A POLYTECHNIC INSTITUTION

Course Outline

School of Manufacturing, Electronics and Industrial Processes
Program: Chemical Sciences
Option: Pulp and Paper, Industrial,

CHSC 4441
Unit Operations 2

Start Date:	January, 2006				**End Date:**	May, 2006			
Total Hours:	120	**Total Weeks:**	20		**Term/Level:**	4	**Course Credits:**	8.0	
Hours/Week:	6	**Lecture:**	3	**Lab:** 3	**Shop:**		**Seminar:**	**Other:**	

Prerequisites		**CHSC 4441 is a Prerequisite for:**	
Course No.	**Course Name**	**Course No.**	**Course Name**
CHSC 3341	Unit Operations 1	None	

Course Description

This course is a continuation of CHSC 3341, Unit Operations 1, and deals with the chemical engineering topics of psychrometry, heat transfer, distillation, liquid-liquid extraction, and gas absorption.

Detailed Course Description

Determination of psychrometric properties of air experimentally and by calculation and/or psychrometric charts, and applying this information when performing mass and energy balances to the unit operations of evaporative cooling, air conditioning, and water cooling towers. Estimate heat transfer rates by conduction, convection, and radiation. Determination of heat transfer coefficients. Application of experimental mass and energy balances to chemical engineering unit operations. Separation of the components of miscible liquid mixtures by distillation. Determination of the number of stages required to separate miscible liquid mixtures by liquid/liquid extraction. Absorption of a soluble gas from a mixture of soluble gas and inert gas by means of a suitable solvent.

Evaluation

Midterms (3)	30%
Laboratory	30%
Final Exam	40%
TOTAL	100%

Comments: See attached schedule for subjects covered in each examination.

Course Learning Outcomes/Competencies

Upon successful completion, the student will be able to completely cover the following topics:

1.0 Psychrometry

Determine psychrometric properties of air experimentally and by calculation and/or psychrometric charts, and apply this information to perform mass and energy balances to the unit operations of evaporative cooing, air conditioning, and water cooling towers.

1.1 Define Dalton's and Amagat's laws of partial pressures and partial volumes.

■ Course Learning Outcomes/Competencies (cont'd.)

1.2 Define and calculate specific humidity, relative humidity, and percent saturation from partial pressure data of air and water vapor.
1.3 Define dew point.
1.4 Calculate the specific enthalpy and specific volume of air/water vapor mixtures utilizing thermodynamic data.
1.5 By calculation, determine the moisture content of atmospheric air using dry bulb and adiabatic saturation temperatures.
1.6 Utilize psychrometric charts to determine the thermodynamic state properties of air/water vapor mixtures.
1.7 Determine mass and energy balances for evaporative cooling and air conditioning units.
1.8 Describe the operation of a water cooling tower, including the calculation of mass and energy balances.

2.0 Heat Transfer

Estimate heat transfer rates by conduction, convection, and radiation.

2.1 Describe the concept of driving force and resistance as applied to the rate of heat transfer.
2.2 Apply Fourier's law for determining steady state heat transfer rates by conduction through planar solids and cylindrical sections.
2.3 Apply the concepts of logarithmic mean radius, area and temperature differences to heat transfer calculations.
2.4 Describe the various types of heat exchangers used in the process industries (shell/tube, fin-type, countercurrent, cocurrent, liquid/liquid, vapor/liquid, vapor/vapor).
2.5 Experimentally, and by calculation, determine the heat transfer performance of shell and tube heat exchangers.
2.6 Grouping of fluid physical properties and solids characteristic dimensions affecting heat transfer rates into dimensionless numbers such as Reynolds, Prandtl, Grashof, Raleigh, and Nusselt numbers.
2.7 Explain the concept of fluid laminar boundary layer effects on the rate of heat transfer from solid objects.
2.8 Estimate convective film heat transfer coefficients by experiment and the use of standard semi-empirical relationships.
2.9 Estimate overall heat transfer coefficients experimentally, and by calculating the combined effect of fluid film heat transfer coefficients and solids heat transfer by conduction.
2.10 Perform a heat balance at an insulated steam pipe surface by considering conduction, convection, and radiation.
2.11 Explain the concepts of boiling point rise and steam economy as encountered in multi-effect evaporators.
2.12 Apply experimental mass and energy balance calculations to multi-effect evaporation operations.

■ Course Learning Outcomes/Competencies (cont'd.)

3.0 Distillation

Separate one or more components from a miscible liquid mixture by partial vaporization of the liquid solution and subsequent condensation of the vapors with the requirement that the composition of the vapors be different than the composition of the liquid with which it is in equilibrium.

3.1 Define relative volatility.
3.2 Apply Raoult's and Dalton's laws for constructing boiling point and equilibrium diagrams from vapor pressure data of pure components for ideal binary liquid mixtures.
3.3 Use of published reference material for obtaining boiling point and equilibrium diagrams for non-ideal binary liquid mixtures.
3.4 Perform mass and energy balances calculations for the processes of batch distillation (constant and non-constant relative volatility), equilibrium distillation, steam distillation, and flash distillation.
3.5 Perform calculations and graphical constructions to determine the number of theoretical equilibrium stages required in distillation according to the methods of McCabe-Thiele and Ponchon-Savarit.

