Chemical Engineering 4N04

Engineering Economics and Problem Solving

Course Outline - Fall 2017

General Information

Instructor

Jake Nease	che4n4instructor@gmail.com	BSB/B105

Teaching Assistants

Lingyan Deng	che4N4TA@gmail.com	JHE/370
Jonathan Dorogin	che4N4TA@gmail.com	ETB/301/303
Nicola Muzzin	che4N4TA@gmail.com	JHE/133

Class Time and Location

Lectures	Mon/Wed/Thu	13:30-14:20	BSB/B135
Tutorial Group A	Tuesday	09:30-11:20	BSB/105
Tutorial Group B	Tuesday	14:30-16:20	JHE/A101
Tutorial Group C	Wednesday	08:30-10:20	ITB/139

Disclaimer

The instructor reserves the right to modify elements of the course during the term. If either dates or deadlines must be modified, reasonable notice and communication with students will be given, with explanation, and the opportunity to comment on changes will be possible. It is the responsibility of the student to check the website daily during the term and to note any changes.

About this Course

Please read carefully *- ChE 4N04 is a different course to any other Chemical Engineering course you have taken to this point*.

Formal Course Description

Making decisions about the design and operation of engineering systems with analyses emphasizing safety, economics, equipment performance, uncertainty, flexibility and monitoring. Includes the coalescence of the terms above for troubleshooting. Students will work individually and in groups on problem-based projects.

Prerequisites

Chemical Engineering 2004; 3P04; 3G04; 3K04; 3M04

Course Learning Objectives

Given a strong foundation in the fundamentals of Chemistry, Physics, Mathematics, and Engineering Science, it is the objective of this course to help you learn to apply these skills (together with safety, ethical, environmental, sustainability, and financial criteria) to solve practical and industrially relevant problems. The emphasis is on gaining confidence in applying what you know. This course gives you an opportunity to consolidate and apply skills learned in the extensive list of course prerequisites. The course is approximately half "chemical engineering" and half "problem solving and process skills." The course integrates technical skills and professional skills that you will apply for the rest of your career, whether you remain a chemical engineer or not. As a final note, 4N04 leads directly into your final design project in 4W04, where you will be expected to apply the skills practiced in this course along with new skills learned to complete a full design project from the ground-up.

With this thought in mind, those that complete 4N4 are intended to achieve these goals:

- Aim to become professional engineers that invest in lifelong learning
- Develop confidence in exploiting research resources (libraries, internet resources, and reference books), and judge the quality of these resources
- Develop the skill to learn on their own (self-directed learning, SDL): define your goal, investigate the topic and test/refine your learning
- Understand basic approaches for providing safety in process design and operation and realize that process safety is of paramount importance
- Understand engineering ethics and their role in professional engineering practice
- Evaluate, compare and contrast the financial attractiveness of alternative engineering decisions
- Thoroughly review a complex process system (via its process and instrumentation diagram) for all major categories of operability
- Recognize that process equipment does not operate exactly as designed and will experiences faults that must be handled in safe and reliable manners
- Know how to go about systematically troubleshooting a process by creating a hypothesis, performing experiments, and drawing valid conclusions
- Work effectively in group projects, especially building chairperson skills, preparing agendas and diagnosing team dynamics
- Clearly communicate by letter, formal report and email
- Be able to apply a systematic problem solving approach and cope with ambiguity and uncertainty
- Develop skills in time management for managing projects and other activities
- Understand economic principles as applied not only to engineering projects, but also personal finances

By the end of the course you will [hopefully!] be able to come back to this list and see that you've been given opportunities to try and use all of these skills.

The Purpose of 4N04

Up until this point, all of the courses you have taken in Chemical Engineering have taught you the fundamentals of being a Chemical Engineer both from technical (mass/heat transfer, balances, fluids, controls) and professional (collecting data, writing technical and lab reports) standpoints.

4N04 will build on these previously developed skills and have you apply them in a **group setting** while working on a comprehensive project. We will practice these group skills in smaller, tutorial-focused assignments as well.

