Faculty of Engineering

GPE 3382B – Fundamentals of Green Process Engineering and Safety
Course Outline 2017-2018

Description
This course reviews the fundamental concepts of green/sustainable process engineering and process safety, and principles of green engineering and green chemistry. The general objectives are for the student to be aware of the environmental and safety issues associated with industrial processes, and to be able to minimize the environmental footprint, risk and hazards of existing industrial chemical processes, design alternative green processes with considerations of economics and safety.

Prerequisites
CBE 2207A/B or GPE 2214A/B, CBE 2224A/B or GPE 2218A/B, ECE 2208A/B or ECE 2238A/B.

Unless you have either the requisites for this course or written special permission from your Dean to enrol in it, you may be removed from this course and it will be deleted from your record. This decision may not be appealed. You will receive no adjustment to your fees in the event that you are dropped from a course for failing to have the necessary prerequisites.

Corequisite
CBE 3319 A/B

Anti-requisite
CBE 4467A/B.

Contact Hours
3 lecture hours, 1 tutorial hour, 0.5 course.

Instructor
Prof. Charles Xu (CMLP 2335) Telephone: 661-2121 ext: 86414 email: cxu6@uwo.ca

Undergraduate Assistant
(TEB 477) Telephone: 519-661-2131 email: cbeundergraduate@uwo.ca

Recommended Textbooks:

Course Notes

Course notes will be available for download from OWL, powered by Sakai.
https://owl.uwo.ca/portal

Units
SI units will be used in lectures and examinations.

General Learning Objectives

<table>
<thead>
<tr>
<th>A knowledge base for engineering</th>
<th>Individual and team work</th>
<th>Economics and project management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem analysis</td>
<td>Communication skills</td>
<td>Life-long learning</td>
</tr>
<tr>
<td>Investigation</td>
<td>Impact of engineering on society and the environment</td>
<td>Professionalism</td>
</tr>
<tr>
<td>Design</td>
<td>Ethics and equity</td>
<td>D</td>
</tr>
<tr>
<td>Use of engineering tools</td>
<td></td>
<td>D</td>
</tr>
</tbody>
</table>

Key:
I: Introduction,
D: Developing,
A: Advanced.
n.e.: not evaluated

- Understand the principles of green engineering & green chemistry
- Learn strategies to minimize waste generation
- Become familiar with chemical processes, their configurations and graphical representations and history of process development.
- Develop understanding of safety and hazard and environmental issues in plant design and operations.
- Apply engineering judgment in approximate design calculations by hand.
- Identify and formulate a process area of interest to the chemical, biochemical or the paracheemical industries.
- Process simulation using Hysys or other available softwares
- Search the academic and technical literatures for information on the selected process area.
- Present in formal reports, a review of the up-to-date state of the art for the selected process area, a simple process flow diagram and simple cost analysis.
- Understand most common safety hazards met in the chemical industry
- Understand ethics-based approach to business management decisions, and understand the importance of work safety for a business

Specific Learning Objectives

1. Introduction to green engineering and chemical process safety
At the end of this topic, students should be able to:
- Tell what green process engineering is, how it differs from conventional chemical and
environmental engineering;
• know about sustainability and clean production concepts;
• know the concepts of acceptable risk and inherent safety in plant design.

2. Principles of green engineering & green chemistry
At the end of this topic, students should be able to:
• understand the principles of green engineering, and use the green engineering methodologies to design green processes;
• understand the principles of green chemistry, and use the green chemistry methodologies to design green chemical synthesis pathways.

3. Strategies for waste minimization and pollution prevention
At the end of this topic, students should learn strategies to minimize waste generation,
• in reactors;
• in separation processes;
• in utility systems;
• in plant operations;
• via energy conservation;
• via materials recycling

4. Introduction to chemical process and plant design
At the end of this section, students should learn:
• Graphical representation of chemical processes
  o Different types of flow diagrams used for communication in chemical industry.
  o General rules followed and equipment symbols used in flow sheet drawing.
  o Use of software in flow sheet drawing.
• Design of standard equipment
  o Vapor-Liquid separators
  o Heat exchangers
  o Rotary equipment (Pumps and piping, fans, blowers, compressors)

5. Process safety, loss prevention and risk management
At the end of this section, students should become familiar with:
• Types of hazards in chemical process industry.
• Fire, explosion, toxic release.
• Construction of flammability diagram and its advantages in preventing fire and explosion
• Fire, explosion, toxic release.
• Design to prevent fire and explosion.
• Layer of Protection Analysis, LOPA, for risk migration
• Risk management procedures
• Pressure relief concepts and design.
• Health hazard
• Inherent safety in plant design

6. Case studies on major accidents and lessons learned in chemical industry
• Bhopal gas tragedy, Bhopal, India, 1984
• Monomers handling, Explosion of a rail car containing methacrylic acid, Houston, USA, 1988

