBLEMS: About 1/2

UNIVERSITY OF IDAHO

TX: 1. Thomson & Scheldorf: "Rates of Transport Processes" (Sr/2/1/2)
2. McCabe & Smith (Jr/3/1/2)

ORIENTATION: 1. Transport; 2. Unit Op. & Transport
SI PROBLEMS: 1. Less than 10%; 2. About 1/2
TEXT COMMENTS: More diverse illustrations; Treat all stage equilibrium processes alike.
DIFFICULT TOPICS: Relating triangular solvent-free phase diagrams.

UNIVERSITY OF IOWA

TX: 1. McCabe & Smith (Jr/3/0)
2. McCabe & Smith (Sr/2/0)

ORIENTATION: Unit Op.
SI PROBLEMS: About 3/4
DIFFICULT TOPICS: Mass transfer-heat transfer analogy; humidification.

IOWA STATE UNIVERSITY

TX: 1. McCabe & Smith (Jr/4/0)
2. McCabe & Smith, Bennett & Myers (Sr/4/0)

ORIENTATION: Both
SI PROBLEMS: 1. Less than 10%; 2. About 1/2
TEXT COMMENTS: Better integration of theory and design problems.
DIFFICULT TOPICS: Non-ideal vapor-liquid equilibria.

UNIVERSITY OF KANSAS

TX: 1. Treybal (Jr/3/3)

ORIENTATION: Unit Op.
SI PROBLEMS: Less than 10%
DIFFICULT TOPICS: Distillation seems a mystery to some.

KANSAS STATE UNIVERSITY

TX: 1. Treybal (Sr/2/0)

ORIENTATION: Unit Op.
SI PROBLEMS: About 1/2

UNIVERSITY OF KENTUCKY

TX: 1. Treybal (Jr/2/0)
2. Treybal (Jr/3/0)

ORIENTATION: Unit Op.
SI PROBLEMS: Less than 10%
TEXT COMMENTS: Separate the staged and rate portions into separate sections of the book. Introduce a number of computer-oriented problems.
DIFFICULT TOPICS: Simultaneous heat and mass transfer.

LAFAYETTE COLLEGE

TX: 1. Treybal (Sr/4/3)

ORIENTATION: Unit Op.
SI PROBLEMS: About 1/4

LAMAR UNIVERSITY

TX: 1. Treybal (Sr/3/3)

ORIENTATION: Both
SI PROBLEMS: About 1/4
TEXT COMMENTS: Give more illustrations and problems in SI units.
DIFFICULT TOPICS: Mass transfer coefficient under different conditions.

LOUISIANA STATE UNIVERSITY

TX: 1. Bennett & Myers or Welty, Wicks and Wilson (Jr/4/0)

ORIENTATION: Transport
SI PROBLEMS: About 1/2
TEXT COMMENTS: More realistic problems on absorption and extraction.
DIFFICULT TOPICS: Fluxes with respect to various coordinate systems.

UNIVERSITY OF LOUISVILLE

TX: 1. McCabe & Smith and Treybal (Jr/3/0)

ORIENTATION: Unit Op.
SI PROBLEMS: About 1/4

MANHATTAN COLLEGE

TX: 1. McCabe & Smith (Jr/3/0)

ORIENTATION: Unit Op.
SI PROBLEMS: Less than 10%
TEXT COMMENTS: Redo over 1/2 of the mass transfer material.

UNIVERSITY OF MARYLAND

TX: 1. Treybal (Jr/3/0)

ORIENTATION: Unit Op.
SI PROBLEMS: Less than 10%
DIFFICULT TOPICS: Diffusion

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

TX: 1. Bird, Stewart & Lightfoot (Jr/4/0)
2. King (Sr/3/0)

ORIENTATION: Both
SI PROBLEMS: Less than 10%

UNIVERSITY OF MASSACHUSETTS

TX: 1. McCabe & Smith and Bird, Stewart & Lightfoot (Jr/3/0)
2. King (Sr/3/0)

ORIENTATION: Both
SI PROBLEMS: About 1/4

MC NEESE STATE UNIVERSITY

TX: 1. Sherwood, Pigford & Wilke (Jr/3/0)
2. King (Jr/3/0)

ORIENTATION: Unit Op.
SI PROBLEMS: About 3/4
TEXT COMMENTS: Better integration of unit operations and transport phenomena.
DIFFICULT TOPICS: Multicomponent diffusion.