Course References and Materials

There is no required textbook for this course. Rather, we will be using the materials developed over the last 30+ years by Dr. Don Woods and Thomas Marlin, and modernized by Kevin Dunn and myself. Links to past materials and references will be posted on the course A2L page and will be provided to you whenever necessary. I would only ask that you please respect the rights of the original authors of these documents and not share them with others outside of 4N04.

Some recommended texts are listed below. These are **not mandatory** but may serve as useful references for your course project (and for 4W04):

Author(s)	Title	Library Link	Amazon Link
Seider, Seader, Lewin & Widagdo	Product and Process Design Principles - Synthesis, Analysis and Evaluation	McMaster Library	Amazon
Turton, Bailie, Whiting, Shaeiwitz and Bhattacharyya	Analysis, Synthesis and Design of Chemical Processes	McMaster Library	Amazon
N. Lieberman and E. Lieberman	A Working Guide to Process Equipment	McMaster Library	Amazon
Perry and Green (Editors)	Perry's Chemical Engineers' Handbook (8th edition)	McMaster Library	Amazon
Uhlmann (and others)	Ullmann's Encyclopedia of Industrial Chemistry	McMaster Library	N/A
Woods	Process Design and Engineering Practice	McMaster Library	Amazon

You will likely use all kinds of other references throughout this project: articles, books, internet sources and so on. It is up to you to know how and when to use these resources and to reference them appropriately.

Please remember to use an appropriate reference style when using external resources, even if you are using a website.

Course Website and Material Distribution

This course has an Avenue 2 Learn course shell. All relevant assignments, lecture notes, vidoes, past materials, project information, and announcements will be made on A2L. It is expected that you will check A2L daily, and it is your responsibility to ensure that you are up-to-date at all times. All assignments and important documentation will also be shared with you **via Google Docs**.

Assignment submission will be **via Google Docs**, which is going to be a standard practice used for this course. There will be specific instructions on assignment and project submission and correspondence in a separate document, so please ensure that you read that closely. Furthermore, all assignments and project memos will be shared with you from myself and the TAs as Google Docs, so get used to the concept sooner rather than later! As a matter of fact, **this course outline was written using Google Docs!**

Course Format

Let's Set the Scene

In a method inspired by Kevin Dunn from years past, this course is going to act more like a workplace simulation than a straight-up instructor-student scenario. This will hopefully help get you some experience with industry projects and relationships as you head into the workplace beyond university. Let's call our company Ethereal Energies Inc.

There will be challenging assignments set by your manager (Jake) and colleagues (Lingyan, Jon and Nicola). These could easily consume a huge portion of your time. Your manager and his colleagues may seem to ask for more complicated answers than are humanly possible in the time available. Part of the learning experience in this course is for you to define the scope the problem and provide a solution given the available time. Scoping the problem requires using your group's judgement and consulting with your manager (he is busy though), so you should first try his colleagues. Based on this, your group will set goals, develop a feasible plan, and (hopefully) complete the tasks within the allotted time.

Group Work

A great deal of the work you will do in this course will be in groups of 5 students. You will be assigned a group **after the first class** and will be expected to work as a team throughout the remainder of the term.

Your group will consist of **yourself, [up to] three preferred team members** and **two other members assigned randomly by the instructor**. This is intended to emulate a real-world scenario where you don't have complete control over who you will work with for a given project. Please note that once the groups are finalized, *there will be no opportunities for changes*. Along with your preferred group members, you will be required to report **which tutorial you are able to attend (or both, if applicable)**. Tutorial attendance is mandatory (see the section on attendance below) and is thus a required meeting time for your group to work on assignments or components of your group project.

This experience will help you build your group skills, both as leader and supporter. If possible, the group should resolve conflicts based on established group norms. Important conflicts that cannot be resolved by the students should be discussed with myself as soon

as possible. You will establish what is effective and acceptable group behaviour at the start of the course.

Group submissions will have the names of all group members who participated. If any member was absent (or did not participate), this must be noted on the assignment. Do not submit the names of people who have not contributed: this is academic dishonesty.