7. Guest lectures on process safety and plant design
• Safety topics on the most common safety hazards met in the chemical industry (by Robert Ham, ARLANXEO Canada Inc.)
  o This guest lecture will cover several ca. 10 minute safety topics on some of the most common safety hazards met in the chemical industry from the perspectives of a chemical engineer working in a chemical company. Some safety topics will come up weekly in the "safety huddle" at ARLANXEO, and some originate in the "safety beacons" from the Center for Chemical Process Safety (CCPS) in the US.
• Responsible care and human factors in plant design (by Cam Dillabough and David Powell, U of T).
  o Responsible Care is grounded in the Responsible Care Ethic and adherence to it. It applies to health and safety as well as to environmental concerns. Many employers will consider the trade-off between costs and safety, as in a business decision, workplace safety has implications of expenses and time. However, employers must take ethics-based approach to their business management decisions, and understand the importance of work safety, and not view it as a sunk cost, but as an investment for a business. While management decisions based on the thinking of trade-off between costs and safety are prevalent in many industries and businesses, a C.I.A.C. member could never be verified as a Responsible Care company if this thinking is part of their management philosophy. The guest lecture on responsible care will cover positive anecdotal examples in the presentations.

8. Literature search and report writing for a green process
At the end of this section, students in group should be able to:
• Conduct on-line literature search on selected green processes.
• Present a written report based on an up-to-date review of the selected process area.
• Present a simplified process flow diagram (PFD) for the selected process.
• Present simple costs analysis simply based on the raw materials costs and the final products values.
• Present clean justification on why the selected process is a green process, referring to the principles of green engineering and green chemistry.

Evaluation
The final course mark will be determined as follows:
Assignments/In-class quizzes 10%
Report on literature review and conceptual design of selected process 20%
Mid-Term Examinations 30%
Final Examination 40%

The midterm exam will be a 2-hour exam while the final exam is a 3-hour exam covering all
aspects of the course. A one-sided “cheat” sheet can be used for the midterm exam while the final exam can use both sides.

Notes
1) Students must pass the final examination to pass this course. Students who fail the final examination will be assigned 48% if the aggregate mark is higher than 50%, or the aggregate mark.
2) Submitting your assignments: All assignments must be submitted electronically individual Drop Box on https://owl.uwo.ca/portal by the specified due time. 10% mark PER DAY OF LATE deduction will apply for a late submission.
3) There will be no make-up tests for assignments/quizzes or mid-term exam, if missed. If you are unable to write an assignment/quiz/test for medical or other compassionate reasons, you must provide the appropriate documentation to the instructor and the weighting of the evaluation items may be adjusted accordingly. Failure to provide the adequate documentation will result in a mark of 0 for the item missed.

Repeating All Components of the Course
In accordance with Senate and Faculty Policy, students who have failed an Engineering course (i.e. <50%) must repeat all components of the course. No special permissions will be granted enabling a student to retain laboratory, assignment or test marks from previous years. Previously completed assignments and laboratories cannot be resubmitted for grading by the student in subsequent years.

Use of English
In accordance with Senate and Faculty Policy, students may be penalized up to 10% of the marks on all assignments, tests, and examinations for the improper use of English. Additionally, poorly written work with the exception of the final examination may be returned without grading. If resubmission of the work is permitted, it may be graded with marks deducted for poor English and/or late submission.

Attendance
Attendance in lectures, tutorials and labs is mandatory. Any student who, in the opinion of the instructor, is absent too frequently from class or laboratory periods in any course, will be reported to the Dean (after due warning has been given). On the recommendation of the Department concerned, and with the permission of the Dean, the student will be debarred from taking the regular examination in the course.

Cheating
University policy states that cheating is a scholastic offence. The commission of a scholastic offence is attended by academic penalties, which might include expulsion from the program. If you are caught cheating, there will be no second warning (see Scholastic Offence Policy in the Western Academic Calendar).

Plagiarism
Students must write their essays and assignments in their own words. Whenever students take an idea or a passage from another author, they must acknowledge their debt both by using quotation marks where appropriate and by proper referencing such as footnotes or citations. Plagiarism is a major academic offence (see Scholastic Offence Policy in the Western Academic Calendar).

The University of Western Ontario has software for plagiarism checking. Students may be required to submit their work in electronic form for plagiarism checking.

**Conduct**
Students are expected to arrive at lectures on time, and to conduct themselves during class in a professional and respectful manner that is not disruptive to others.

**Sickness and Other Problems**
Students should immediately consult with the instructor if they have any problems that could affect their performance in the course. Where appropriate, the problems should be documented. The student should seek advice from the Instructor regarding how best to deal with the problem. Failure to notify the Instructor immediately (or as soon as possible thereafter) will have a negative effect on any appeal.

Please contact the course instructor if you require material in an alternate format or if any other arrangements can make this course more accessible to you. You may also wish to contact Services for Students with Disabilities (SSD) at 661-2111 x 82147 for any specific question regarding an accommodation.

**Notice**
Students are responsible for regularly checking their Western email and notices posted through OWL.

**Consultation**
Students are encouraged to discuss problems with their teaching assistant and/or instructor in tutorial sessions. Office hours will be arranged for the students to see the instructor and teaching assistants. Other individual consultation can be arranged by appointment with the appropriate instructor.

**Accreditation (AU) Breakdown**
- Engineering Science = 45%
- Engineering Design = 55%

January 2018/CX