MICHIGAN STATE UNIVERSITY

TX: 1. Bennett & Myers or McCabe & Smith (Jr/5/0)
2. Bennett & Myers or McCabe & Smith (Jr/5/0)

ORIENTATION: Both
SI PROBLEMS: About 1/4

MICHIGAN TECHNOLOGICAL UNIVERSITY

TX: 1. McCabe & Smith (Jr/6/0)

ORIENTATION: Unit Op.
SI PROBLEMS: Less than 10%
TEXT COMMENTS: Improve treatment of Gas Absorption, Cooling Towers, Continuous Drying, Leaching and Extraction.
DIFFICULT TOPICS: Diffusion theory.

UNIVERSITY OF MISSISSIPPI

TX: 1. McCabe & Smith (Jr/3/0)
2. McCabe & Smith (Sr/3/0)

ORIENTATION: Unit Op.
SI PROBLEMS: About 1/4
TEXT COMMENTS: Make it somewhat more theoretical including some of the approach of Bird, Stewart & Lightfoot.
DIFFICULT TOPICS: Phase rule and phase diagrams; trial and error solutions.

UNIVERSITY OF MISSOURI-COLUMBIA

TX: 1. Bennett & Myers (Jr/3/0)

ORIENTATION: Both
SI PROBLEMS: About 1/4
DIFFICULT TOPICS: Extension of mass transfer theory to applications.

UNIVERSITY OF MISSOURI-ROLLA

TX: 1. Foust, et al (Jr/3/0)
2. Bennett & Myers (Jr/3/0)

ORIENTATION: 1. Unit Op.; 2. Some of both.
SI PROBLEMS: Less than 10%
TEXT COMMENTS: Expansion of treatment of multicomponent sections.

MONTANA STATE UNIVERSITY

TX: 1. Bennett & Myers (Jr/4/0)

ORIENTATION: Both
SI PROBLEMS: About 1/4
DIFFICULT TOPICS: Simultaneous mass and heat transfer; multicomponent distillation.

UNIVERSITY OF NEBRASKA

TX: 1. McCabe & Smith (Jr/3/0)

ORIENTATION: Unit Op.
SI PROBLEMS: About 1/4

UNIVERSITY OF NEVADA-RENO

TX: 1. Bennett & Myers (Jr/3/0)
2. Bird, Stewart & Lightfoot (Sr/3/0)

ORIENTATION: 1. Transport; 2. Both
SI PROBLEMS: Less than 10%
DIFFICULT TOPICS: Physical interpretation, mathematics.

UNIVERSITY OF NEW HAMPSHIRE

TX: 1. McCabe & Smith (Sr/3/1)

ORIENTATION: Unit Op.
SI PROBLEMS: About 1/2
TEXT COMMENTS: Change to Treybal.
DIFFICULT TOPICS: Diffusion, Drying.

NEW JERSEY INSTITUTE OF TECHNOLOGY

TX: 1. Foust, et al (Sr/4/0)

ORIENTATION: Unit Op.
SI PROBLEMS: Less than 10%
TEXT COMMENTS: Increase the number of illustrative problems, and include a narrative of how the solution was obtained.
DIFFICULT TOPICS: Graphic solution methods.

UNIVERSITY OF NEW MEXICO

TX: 1. Treybal (Jr/3/0)

ORIENTATION: Both
SI PROBLEMS: About 1/4
DIFFICULT TOPICS: This is the first course where students have several approaches to solve a problem, all of which are correct. Up to this point, all a student had to do was to find the right equation and chug.

NEW MEXICO STATE UNIVERSITY

TX: 1. Foust, et al (Jr/2/3)

ORIENTATION: Unit Op.
SI PROBLEMS: Less than 10%

NORTH CAROLINA STATE UNIVERSITY

TX: 1. McCabe & Smith (Jr/3/0)
2. King (Sr/3/0)

ORIENTATION: Unit Op.
SI PROBLEMS: Less than 10%
TEXT COMMENTS: Include more basics on mass transport.
DIFFICULT TOPICS: Diffusion.

UNIVERSITY OF NORTH DAKOTA

TX: 1. Treybal (Sr/3/0)
2. Bird, Stewart & Lightfoot (Jr/4/0)

ORIENTATION: 1. Unit Op., 2. Transport
SI PROBLEMS: Less than 10%
TEXT COMMENTS: Change order of McCabe-Thiele & Ponchon-Savarit Methods.
DIFFICULT TOPICS: For students to see similarities in various stage operations.