Attendance

While with other courses it is quite acceptable to not attend classes, with this course, not attending classes, tutorials, and other events where group work is required would be equivalent of not showing up at work, and leaving your colleagues to carry your load.

This semester is very busy because you will likely be participating in employment interviews and company visits. This complicates course grading and impacts your group work. Follow this procedure please:

1. Gain the agreement of the members of your group that you can miss a course activity.
2. Submit a written explanation to the course instructor before the absence. Details regarding your absence must be provided. The instructor will reply in writing.

This procedure **does not** replace the standard approach of contacting the Associate Dean of Engineering for medical or family reasons; these MSAFs will be dealt with, as needed, by the instructor. However, no one will be excused from the SDL Project or final exam.

Feedback

Please feel free to give feedback personally to me at any time throughout this course. Since I am new to this whole "teaching" thing, especially when it comes to a senior course like 4N04, I am always looking to improve my methods and practices. If you would prefer to provide constructive feedback *anonymously*, feel free to use the anonymous survey below (also on the course A2L page) to do so. Here is the link to the Google Form.

Grading

The grading for this course will be tailored to the importance of the task. There will be one midterm, a final examination, and a self-reflection, which will be individual assessments. The remaining assessments will be group based:

- We require you to complete all group tasks in your selected groups. There are no exceptions to this rule: *individual hand-ins will not be graded*. Assemble a **single submission** for the group - the TAs will not grade loose sheets or any type of paper submission. All group submissions must clearly show the names and student numbers of the group members that actually contributed to the work. Do not add a name of a group member that did not contribute.
- The term work will depend to some extent on decisions during the semester; however, the course will not deviate greatly from the point distributions for the key graded tasks during the term, as outlined in the following table.

Task	Weight
Group submitted assignments and tutorial participation *Assignments worth 2-4% each*	24%
Group project (graded meeting, interim and final reports)	32%
Midterm test	15%
Final exam	25%
Peer evaluations and self reflection *Each peer eval is 0.5%* *Course reflection is 1%*	4%
TOTAL	**100%**

- Grades for the **project** will be determined based on the group's result and the student's individual contribution. The grade will be then be modified based on peer evaluation. Since the instructor is not able to observe your individual contribution to the group, we will employ a method successfully employed in the past by Kevin Dunn, which is described below
- Every student must regularly provide a confidential peer evaluation of all other members in his/her group. This evaluation will be completed electronically. Each student will have his/her grade modified by the following formula for the project:

$$\textit{Student Grade} = \textit{Group Grade} \times \sqrt{\frac{\textit{Student Average Peer Score}}{\textit{Group Average Peer Score}}}$$

- The modifier factor under the square root is 1.0 for middle-of-the road performance, but can be higher or lower than this, depending on peer-assessment
- Formative, **descriptive feedback is required in the peer evaluation**. This is to develop your skills at providing critique and development to your peers, as most of you will be in a position where you manage people in the future. Not providing this feedback will lead to individual penalty
- The graded tutorials and workshops provide (a) feedback to students and (b) performance measures for grading. These graded exercises do not require extensive preparation; just keep up with the material.
- All term work is due at the beginning of the class, unless otherwise specified. All material submitted must include a cover memorandum as defined in the course. The total grade for any task may be based entirely on the cover letter, at the discretion of the instructor. Substantial grades will be deducted for not following instructions *completely*; for example you may receive -20% for not including a cover letter on an item of work. The deduction is at the discretion of the TAs and instructor
- Wherever possible, the submissions are evaluated in terms of what would be expected in engineering practice. This applies to the professionalism and clarity used in presenting your results, accurate spelling and grammar, and to the reasonableness of your answer
- You, and your group, will receive the greatest benefit if you plan a strategy for the task where you **all** participate in *all* questions. A deeper understanding will come from

reviewing each other's work in the same way that an engineer's work is always reviewed by their colleagues in companies around the world