4.0 Liquid-Liquid Extraction

Determine the number of theoretical equilibrium stages required to separate miscible liquids by utilizing differences in their solubilities in a solvent.

4.1 Describe the various types of equipment utilized for liquid-liquid extraction.
4.2 Describe the convention used in ternary phase diagrams for solute, diluent, and solvent.
4.3 Construct ternary phase diagrams from published and experimental data.
4.4 Describe the separation of liquid components into an extract phase and a raffinate phase according to equilibrium data and the inverse lever law.
4.5 Describe the use of the concepts of net positive flow and operating point as applied to liquid-liquid extraction.
4.6 Perform calculations and graphical construction for determining the number of theoretical equilibrium stages required for countercurrent continuous liquid-liquid extraction.

5.0 Gas Absorption

Determine the number of equilibrium stages for the absorption of a soluble gas from a mixture of soluble gas and inert gas by means of a suitable solvent.

5.1 Describe typical gas absorption equipment.
5.2 State Henry's law for low concentrations of solute gas in solvent, and calculate the concentration of oxygen in water.
5.3 Perform equilibrium absorption calculations utilizing inert gas and inert liquid flows.
5.4 Perform multi-stage graphical absorption calculations using equilibrium data and mass balances.
5.5 Determine the height equivalent of a theoretical plate for packed towers.
5.6 Introduction to mass transfer coefficients and two-film theory of absorption.

■ Course Learning Outcomes/Competencies (cont'd.)

6.0 Laboratory Exercises

Most laboratory exercises will be done on a rotating basis depending upon class size.

6.1 Introduction to experimental laboratory exercises.
6.2 Sling psychrometry and psychrometry calculations.
6.3 Operation of a water cooling tower.
6.4 Heat transfer from insulated pipes.
6.5 Overall heat transfer coefficients for vapor/liquid and liquid/liquid heat exchangers.
6.6 Determination of film and overall heat transfer coefficients for a liquid/vapor heat exchanger.
6.7 Problem session in heat transfer calculations.
6.8 Operation of a multi-effect evaporation pilot plant.
6.9 Mass and energy balance calculations on multi-effect evaporators.
6.10 Determination of the relative volatility of the isopropyl and normal propyl alcohol systems.
6.11 Separation of IPA and NPA at total reflux in a multi-stage fractionation tower.
6.12 Separation of ethylene glycol and water in a pilot plant distillation unit.
6.13 Calculations using the Panchon-Savarit method.
6.14 Liquid/liquid extraction in the IPA/water/toluene system.
6.15 Gas absorption calculations.
6.16 Problem sessions.

■ Verification

I verify that the content of this course outline is current.

[signature]	2006-01-09
Authoring Instructor	Date

I verify that this course outline has been reviewed.

Mark McDonald	Jan 9, 2006
Program Head/Chief Instructor	Date

I verify that this course outline complies with BCIT policy.

[signature]	2006/01/09
Dean/Associate Dean	Date

Note: Should changes be required to the content of this course outline, students will be given reasonable notice.

Instructor(s)

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	Thursday: 11:30–1:30		

Learning Resources

Required:

Sharp EL-520 WB calculator (required for Midterm and Final exams — **no other calculator will be allowed**).

Recommended:

The library contains many excellent references such as:

Transport Processes and Unit Operations by C. Geankoplis.

Applied Thermodynamics for Engineering Technologists by T.D. Eastop and A. McConkey.

Information for Students

(Information below can be adapted and supplemented as necessary.)

The following statements are in accordance with the BCIT Student Regulations Policy 5002. To review the full policy, please refer to: http://www.bcit.ca/files/pdf/policies/5002.pdf.

Attendance/Illness:
In case of illness or other unavoidable cause of absence, the student must communicate as soon as possible with his/her instructor or Program Head or Chief Instructor, indicating the reason for the absence. Prolonged illness of three or more consecutive days must have a BCIT medical certificate sent to the department. Excessive absence may result in failure or immediate withdrawal from the course or program.

Academic Misconduct:
Violations of academic integrity, including dishonesty in assignments, examinations, or other academic performances are prohibited and will be handled in accordance with the 'Violations of Standards of Conduct' section of Policy 5002.

Attempts:
Students must successfully complete a course within a maximum of three attempts at the course. Students with two attempts in a single course will be allowed to repeat the course only upon special written permission from the Associate Dean. Students who have not successfully completed a course within three attempts will not be eligible to graduate from their respective program.

Subject Matter by Week

Week(s)	Subject Matter
1–3	Psychrometry
4–8	Heat Transfer
9–12 (including Spring Break)	Evaporation
13–16	Distillation
17–18	Extraction
19–20	Gas Absorption

Examination Schedule

Week of	Topics Covered
February 27	Psychrometry and Heat Transfer
March 27	Evaporation
April 17	Distillation
May 22	Gas Absorption/Extraction/General Concepts of Unit Operations