



Unit Outline

School of Mechanical Engineering

School web site (if desired)

Process Module

CHPR 8503

6.0

Semester 1

Campus (Crawley)

Unit Coordinator: Professor Dongke Zhang FTSE

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In the **View** menu

Select **Header and Footer**.

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UNIT DESCRIPTION

Introduction

Welcome to the Unit CHPR 3530 Process Modules!

Process Modules, or Unit Operations, is a core subject in chemical engineering discipline and a historical landmark that separated Chemical Engineering from its parent disciplines, Industrial Chemistry and Mechanical Engineering in 1921. A uniqueness of the chemical engineering discipline is its systems approach towards a process that converts raw materials to final products that are wanted in the marketplace. The process comprises of a number process units, or process modules, performing specific operations as an integral part of the whole process.

The Process Modules unit will discuss the design and working principles common operation units and prepare our candidates for process synthesis and design and plant design project, the ultimate goal of our chemical engineering education.

The unit will be delivered by my colleagues, Professor Yee-Kwong Leong and Professor Terence Edwards.

Unit content

Following an introduction of the mass and heat transfer principles, Professor Leong will discuss topics of Gas Absorption; Liquid-liquid extraction; Multiple Effects Evaporators; and Distillation in the first 7 weeks.

Professor Edwards will cover topics of Heat Exchangers; Cooling Towers; and Gas – Solid Separations in Weeks 8 – 12 and will complete the unit with an illustration of the applications of the unit operations in the process of LNG Production Transport and Re-gasification

Learning outcomes

On completion of this unit, you should be able to:

- have mastered the fundamental science and working principles of Unit Operations;
- have possessed the basic knowledge and skills for the design of various operations units
- perform quantitative analysis of the process operation units, including scaling up/down for varying applications.
- conduct diagnosis and trouble-shooting of operations units.

Educational Principles

In this unit, you will be encouraged and facilitated to develop the following Graduate Generic Attributes, in accordance with the requirements of Engineers Australia

- understand the underlying physics and chemistry in each of the Unit Operations. In particular, this means developing the ability to recognise the fundamental role of heat and mass transfer in process design and recognising that the Conservation Laws of Energy and Mass underlie heat and mass transfer

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- the ability to apply knowledge of basic science and engineering fundamentals;
- the ability to utilise a system approach to design and operational performance;
- recognise that economic processing of source materials into products must maximise the efficient use of energy, and minimise waste;
- recognise that chemical engineering takes place in a real economy where practical considerations, and cost implications, will influence the design of process plant – the plant must be fit for purpose;
- an expectation of the need to undertake lifelong learning, and capacity to do so.

CONTACT DETAILS

Unit contact

Unit coordinator

name: Professor Dongke Zhang
email: Dongke.Zhang@uwa.edu.au
phone: 6488 8668
fax: 6488 1024

consultation hours: By appointment

Lecturer

name: Professor Yee-Kwong Leong
email: leong@mech.uwa.edu.au
phone: 6488 3602
fax: 6488 1024

consultation hours: By appointment

Lecturer

name: Professor Terry Edwards
email: terence.edwards@bigpond.com
phone: 9447 0462/0411 887 784
fax:

consultation hours: By appointment

TEACHING AND LEARNING RESPONSIBILITIES

Teaching and learning strategies

All governing and performance equations in Heat and Mass Transfer Unit Operations will be derived from first principles. This ensures the students understand the fundamental physics, and materials and energy balance principles underpinning the topics.

Charter of student rights

This Charter of Student Rights upholds the fundamental rights of students who undertake their education at the University of Western Australia.

It recognises that excellence in teaching and learning requires students to be active participants in their educational experience. It upholds the ethos that in addition to the University's role of awarding formal academic qualifications to students, the University must strive to instil in all students independent scholarly learning, critical judgement, academic integrity and ethical sensitivity.

Please refer to the guild website the full charter of student rights, located at http://www.guild.uwa.edu.au/info/student_help/student_rights/charter.shtml.

Student Guild contact details

The University of Western Australia Student Guild
35 Stirling Highway
Crawley WA 6009
Phone: (+61 8) 6488 2295
Facsimile: (+61 8) 6488 1041
E-mail: enquiries@guild.uwa.edu.au
Website: <http://www.guild.uwa.edu.au>

Use of student feedback

This unit is periodically evaluated and the feedback from students will be taken into account when the unit is updated.

ASSESSMENT MECHANISM

Assessment is based on a series of criteria depending upon the nature of the assignment.