- Arrange to meet outside of class and review the work, discuss alternative approaches, and craft a single submission. You are defeating the purpose of the group-based assignment if you simply divide the task into sections and cut-and-paste a single submission without discussion. You also run the risk of losing marks due to any inaccuracies in your colleagues' work. Most importantly, you lose out on the learning opportunity of seeing your mistakes and group member's mistakes, and learning from them. You also will not develop group collaboration skills, which are critical to succeed in any work environment
- Innovative and free tools such as camera-based calling (Skype, FaceTime, *etc*) and free collaborative document editing tools (Google Docs, Microsoft SkyDrive, *etc*) allow within-group teamwork for occasions when your team cannot meet in person. Please make the most of these technologies, especially **google docs**, which will be the required avenue of submission for all assignment and project components
- No sharing of any work may be done between groups. This will be strictly enforced. Please ensure that you have read the University's academic integrity policy (part of which is reproduced in the "Academic Honesty" section below)
- This is a large class of about 100 students, so late hand-ins interfere with the ability to efficiently grade your assignments. Late assignments will be penalized by deducting 25% per day for every late day. A grade of zero will be given for submissions handed in after the solutions are posted (usually within 2 days of assignment hand-in)
- No make-ups will be given for any part of the course (midterm, assignments and tutorials)
- Each student will write the final exam individually. Any paper-based materials (textbooks, notes, *etc*) are allowed during the test and exam. Any calculator may be used during the test and exam
- The final percentage grades will be converted to letter grades using the Registrar's recommended procedure. Adjustment to the final grades may be done at the discretion of the instructor
- The final exam will be cumulative, based on the entire semester's material

Miscellaneous

The use of **electronic resources** is encouraged in the classroom and *recommended* in the tutorials. The tutorial room has some outlets for laptops, but try to bring charged tablets, computers or even phones with you whenever possible.

The course project and assignments MUST be submitted electronically via Google Docs. We are going to completely do away with paper submissions since they would be overwhelming for you and the TAs (save those print credits in Club 296 for 4W04!). It will thus be a good idea for you and your group mates to start working out of Google Docs right away so that you can collaborate from anywhere and at any time. There is a document on A2L detailing how to go about submitting ("sharing") your assignments and projects with the TAs and myself. You are, of course, welcome to use whatever software you like, but please respect the submission requirements.

The TAs and I are **happy to meet with you outside of class** whenever possible. Feel free to email the TAs and myself at the email addresses provided above, just bear in mind that we are busy.

Academic Integrity

You are expected to exhibit honesty and use ethical behaviour in all aspects of the learning process. Academic credentials you earn are rooted in principles of honesty and academic integrity.

Academic dishonesty is to knowingly act or fail to act in a way that results or could result in unearned academic credit or advantage. This behaviour can result in serious consequences, e.g. the grade of zero on an assignment, loss of credit with a notation on the transcript (notation reads: "Grade of F assigned for academic dishonesty"), and/or suspension or expulsion from the university. IIt is your responsibility to understand what constitutes academic dishonesty. For information on the various types of academic dishonesty please refer to the Academic Integrity Policy, located at http://www.mcmaster.ca/academicintegrity

The following illustrates only three forms of academic dishonesty:

1. Plagiarism, e.g. the submission of work that is not one's own or for which other credit has been obtained.
2. Improper collaboration in group work: this point is particularly important and will be strongly penalized in this course.
3. Copying or using unauthorized aids in tests and examinations.

Accessibility

The instructor aims to make this class accessible to all students. Please forward and optionally discuss any accommodation granted by Student Accessibility Services (SAS) with the instructor *before the third week of the course*. Please raise any other accessibility issues with the instructor as soon as possible, e.g. accessibility of the course website and course materials.

CEAB Attributes

In addition to the learning outcomes defined for this course above, the Canadian Engineering Accreditation Board (CEAB) requires that all departments fulfill standardized learning outcomes throughout an undergraduate engineering degree. These outcomes must be communicated to the students and the effectiveness of 4N04 at meeting these outcomes must be assessed at the conclusion of this course. The CEAB attributes for Che 4N04 fall 2017 are that the student:

- Has the ability to identify a range of suitable engineering fundamentals (including mathematical techniques) that would be potentially useful for analyzing a technical problem.
- Recognizes and follows engineering design principles.
- Has experience with techniques for generation of creative ideas such as brainstorming and structured inventive thinking.
- Is able to determine and include appropriate health and safety considerations.
- Has the ability to use of modern/state of the art tools.
- Is able to work in a group, taking a leadership role as appropriate and relinquishing the leadership role as appropriate.