NORTHEASTERN UNIVERSITY

TX: 1. Bird, Stewart & Lightfoot (Jr/4/0)
2. McCabe & Smith (Jr-Sr/4/0)
3. King (Sr/4/0)

ORIENTATION: 1. Transport; 2,3. Unit Op
SI PROBLEMS: Less than 10%

NORTHWESTERN UNIVERSITY

TX: 1. Skelland: "Diffusional Mass Transfer" (Jr/4/0)

ORIENTATION: Both
SI PROBLEMS: Less than 10%
DIFFICULT TOPICS: Extraction.

OHIO STATE UNIVERSITY

TX: 1. Geankoplis (Jr/4/0)
2. Geankoplis (Jr/5/0)

ORIENTATION: 1. Transport; 2. Unit Op.
SI PROBLEMS: About 1/2
DIFFICULT TOPICS: Boundary conditions at interfaces.

OREGON STATE UNIVERSITY

TX: 1. Welty, Wicks & Wilson (Jr/4/0)
2. Treybal (Sr/5/0)

ORIENTATION: 1. Transport; 2. Unit Op.
SI PROBLEMS: About 1/2
DIFFICULT TOPICS: Boundary layer and turbulent eddy transfer.

UNIVERSITY OF PENNSYLVANIA

TX: 1. Bird, Stewart & Lightfoot (Jr/3/0)
2. King (Jr/3/0)
3. Smith (Sr/3/0)

ORIENTATION: Transport
SI PROBLEMS: About 1/2

PENNSYLVANIA STATE UNIVERSITY

TX: 1. McCabe & Smith (Jr/4/0)
2. Treybal (Sr/3/0)

ORIENTATION: Unit Op.
SI PROBLEMS: About 1/4
DIFFICULT TOPICS: Phase Equilibria and Differential Absorption

PRINCETON UNIVERSITY

TX: 1. Welty, Wicks & Wilson (Jr/3/3)
2. Smith (So/3/0)

ORIENTATION: Transport
SI PROBLEMS: About 1/2
TEXT COMMENTS: Material on order-of-magnitude estimates to identify controlling phenomena.
DIFFICULT TOPICS: Bridge between exact equations and empirical correlations for transfer coefficients.

PURDUE UNIVERSITY

TX: 1. McCabe & Smith (So/2/0)
2. Greenkorn & Kessler (Jr/5/0)

ORIENTATION: Both
SI PROBLEMS: About 1/4
DIFFICULT TOPICS: Anything with partial differential equations.

RENSSELAER POLYTECHNIC INSTITUTE

TX: 1. Welty, Wicks & Wilson (Sr/3/0)
2. Smith (Jr/2/0)

ORIENTATION: 1. Transport; 2. Unit Op.
SI PROBLEMS: About 1/2

UNIVERSITY OF RHODE ISLAND

TX: 1. Treybal (Jr/2/3)
2. Treybal (Sr/2/0)

ORIENTATION: Both
SI PROBLEMS: Less than 10%
TEXT COMMENTS: Text is being revised and SI units will be used.

RICE UNIVERSITY

TX: 1. Bird, Stewart & Lightfoot (Sr/3/0)
2. Various texts (Jr/3/0)

ORIENTATION: Transport

UNIVERSITY OF ROCHESTER

TX: 1. Treybal (Sr/3,4/0)
2. Bennett & Myers (Jr/3/0)

ORIENTATION: Both
SI PROBLEMS: About 1/4
TEXT COMMENTS: Clean up the mass transfer coefficient stuff. It appears unnecessarily intimidating in Treybal.
DIFFICULT TOPICS: Various types of mass transfer coefficients.

SAN JOSE STATE UNIVERSITY

TX: 1. McCabe & Smith (Sr/3/3)

ORIENTATION: Unit Op.
SI PROBLEMS: Less than 10%
TEXT COMMENTS: Additional example problems needed.
DIFFICULT TOPICS: Distillation, extraction.

SOUTH DAKOTA SCHOOL OF MINES

TX: 1. McCabe & Smith (Sr/3/0)
2. McCabe & Smith (Sr/2/0)

ORIENTATION: Unit Op.
SI PROBLEMS: About 1/4
DIFFICULT TOPICS: Leaching.

