The University of Western Ontario
Faculty of Engineering

DEPARTMENT OF CHEMICAL AND BIOCHEMICAL ENGINEERING

CBE 4494b -STATISTICAL PROCESS ANALYSIS
CBE 9420 – ADVANCED STATISTICAL PROCESS ANALYSIS

Course Outline 2009-2010

This course is for engineers involved with experimental investigation and interpretation of data. Basic, applied statistical concepts are reviewed. Regression analysis techniques for fitting and discrimination of theoretical models are discussed. Methods for design and analysis of experiments are examined, with emphasis on factorial designs, and response surfaces.

The general objectives will require the student to be able to:
- understand and apply basic applied statistical concepts to engineering problems
- use Matrix methods to develop linear least squares analysis and analysis of variance for both single and multiresponse systems
- understand and apply methods for nonlinear parameter estimation in both algebraic and differential systems
- apply Factorial and Response Surface Methods to experimental design

Prerequisites:
Statistical Sciences 2141a/b or 2143a/b or equivalent
Graduate student status or permission of the department (for CBE 9420)

Unless you have either the requisites for this course or written special permission from your Dean to enroll in it, you will 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.

Corequisites:
None

Antirequisites:
None

Contact Hourss:
3 lecture hours, 1 tutorial hours, 0.5 course.

Instructor:
Dr. A. Hrymak, (SEB 2008) Tel: 519-661-2111 ext: 82128 email:ahrymak@ uwo.ca

Required Text:
Applied Statistics and Probability for Engineers 4th Ed D.C. Montgomery and G.C. Runger
Wiley

You must have a copy of Minitab and the most convenient route is to rent or buy a licence on-line at
http://www.onthehub.com/minitab/minitab_english.htm

Course Notes:
Posted on WebCT

Lab Notes:
None

Reference Texts:
Box, G.E.P., Hunter, W.G. and Hunter, J.S., "Statistics for Experimenters", Wiley.
Draper, N.R. and Smith, H., "Applied Regression Analysis", Wiley.

Laboratory:
None

Units:
SI, British and US Engineering units will be used

General Learning Objectives

Knowledge Base	√	Individual Work	x	Ethics and Equity	x
Problem Analysis	√	Team Work	x	Economics and Project Management	x
Investigation	√	Communication	x	Life-Long Learning	x
Design	x	Professionalism	x		
Engineering Tools	x	Impact on Society	x		

Specified Learning Objectives:

Objectives:
1) To review fundamental statistical inference and uncertainty concepts.
    a) be familiar with normal, chi-squared and F and t distributions
    b) confidence limits
    c) hypothesis tests
2) To be able to fit models to data and to then judge the appropriateness of the models; the model fitting will cover linear models, nonlinear models and multi-response models.
    a) linear least squares
    b) ANOVA
    c) matrix methods
    d) joint confidence regions
    e) multi-response estimation
3) To provide an appreciation for the concepts of statistical process control.
4) To understand the concepts behind the design of experiments and to be able to set up appropriate designs in practice.
    a) understand the concept of design of experiments and confounding of factors
    b) set up full and fractional factorial experiments
    c) set up multi-level experiments and response surface methods

5) To provide an introduction to multivariate statistical methods for analyzing and using large databases commonly arising in science, engineering and business.

CBE 4494 / CBE 9420

Outline: *Note: timing of Assignments is tentative and subject to change*
Part I:
1) Review
   – measures of position (mean, median, mode)
   – measures of spread (variance, standard deviation)
   – measures of uncertainty (confidence intervals, hypothesis tests) (**Assignment 1**)
2) Statistical Process Control
   – philosophy
   – SPC charts (**Assignment 2)**
3) Empirical Modelling
   – Classes of models (linear, nonlinear, dynamic, steady-state, multi-response, empirical, first principles)
   – Steps in model building
   – Parameter estimation
   - linear regression from an optimization perspective
   - uncertainty in parameter estimates
   - testing for lack of fit
   - multiple linear regression (**Assignment 3)**
   - use of dummy variables
   - nonlinear regression (**Assignment 4)**
   - multi-response estimation
    - ridge regression

Part II
4) Design of Experiments (DOE)
   - Concepts behind DOE
   - Randomization and blocking
   - Factorial Designs
   - Fractional Factorial Designs (**Assignment 5**)
   - Response Surface Designs
   - Optimal Designs
5) Introduction to Multivariate Statistics (as time permits)
   - Introduction to Principal Component Analysis (PCA)
   - Troubleshooting processes using plant data (**Assignment 6**)
   - Multivariate SPC
   - Industrial applications
   - Introduction to Partial Least Squares (PLS)
   - Industrial applications of PLS

<u>**Evaluation:**</u>

Assignments	20%
Midterm Test	30%
Final Exam	50%

Grade adjustment techniques may be used.
For those enrolled in CBE 9420, there will be extra questions on assignments, Midterm Test and Final exam.

Note: All students must pass the final examination to pass this course.

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
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 or Associate Chair [Graduate] (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, Department Chair or Associate Chair [Graduate] if they have any problems that could affect their performance in the course. Where appropriate, the problems should be documented (see attached). The student should seek advice from the Instructor, Department Chair or Associate [Graduate]regarding how best to deal with the problem. Failure to notify the Instructor, Department Chair or Associate Chair [Graduate] immediately (or as soon as possible thereafter) will have a negative effect on any appeal.

Notice:
Students are responsible for regularly checking their email and notices posted on Instructors' doors.

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   = 50%
Engineering Design   = 50%

Revision of January 4, 2010/ah