Broadly these criteria relate to

- i) the approach to solving unit operations and design problems (including open-ended problems) in tutorials, assignment, test and examination. The steps and logic employed to solve a given problem will account for more mark than merely a correct answer. A correct answer to a problem will generally account for no more than 20% of the total mark for the problem.
- ii) presentation of laboratory reports and assignments. Report is an form of written communication. A report should be presented in logical and concise fashion that is understandable to whoever reads it

Assessment mechanism summary

Item	Weight	Due date
Tutorial/assignment (Professor Leong)	6	As specified in tutorial/assignment handout
Special assignment	5	As specified in the assignment handout
Laboratory reports	8	Two weeks after each lab
Tutorial/assignment (Professor Edwards)	6	As specified in tutorial/assignment handout
Test	20	Week 7
Final exam	55	

Assessment details

Exam (55%): There will be a 3 hour examination at the end of the course.

Tests (20%): There will be at least 1 Test during the semester as a form of continuous assessment of the students understanding of the subject.

Practicals (8%): There will be at least 1 practical. Students are required to attend the practical and present an individual report. The report is also regarded as a measure of the student ability to communicate effectively engineering topics and problems encountered. Safety is a very important consideration during practicals. Please see Safety Requirements for Engineering Buildings on the School of Engineering web pages

Tutorials and Assignments (17%): Students are required to attend all tutorial sessions and to hand in their tutorials and assignments on time.

Penalties for late assignments

For everyday late for any assignment you will lose 1/2 mark up to a maximum of the value of the assignment. The weekend will be counted as one day. Allowances will be made where a valid reason for late submission can be provided.

Special Considerations – deferral of tests and exam and extension of times

The university policy on special consideration has been altered so that from now on applications for consideration, deferral of tests or exams or extensions of time for assignments on medical, personal or other grounds must be lodged with the faculty office no later than three working days after the due date for the assessment in question. This rule will apply to all students, except in exceptional circumstances ('exceptional' does mean 'exceptional', not 'just didn't have time to get around to it'). Please ask all unit co-ordinators to see that this fact is included in the information students are given at the beginning of semester.

Ethical Scholarship, Academic Literacy and Academic Misconduct

Ethical scholarship is the pursuit of scholarly enquiry marked by honesty and integrity.

Academic Literacy is the capacity to undertake study and research, and to communicate findings and knowledge, in a manner appropriate to the particular disciplinary conventions and scholarly standards expected at university level.

Academic misconduct is any activity or practice engaged in by a student that breaches explicit guidelines relating to the production of work for assessment, in a manner that compromises or defeats the purpose of that assessment. **Students must not engage in academic misconduct.** Any such activity undermines an ethos of ethical scholarship. Academic misconduct includes, but is not limited to cheating, or attempting to cheat, through:

- Collusion
- Inappropriate collaboration
- Plagiarism
- Misrepresenting or fabricating data or results or other assessable work
- Inappropriate electronic data sourcing/collection
- Breaching rules specified for the conduct of examinations in a way that may compromise or defeat the purposes of assessment.

Penalties for academic misconduct vary according to seriousness of the case, and may include the requirement to do further work or repeat work; deduction of marks; the award of zero marks for the assessment; failure of one or more units; suspension from a course of study; exclusion from the University, non-conferral of a degree, diploma or other award to which the student would otherwise have been entitled.

Refer to the [Ethical Scholarship, Academic Literacy and Academic Misconduct](#) and individual Faculty policies.

Appeals against academic assessment

If students feel they have been unfairly assessed, they have the right to appeal their mark by submitting an Appeal Against Academic Assessment form to the Head of School and Faculty Office. The form must be submitted within **twelve working days** of the formal despatch of your unit assessment. It is recommended that students contact the Guild Education Officers to aid them in the appeals process. They can be contacted on +61 8 6488 2295 or education@guild.uwa.edu.au. Full regulations governing appeals procedures are available in the University Handbook, available online at <http://www.publishing.uwa.edu.au/handbooks/interfaculty/PFAAAA.html>.

TEXTBOOK(S) & RESOURCES

Unit Website

This unit will use WebCT (<http://webct.uwa.edu.au/>). You will need your student number and your PHEME password to login

Recommended/required text(s)

Coulson & Richardson, Chemical Engineering Vol 1, 5th Edn, Butterworth-Heinemann

Coulson & Richardson, Chemical Engineering Vol 2, 5th Edn, Butterworth-Heinemann

Warren L McCabe and Julian C Smith, Unit Operations of Chemical Engineering, McGraw Hill

Treybal, R.E., Mass Transfer Operation, McGraw-Hill (1981) 3rd Edn.

Additional/Suggested/Alternate text(s)

JP Holman, Heat Transfer, McGraw Hill

Software requirements

Software is not essential. However students are encouraged to learn HYSYS software package and use it to solve reactor design problems for comparison with theoretical solutions.