UNIVERSITY OF SOUTHERN CALIFORNIA

TX: 1. McCabe & Smith (Jr/4/0)

ORIENTATION: Unit Op.
SI PROBLEMS: About 1/4
TEXT COMMENTS: Eliminate the errors.
DIFFICULT TOPICS: Molecular Diffusion, Absorption.

STEVENS INSTITUTE OF TECHNOLOGY

TX: 1. Treybal (Jr/3/0)
2. Geankoplis (Jr/3/0)

ORIENTATION: 1. Unit Op.; 2. Both
SI PROBLEMS: 1. Less than 10%;
2. About 1/4
TEXT COMMENTS: Change notation; pay more attention to thermodynamics.
DIFFICULT TOPICS: Phase equilibria; convective and diffusive contributions to mass flux in a fixed coordinate frame.

UNIVERSITY OF TENNESSEE

TX: 1. McCabe & Smith (Jr/3/0)
2. McCabe & Smith (Sr/3/0)
3. Chemical Engineers' Handbook (Sr/3/0)

ORIENTATION: Unit Op.
SI PROBLEMS: Less than 10%
DIFFICULT TOPICS: Triangular phase diagrams in liquid-liquid extraction.

UNIVERSITY OF TEXAS-AUSTIN

TX: 1. Bird, Stewart & Lightfoot (Jr/3/0)
2. McCabe & Smith (Sr/3/0)
3. McCabe & Smith and VanWinkle (Sr/3/0)

ORIENTATION: 1. Transport; 2,3. Unit Op.
SI PROBLEMS: About 1/2
TEXT COMMENTS: More applications, but by an author who understands the applied field.

TEXAS A&I UNIVERSITY

TX: 1. Holland (Sr/3/0)

ORIENTATION: Both
SI PROBLEMS: Less than 10%
TEXT COMMENTS: More descriptive materials on Unit Operations.

TEXAS TECH UNIVERSITY

TX: 1. McCabe & Smith (Jr/3/0)

ORIENTATION: Unit Op.
SI PROBLEMS: Less than 10%

TENNESSEE TECHNOLOGICAL UNIVERSITY

TX: 1. McCabe & Smith (Sr/3/0)
2. McCabe & Smith (Sr/3/0)

ORIENTATION: Unit Op.
SI PROBLEMS: About 1/2
TEXT COMMENTS: Improve VLE section; rewrite distillation treatment; improve multicomponent coverage; rewrite mass transfer section.
DIFFICULT TOPICS: Multicomponent distillation.

UNIVERSITY OF TOLEDO

TX: 1. McCabe & Smith (Jr/3/0)

ORIENTATION: Unit Op.
SI PROBLEMS: About 1/2
TEXT COMMENTS: More example problems.

TUFTS UNIVERSITY

TX: 1. McCabe & Smith (Jr/3/0)
2. Bird, Stewart & Lightfoot (Sr/3/0)

ORIENTATION: 1. Unit Op.; 2. Transport
SI PROBLEMS: About 1/4
TEXT COMMENTS: More practical applications; more pictures of actual equipment.
DIFFICULT TOPICS: Modeling differential equations.

UNIVERSITY OF TULSA

TX: 1. Coulson & Richardson, Vol. II (Jr/3/0)

ORIENTATION: Unit Op.
SI PROBLEMS: Less than 10%
DIFFICULT TOPICS: Continuous counter-current contacting is more difficult than stagewise.

VANDERBILT UNIVERSITY

TX: 1. Bird, Stewart & Lightfoot (Jr/3/0)
2. Treybal (Jr/3/0)

ORIENTATION: 1. Transport; 2. Unit Op.
SI PROBLEMS: Less than 10%

UNIVERSITY OF VIRGINIA

TX: 1. Welty, Wicks and Wilson; Bennett & Myers (Jr/3/1)

ORIENTATION: Both
SI PROBLEMS: About 1/4
DIFFICULT TOPICS: Unsteady state analysis; cooling towers.

UNIVERSITY OF WASHINGTON-SEATTLE

TX: 1. Treybal (Sr/4/0)

ORIENTATION: Unit Op.
SI PROBLEMS: About 1/4
TEXT COMMENTS: Emphasize similarities between operations rather than treating each topic as unique.
DIFFICULT TOPICS: Diffusion controlled operations; simultaneous mass and heat transfer.

