CHEMICAL ENGINEERING 4C03/6C03
Statistics for Engineers
January-April, 2016

Instructor: Dr. Kyla Sask
saskkn@mcmaster.ca
Available by email and appointment

Teaching Assistants: Carla Abarca, abarcacp@mcmaster.ca, JHE 138-A
Felipe Pedro Gomes, gomesfd@mcmaster.ca, JHE 133

Class Times and Location: Mon. 12:30-1:20pm, Tue. 1:30-2:20pm, Thu. 12:30-1:20pm
First Class: Tuesday, January 5, 2016 @ 1:30pm
Building T13, Room 127

Disclaimer: This outline may be modified, by the instructor or university, as circumstances change.

ABOUT THE COURSE

Official Course Description:
Univariate statistics and process monitoring. Linear regression. Experiments: full and fractional factorial designs. Introduction to latent variable methods and other current statistical tools. Applications to relevant engineering problems. Interpretation of computer-based output.

Intended Learning Outcomes:
By the end of this course students will be able to:

- Understand that all data has variability: separate that variability into information (knowledge) and error (unknown structure, noise, randomness).
- Interpret confidence intervals and univariate data statistics (mean, median, histograms, significant differences).
- Fit and interpret a least squares model, the confidence limits and the model limitations.
- Design your own experimental program and then interpret experimental data.
- Use and react appropriately to process monitoring charts.
- Recognize the need for latent variable methods for engineering data.

Prerequisites:
A basic course in statistics that covers probability, means, variances, confidence intervals and linear regression. However, all of these topics are briefly covered in this course, focusing on their practical application to engineering problems.

Course Materials:
Course materials, assignments, quizzes, solutions and announcements will be posted on Avenue to Learn (http://avenue.mcmaster.ca/). Students are expected to login and check the site frequently. Materials from previous years of the course are permanently available from Kevin Dunn at http://learnche.mcmaster.ca/4C3. You may use these materials as a resource during the course and after you graduate.

Course Software:
Use of a computer is required in the course. The R-language (http://www.r-project.org/) will be used, and is a freely available software package that runs on Linux, Apple and Windows computers. The software is available in the 4th year Chemical Engineering computer labs. Minitab (you can rent a 6-month version very cheaply), MATLAB, or Python may be used as well; you should not use Microsoft Excel. R software tutorials are available at: http://learnche.mcmaster.ca/4C3/Software_tutorial.

Required Textbook:
There is no official course textbook. We will be using material from the previous instructor, Kevin Dunn's book, Process Improvement using Data. The book was written specifically for this course, and will be available as a PDF from the http://learnche.org website. It is your responsibility to print out these notes and bring them to class.

Recommended Readings:
If you would like to buy one book to supplement the course material, the Box, Hunter and Hunter book is highly recommended for its practical engineering perspectives on data analysis.

> G.E.P. Box, J.S. Hunter, and W.G. Hunter, Statistics for Experimenters – Design, Innovation and Discovery, 2nd edition, Wiley. ISBN: 978-0471718130.

A list of other reference texts is provided at: http://learnche.mcmaster.ca/4C3/Suggested_readings.

Course Topics:
The course is divided into 6 main sections, taught over 12 weeks.

1. *Visualizing data*: creating high-density, efficient graphics that highlight the data honestly.
2. *Univariate data analysis*: Probability distributions and confidence intervals
3. *Least squares regression modelling*: correlation, covariance, ordinary and multiple least squares models. Enrichment topics will be covered, time permitting.
4. *Design and analysis of experimental data* and response surface methods for continual process improvement and optimization.
5. *Process monitoring*, aka statistical process control (SPC), for monitoring process behaviour.
6. Introduction to *latent variable modelling*: a general overview of latent variable models and their use in (chemical) engineering processes.

Several enrichment topics are covered throughout the course: robust methods, cross-validation for model assessment, nonparametric methods, real-time application of the above methods, correlation and causality, missing data handling, Bayesian methods, nonlinear regression.