- Understands the role of the engineer in society, especially in protection of the public and public interest.
- Understands legal requirements governing engineering activities (including but not limited to personnel, health, safety, and risk issues).
- Is aware of the PEO and the role of licensing.
- Is able to address uncertainties in the prediction of interactions on society and the environment in a structured and transparent manner.
- Applies the engineering code of ethics, understanding of the stakeholders: the individual, the employer, and the public.
- Possesses the ability to apply ethical frameworks and reasoning in situations where there may be conflicting interests among the stakeholders.
- Is able to apply economic principles in decision making.
- Can plan and effectively manage time, resources, and scope.
- Be able to critically evaluate and apply knowledge, methods and skills procured through self directed and self identified sources, including those that lie outside the nominal course curriculum.

Anticipated Schedule of Topics

The topics that we should be able to cover in 4N04 this year will include those in the following table. Note that the sequence that material is covered is subject to change!

Section	Topics

Section 01
Engineering Economics
 	
Estimated Dates
5 Weeks
(Sept 5th - Oct 6th)
	• Introduction to time value of money
	  ○ Cash flow balances
	  ○ Interest and discount rates
	  ○ Present and Future value
	• Methods of valuation
	  ○ Lang factors and breakeven points
	  ○ Net-present value
	  ○ Internal Rate of return
	• Taxation and depreciation
	• Sensitivity analysis
	• Process unit cost estimation
	  ○ Inflation/capacity/material/pressure factors
	  ○ Applications to chemical process industry

Section 02
Process Operability
 	
Estimated Dates
2 ⅓ Weeks
(Oct 19th - Nov 7th)
	• Introduction to operability
	  ○ Operating windows of common equipment
	  ○ Expanding and shrinking operating windows
	• Reliability
	  ○ Computing process reliability from equipment
	  ○ Improving reliability of equipment
	  ○ Connecting reliability to operability
	• Flexibility of process units
	  ○ The role of controls in flexibility
	  ○ Moving around the operating window
	• Transitions
	  ○ Startup/shutdown procedures
	  ○ Design allowances for startups and shutdowns

Section 03
Process Safety
 	
Estimated Dates
2 Weeks
(Nov 6th - Nov 16th)
	• Case studies of previous chemical plant disasters
	• The Six Layers of Safety and their Roles
	  ○ [1] Basic process control systems (BPCS)
	  ○ [2] Alarms and cues
	  ○ [3] Safety interlock systems (SIS)
	  ○ [4] Relief and material diversion
	  ○ [5/6] Containment and emergency response
	• **HAZOP**: **Haz**ard and **Op**erability Studies

Section 04
Troubleshooting
 	
Estimated Dates
1 Week
(Nov 20th - Nov 23rd)
	• Process of troubleshooting method
	• Troubleshooting documentation
	• Brainstorming symptoms and root causes
	• Case studies
	  ○ In-Class fired heater example
	  ○ TWO WEEKS of tutorial case studies (6 total)

Anticipated Schedule of Topics (Continued)

Section	Topics
Section 05 **Special Topics in Design** *Estimated Dates* **⅔ Weeks** (Nov 27th - Nov 29th)	● Process scheduling ○ Minimization of dead time ○ Batch time ● Role of optimization in process design ○ Superstructure design ○ Flexible designs for volatile markets
Section 06 **Professionalism and Ethics** *Estimated Dates* **⅔ Weeks** (Nov 30th - Dec 4th)	● Engineering Professionalism ○ Existence of the PEO ○ The role of licensing in the engineering practice ● Engineering Ethics ○ Existence of mobile truth ○ Ethical dilemmas and case studies ○ Identification, coalescence and communication of critical information to involved parties