WASHINGTON UNIVERSITY

TX: 1. McCabe & Smith (Jr/3/0)

ORIENTATION: Unit Op.
SI PROBLEMS: Less than 10%
TEXT COMMENTS: Better sections on gas absorption and air-water contact operations.
DIFFICULT TOPICS: Two film theory of gas absorption.

WASHINGTON STATE UNIVERSITY

TX: 1. McCabe & Smith (Sr/4/0)

ORIENTATION: Unit Op.
SI PROBLEMS: About 1/4
DIFFICULT TOPICS: Humidification.

WAYNE STATE UNIVERSITY

TX: 1. Treybal (Jr/4/0)

ORIENTATION: Unit Op.
SI PROBLEMS: Less than 10%
TEXT COMMENTS: More design information.
DIFFICULT TOPICS: Gas absorption and humidification.

WEST VIRGINIA UNIVERSITY

TX: 1. McCabe & Smith (Jr/3/2)
2. Bennett & Myers (Jr/3/2)

ORIENTATION: 1. Unit Op.; 2. Transport
SI PROBLEMS: About 1/2
TEXT COMMENTS: Emphasize similarities between separations.
DIFFICULT TOPICS: Packed column design.

WIDENER COLLEGE

TX: 1. Treybal (Sr/4/0)

UNIVERSITY OF WISCONSIN-MILWAUKEE

TX: 1. Sherwood, Pigford & Wilke (Sr/3/0)

ORIENTATION: Both
SI PROBLEMS: About 1/2

WORCESTER POLYTECHNIC INSTITUTE

TX: 1. McCabe & Smith and Bird, Stewart & Lightfoot (Jr/5/0)

ORIENTATION: Both
SI PROBLEMS: About 3/4
TEXT COMMENTS: Needs more "real life" problems.
DIFFICULT TOPICS: Getting a physical feel for reference frames.

UNIVERSITY OF WYOMING

TX: 1. Foust, et al (Sr/3/0)

ORIENTATION: Unit Op.
SI PROBLEMS: About 1/4

UNIVERSITY OF PUERTO RICO

TX: 1. Treybal (Jr/4/0)
2. King (Sr/3/0)

ORIENTATION: 1. Unit Op.; 2. Transport
SI PROBLEMS: Less than 10%
DIFFICULT TOPICS: Diffusion.

UNIVERSITY OF ALBERTA

TX: 1. Treybal (Sr/3/2)
2. Treybal (Sr/2/2)

ORIENTATION: Both
SI PROBLEMS: About 3/4
TEXT COMMENTS: Should have more worked out problems.
DIFFICULT TOPICS: Correct usage of k and F values.

UNIVERSITY OF CALGARY

TX: 1. McCabe & Smith (Sr/3/0)
2. Treybal (Jr/3/0)

ORIENTATION: Unit Op.
SI PROBLEMS: About 3/4
TEXT COMMENTS: Add furnace design.
DIFFICULT TOPICS: Humidification.

LAVAL UNIVERSITY

TX: 1. Treybal (Sr/3/0)
2. Treybal (Sr/3/0)

ORIENTATION: Both
SI PROBLEMS: About 3/4

MC MASTER UNIVERSITY

TX: 1. Treybal and Bennett & Myers (2 1/2 /0)

ORIENTATION: Both
SI PROBLEMS: About 1/4
TEXT COMMENTS: Need a single unified book (not too long) on both Unit Operations and transport phenomena.

UNIVERSITY OF NEW BRUNSWICK

TX: 1. Brid, Stewart & Lightfoot (Jr/3/0)
2. Treybal (Sr/3/0)

ORIENTATION: Both
SI PROBLEMS: About 1/4
TEXT COMMENTS: Book combining transport phenomena and mass transfer correlations.
DIFFICULT TOPICS: Stationary and moving coordinate frames.

NOVA SCOTIA TECHNICAL COLLEGE

TX: 1. McCabe & Smith (Sr/3/3)
2. Treybal (Sr/2/3)
3. Bird, Stewart & Lightfoot (Sr/3/0)

ORIENTATION: 1,2. Unit Op.; 3. Transport
SI PROBLEMS: About 1/2
TEXT COMMENTS: More theoretical treatment in course 1.