ASSESSMENT

Grading Scheme:

#	Component	Weight	Description
1	Assignments	20%	Expect approximately 6 or 7 assignments. Can be completed individually or in groups of 2 (6C03), or a maximum of 3 (4C03).
2	Quizzes	10%	Quizzes given periodically on Avenue to Learn to test knowledge of material. Expect 1 or 2 per course section.
3	Midterm Exam	15%	A written exam.
4	DOE Project	10%	A design of experiments project where you work in groups to plan and perform experiments of your choice, analyze the data and complete a report.
5	Participation	5%	Participating in discussion boards online by posting questions or responses. Must be of good quality.
6	Final Exam	40%	A written exam.

*6C03 students will have extra questions on all assignments, quizzes, exams and project.

Notes on Assessment:

Assignments

• We strongly encourage you to complete the assignments in groups of 2 or 3 members if you are in 4C03. For 6C03 students the group size can be 2 people (you, and one other person).

• You, and your group, will receive the greatest benefit if you each do all the questions yourselves. Arrange to meet and review your solutions, discussing various approaches.

• Assemble a single submission for the group - the TA's will not grade loose sheets handed in after the first submission. All group submissions must clearly show the names of the group members.

• You are defeating the purpose of the group-based assignment if you simply divide it into sections, one for each group member. This is definitely not recommended, because you are losing out on the learning opportunity of seeing your mistakes and the group member's mistakes, and learning from them.

• No sharing of any work may be done between groups for assignments. This includes handwritten documents and electronic files of any type. This will be strictly enforced. Please ensure that you have read the University's academic integrity policy (part of which is reproduced below).

• This is a large class of around 100 students, so late hand-ins interfere with the TA's ability to efficiently grade your assignments. Late assignments will be penalized by deducting 30% per day for every late day. A grade of zero will be given for submissions handed in after the solutions are posted. Note: a "day" in this outline refers to any day of the week, not only working days.

• Emergencies and such arise, so each person has 2 "late day" credits for assignments. So you can hand in one assignment 2 days late, or 2 assignments each one day late, without penalty.

• All assignments will be graded, and the mean of the best N - 1 assignments used to calculate the assignment grade. You should expect $N \approx 7$.

Midterm and Final Exam

• The midterm is optional and there is no make-up for it. If you choose not to write the midterm, or cannot write it due to illness or other reasons, then the usual approach will be followed: the percentage contribution from the midterm will be added to the final examination weighting.

• Any paper-based materials (textbooks, notes, etc.) are allowed during the midterm and the final exam.

• Electronic textbooks and resources are, unfortunately, not permitted at the midterm or final exam, but may be used during class time and for your assignments.

• Only the standard McMaster calculator may be used during quizzes and exams.

• The final exam will be cumulative, based on the entire semester's material.

Missed Work

• No make-ups will be given for missed assignments, quizzes or midterms. Assessments for which an MSAF is received may have an alternative piece of work prescribed, at the instructor's discretion, or the weight transferred to the final exam.

Grading Policies

• Grading of all work in this course will include contributions for clarity and organization of presentation. This is an important professional skill that you have now successfully developed since second year.

• 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.

Important Dates:

A list of tentative dates is below. Some changes will occur as the course progresses. Please check Avenue to Learn frequently for updates.

Date (2016)	**Description**
Tue. Jan. 5th	First class – overview of course content and administrative issues
February	Written midterm, date TBD
Feb. 15-19th	Midterm break
Fri. Mar. 11th	*Kipling*
end of March	DOE project due, date TBD
Thu. Apr. 7th	Last class – review of material prior to final exam
Apr. 12-29th	Final exams

POLICY STATEMENTS

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.

It 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 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.
3. Copying or using unauthorized aids in tests and examinations.

Academic Accommodation of Students with Disabilities:

Students who require academic accommodation must contact Student Accessibility Services (SAS) to make arrangements with a Program Coordinator. Academic accommodations must be arranged for each term of study. Student Accessibility Services can be contacted by phone 905-525-9140, ext. 2865 or e-mail sas@mcmaster.ca. For further information, consult McMaster University's Policy for Academic Accommodation of Students with Disabilities.

Privacy:

In this course we will be using Avenue to Learn. Students should be aware that, when they access the electronic components of this course, private information such as first and last names, user names for the McMaster email accounts, and program affiliation may become apparent to all other students in the same course. The available information is dependent on the technology used. Continuation in this course will be deemed consent to this disclosure. If you have any questions or concerns about such disclosure please discuss this with the course instructor.