Additional resources & reading material

- **Books**

J Kidnay and William, R Parrish Fundamentals of Natural Gas Processing, CRC Press, Taylor and Francis Group, 2006

A Rojey et al, Natural Gas Production Processing Transport, Editions Technip, Paris, 1997

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UNIT SCHEDULE

Week # & date	Lecture 1 & 2 3-5pm	Tutorial 12pm Tuesday	Lecture 3 11pm Thursday		Comments	laboratories
1(23/2)	√		√		Prof Leong will be teaching from wk 1 to 7. Laboratory classes commence in wk 2.	
2 (2/3)	√	√	√			√
3 (9/3)	√	√	√			√
4 (16/3)	√	√	√			√
5 (23/3)	√	√	√			√
6 (30/3)	√	√	√			√
7 (6/4)	Test	√	√			√
Semester Break						
8(20/4)	√	√	√		i) Prof Edward will teach from wk 8 to 13.	
9(27/4)	Univ holiday	√	√			
10 (4/5)	√	√	√			
11(11/5)	√	√	√			
12(18/5)	√	√	√			
13(25/5)	√	√	√			

UNIT SCHEDULE

Week # & date	Topic	Lecture	Tutorial/workshop questions	Independent activity (e.g. readings)
1 23 Feb – 27 Feb	Introduction to the unit; Mass transfer principles	Introductory materials; Mass transfer by diffusion, Fick's first law; Mass transfer by bulk flow; Stefan Law; Relationship between mass transfer and diffusion coefficients, mass transfer velocities; Mass transfer across phase boundary; two film theory and The penetration theory		
2 2 Mar – 6 Mar	Mass transfer principles; Gas Absorption	Interphase Mass Transfer based on 2- film theory; local and overall mass transfer coefficient relationships Gas Absorption; packed tower Theory of height of column based on number and height of transfer unit; Gas Absorption; packed tower Height based on gas film and liquid film conditions; Height based on overall mass transfer coefficient, operating line equation	Practical 1 & 2; Tutorial 1	

<p>3 9 Mar – 13 Mar</p>	<p>Transfer units and Examples, Liquid-liquid extraction</p>	<p>Gas absorption and stripping via plate towers; Examples for non-linear equilibrium line; Liquid-liquid extraction; immiscible and partially miscible solvent systems Ternary diagram of partially miscible solvents</p>	<p>Tutorial 2</p>	
<p>4 16 Mar – 20 Mar</p>	<p>Liquid-liquid extraction</p>	<p>Calculation of number of theoretical stages for immiscible solvents extraction under concurrent and countercurrent flow conditions; Partially miscible solvent systems: cocurrent and counter current extraction</p>		
<p>5 23 Mar – 27 Mar</p>	<p>Liquid-liquid extraction; Multiple effects evaporators</p>	<p>Pack column immiscible solvent extraction; Multiple effects evaporators – material and energy balance of single effect evaporator; Triple effect evaporators calculation</p>	<p>Tutorial 3</p>	

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<p>6 30 Mar – 3 April</p>	<p>Multiple effects evaporators ; Distillation</p>	<p>Distillation; Crude refining and natural gas processing; vapor-liquid equilibrium for zeotrope; azeotrope Dalton, Raoult and Henry laws; Relative volatility, K values and DePriester Chart for hydrocarbons Flash distillation for binary and multicomponents systems, level Rule</p>	<p>Tutorial 4</p>	
<p>7 6 April – 10 April</p>	<p>Distillation</p>	<p>Multi-trays distillation, description, materials and energy balance, derivation of the Top and bottom operating lines, and q-line, condition of feed and reflux ratio effect; MaCabe-Thiele method for the determination of the theoretical number of plates; State of feeds or type of q-lines, minimum reflux ratio Fenske equation for the minium number of plates for binary and multicomponents distillation</p>	<p>Test 1</p>	

8 20 April – 24 April	Heat Exchangers	Review of heat transfer mechanisms - conduction, convection, radiation; Simple, single mode examples & calculations. Pink Bats & R values; Combined transfer examples. Fins. Thermal contact resistance	Test 1, Discussion and Feedback	
9 27 April – 1 May	Heat Exchangers	Design principles and calculations for flare systems in an FPSO	Tutorial 5	
10 4 May – 8 May	Heat Exchangers	Overall heat transfer coefficient. Double pipe heat exchanger; Shell&tube HXs. Compact heat exchangers: plate-fin, Printed circuit; Heat exchanger networks		
11 11 May – 15 May	Cooling Towers	Humidification operations. Humidity, dew points, Charts; Wet bulb temperature. Natural draft cooling tower; Forced draft cooling towers. Condensation: film and dropwise	Tutorial 6	

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<p>12 18 May – 22 May</p>	<p>Gas and Liquid Separation Technologies</p>	<p>3-phase gravity separators: design basis. Oil/water separation, Acid gas removal: Absorber stripper review, Membrane removal of CO₂ De-watering and dehydration: TEG contactors, molecular sieve towers</p>	<p>Field Trip: Heat Exchangers and Separators</p>	
<p>13 25 May – 29 May</p>	<p>LNG Production, Transport and Re- gasification</p>	<p>Offshore and onshore processing of natural gas, Extraction of natural gas components, Preparation of pipeline natural gas, LNG Trains. Cascade cycle, C3- MR cycle, cryogenic heat exchangers</p>	<p>Tutorial 7</p>	