UNIVERSITY OF OTTAWA

TX: 1. Treybal (Sr/3/0)

ORIENTATION: Unit Op.
SI PROBLEMS: About 1/4
TEXT COMMENTS: Convert part of course to SI units.
DIFFICULT TOPICS: Significance of the mass transfer coefficient.

QUEEN'S UNIVERSITY

TX: 1. None (Jr/5/0)

ORIENTATION: Unit Op.
SI PROBLEMS: About 1/4
TEXT COMMENTS: Thorough disucssion on distillation first, then analogies of other processes.
DIFFICULT TOPICS: Batch distillation in tray towers and gas-liquid operation in packed towers.

ROYAL MILITARY COLLEGE

TX: 1. Treybal (Sr/2/0)

ORIENTATION: Unit Op.
SI PROBLEMS: Less than 10%
DIFFICULT TOPICS: Convection driving forces and mass transfer coefficients.

UNIVERSITY OF SASKATCHEWAN

TX: 1. Bennett & Myers (Sr/3/0)

ORIENTATION: Both
SI PROBLEMS: Less than 10%
DIFFICULT TOPICS: Continuous contacting concentrated solutions.

UNIVERSITY OF TORONTO

TX: 1. Treybal (Sr/4/0)
2. King and McCabe & Smith (Sr/4/4)

ORIENTATION: Unit Op.
SI PROBLEMS: More than 90%

UNIVERSITY OF WATERLOO

TX: 1. Treybal (Jr/3/2)

ORIENTATION: Both
SI PROBLEMS: Less than 10%
DIFFICULT TOPICS: General continuing equation.

UNIVERSITY OF WESTERN ONTARIO

TX: 1. McCabe & Smith (Jr/3/3)
2. McCabe & Smith (Sr/3/3)

ORIENTATION: Both
SI PROBLEMS: About 1/2

HOWARD UNIVERSITY

TX: 1. McCabe & Smith (Sr/4/0)

ORIENTATION: Unit Op.
SI PROBLEMS: About 1/4
TEXT COMMENTS: Stress more analytical techniques, including computer analysis of mass transfer systems.
DIFFICULT TOPICS: Distillation (Enthalpy-concentration).

ILLINOIS INSTITUTE OF TECHNOLOGY

TX: 1. Treybal (Jr/4/2)

ORIENTATION: Unit Op.
SI PROBLEMS: About 1/4
TEXT COMMENTS: Provide introductory chapter on transport phenomena approach to mass transfer.
DIFFICULT TOPICS: Vector notation; similarity transformation.

STATE UNIVERSITY OF NEW YORK-BUFFALO

TX: 1. Bennett & Myers; Welty, Wicks & Wilson (Jr/3/1)

ORIENTATION: Transport
SI PROBLEMS: About 1/4
TEXT COMMENTS: Some organizational changes.

UNIVERSITY OF UTAH

TX: 1. Treybal (Jr/3/0)
2. Bird, Stewart & Lightfoot (Jr/3/0)

ORIENTATION: 1. Both; 2. Transport
SI PROBLEMS: Less than 10%
TEXT COMMENTS: Treatment of degrees of freedom for equipment and processes.
DIFFICULT TOPICS: Treatments of interfacial conditions, nature and direction of mass transfer driving forces.

B I B L I O G R A P H Y

Bennett, C. O. and Myers, J. E.: "Momentum, Heat and Mass Transfer", 2nd ed., McGraw-Hill, New York, 1967.

Bird, R. B., Stewart, W. E. and Lightfoot, E. N.: "Transport Phenomena", Wiley, New York, 1968.

Coulson, J. M. and Richardson, J. F.: "Chemical Engineering", 2nd rev. ed., Pengamon, 1968.

Edwards, D. K., et al: "Transfer Processes", McGraw-Hill, New York, 1976.

Foust, A., et al: "Principles of Unit Operations", Wiley, New York, 1962.

Holland, C. D.: "Multicomponent Distillation", McGraw-Hill, New York, 1963.

King, C. J.: "Separation Processes", McGraw-Hill, New York, 1971.

McCabe, W. L. and Smith, J. C.: "Unit Operations in Chemical Engineering", 3rd ed., McGraw-Hill, New York, 1976.

Sherwood, T. K., Pigford, R. L. and Wilke, C. R.: "Mass Transfer", McGraw-Hill, New York, 1975.

Skelland, A. H.: "Diffusional Mass Transfer", Wiley, New York, 1974.

Smith, J. M. and VanNess, H. C.: "Introduction to Chemical Engineering Thermodynamics", 3rd ed., McGraw-Hill, New York, 1975.

VanWinkle, M.: "Distillation", McGraw-Hill, New York, 1968.

Treybal, R. E.: "Mass Transfer Operations", 2nd ed., McGraw-Hill, New York, 1968.

Welty, J. R., Wicks, C. E. and Wilson, R. E.: "Fundamentals of Momentum, Heat and Mass Transfer", Wiley, New York, 1969.

structor ______________________ University ______________________

RT I - GENERAL INFORMATION

Course Identification

Course Number	Catalog Number	Title	Hrs/Wk Class	Hrs/Wk Lab	Year (Circle)	Sem/Qtr (Circle)
1	______	______________________	____	____	Jr/Sr	1 2 3
2	______	______________________	____	____	Jr/Sr	1 2 3
3	______	______________________	____	____	Jr/Sr	1 2 3

Course Resources/Class Data (Please attach a course outline)

Course Number	Text (Author, Title, Ed.)	Class Size	%**	RE* (Circle)
1	______________________	____	____	R E
2	______________________	____	____	R E
3	______________________	____	____	R E

* Required (R) or Elective (E) Course
** % of Course Allocated to Mass Transfer (if other than 100%)

Time Allocations

__________ Weeks per (Semester/Quarter) (Circle 1)

__________ Minutes per Class Session (based on three sessions/week)

(do, do not) plan to attend the Miami meeting.

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

Would you classify the text as unit operations oriented (e.g. McCabe & Smith) or transport phenomena (e.g. Bird, Stewart & Lightfoot) oriented? (Circle 1)

Unit Op. Transport Some of Both Neither

What portion of the problem assignments are solved in SI units (as contrasted with English units)? (Circle 1)

Less than 10% About 1/4 About 1/2 About 3/4 More than 90%

Is this text used as the principal text for another course? If so, please give course title.

5. About what percent of the assignments <u>require</u> use of a digital or analog computer? (Express to nearest 10%)

________%

6. Do you require students to turn in assigned problems? (Circle 1)

Most of the time   Sometimes   Rarely   Never

7. Do you supplement your lectures with articles from the chemical engineerin literature? (e.g. Chemical Engineering, I/EC, CEP) If so, how are these articles used?

8. Approximately what percent of your course time is devoted to lecture_____% problem solving_____%, questions and answers_____%.

9. Are your tests

a. mainly theory
b. mainly application problems
c. about evenly split between a and b.

10. What are some typical students' reactions upon completion of the course?

11. What topics, if any, seems particularly difficult for the student?

12. If you were revising the text for the course, what additions or changes would you make?

13. Which methods do you cover in distillation (e.g. Ponchon-Savarit, Thiele-Geddes)?

14. Do students have access to a multi-component distillation computer program If so, which?

Instructor ____________ University ____________

PART II - TOPICS IN MASS TRANSFER

	Course #[a]	Sessions
Molecular Diffusion		
Gases	____	____
Liquids	____	____
Solids	____	____
Mass Transfer Coefficients		
Laminar Flow	____	____
Turbulent Flow	____	____
Local/Overall	____	____
____________	____	____
Equilibrium Stage Operations		
Principles	____	____
Equipment	____	____
Simultaneous Heat & Mass Transfer	____	____
____________	____	____
Humidification	____	____
Gas Absorption		
Single Component, Isothermal	____	____
Non-isothermal	____	____
Multicomponent	____	____
____________	____	____
Distillation		
Differential	____	____
Multistage	____	____
Multicomponent	____	____
Azeotropic	____	____
____________	____	____
____________	____	____
____________	____	____

	Course #[a]	Sessions
Liquid Extraction		
Equipment	____	____
Equilibria	____	____
Single Stage	____	____
Multistage	____	____
Multicomponent	____	____
____________	____	____
____________	____	____
____________	____	____

PART III - OTHER UNIT OPERATIONS

	Course #[a]	Sessions
Adsorption	____	____
Ion Exchange	____	____
Drying	____	____
Leaching	____	____
Crystallization	____	____
Membrane Separations	____	____
Filtration	____	____
____________	____	____
____________	____	____
____________	____	____
____________	____	____
____________	____	____

a From Part IA