

## STATISTICAL ASPECTS OF EXPERIMENTAL DESIGN

QA 726 Spring 2006 Tuesday 6:00 – 8:40 PM

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Office Hours: 4:00 – 5:30 PM Tuesday and by appointment.

Office hours provide you with an opportunity for personal discussion with me concerning course-related problems such as homework, clarification of classroom discussion, text interpretation, test grading, etc. If the formal hours are unsuitable for you, please make an appointment with me at a mutually agreeable time. I strongly urge you to take advantage of these hours.

Tests: There will be a midterm exam given on the sixth week of class. The midterm exam will have the character of a data analysis *project* in which you will be expected to exercise computational skills. The comprehensive final exam/project will be due on the day indicated in the university schedule. No one is exempt from either exam. If you cannot take the midterm at the time indicated due to a reason beyond your control, you must inform me in advance so that we may make an alternative arrangement. Failure to do so will result in a grade of zero for that exam.

Homework: Assignments of text (or other) problems will be given in class. You are welcome to discuss the solution of your problems with me during office hours. I strongly urge you to collaborate with your colleagues in a responsible manner in attempting these problems, that is each party contributing equally to any cooperative arrangement.

Grading: Midterm = 40%  
Final = 50%

The remaining 10% will be based on any 'intangible' sources that may reflect 'attitude' such as participation in class discussion, and helping with the SAS implementation of the computations and any assignments that may be collected.

Group Work Structure of the Course: After the first class, each student may join a work group. A work group will consist of at least two students, but no more than six. This work group will be maintained for the length of the quarter. The work group will cooperate in all work given during the quarter including practice problems, studying, and projects (midterm and final projects). All members of a group will share grades on any submitted work. All members are to contribute equitably to the shared workload, carrying a fair weight for the burden. Group-work is not an invitation to slouch! At the end of the quarter, members of each group will be asked to evaluate the contribution of the other work group peers on the basis of a number of criteria taking into consideration such factors as intellectual contribution, attendance at group meetings, mentoring and sharing knowledge, writing up the results, and running relevant SAS codes. The peer score will reflect, in some sense, an average over all of the work assigned as well as an average of the criterion above. Thus, a student in a work group who may have contributed much on one assignment, may not have contributed the majority of the work on another, yet still such work may be considered by other members to be meritorious "on the average".

Miscellaneous: The grade of Incomplete will be given only for fully documented medical conditions or other catastrophes as judged by me. You may drop the course without penalty up to Friday of the 8th week of the quarter (or whatever the date set by the University for such Eventualities). No special exams/projects, or assignments will be given at quarter's end for grade improvement. Students are responsible for all material, assignments and announcements made in class. All exams/projects will be carried out as described in the section on group work activity. The final exam/project will remain in my possession for two quarters. You should retain all other assignments or graded material throughout this course. If a notice of cancellation appears on the classroom door, or if you hear of such a cancellation, you must remain in the classroom for a period of ten minutes to confirm this action. I regard a student's attitude and interest to be a very important component in evaluation and I reserve the right to raise a grade based on my impression. You are strongly urged to suggest any improvements in the teaching or classroom procedure. Every student will obtain a **Blackboard** account by going to <http://blackboard.uc.edu/> on

the INTERNET. We will use Blackboard to communicate. All of the SAS manuals that you could possibly need are on this site (with the exception of the Littell, Stroup, and Freund book) as well as all of the class notes. All of the SAS recipes I use in class are there and much, much more. Please explore this site

Text: **Design and Analysis of Experiments**, Douglas C. Montgomery, 6<sup>th</sup> Ed.

References: **Analysis of Messy Data**, Milliken and Johnson, Vol. 1 – This is an excellent reference. Many of my notes come from this book

**SAS for Linear Models**, Littell, Stroup, Freund, 4<sup>th</sup> Ed. – I find this book to be the most helpful SAS reference for using PROC GLM and other procedures we will use. I strongly urge you to somehow find a copy.

**SAS manuals** (see below).

#### Additional Documentation and Other Resources:

We will be analyzing the data provided in the text problems and other problems. It is convenient to use a computer to aid in these analyses. Therefore you may wish to use SAS. There are several PC's in Lindner 215 and a few in the room 202 with these same SAS procedures available using SAS for Windows. Access to the room 202 is obtained by requesting that a consultant open the otherwise locked door for you. Computer labs all around campus in, e.g., Engineering, Education, etc. also have SAS installed. Using these machines carries the disadvantage of requiring your presence on campus but the computing environment is superior to using the mainframe which I am told no longer does have a facility for using SAS remotely via an FTP client. I suggest that you ask the UCIT consultants about this. But I also I suggest that you make the former choice for using SAS in any case. I will provide you with many 'recipes' for implementing the analyses, but for the most part, you will be able to refer to the SAS manual mentioned below for guidance. Note that you do not have to buy any SAS manuals. All of them are available on **SAS ONLINE Version 8.2** (the version I have) that you may access at the URL

<http://www.uc.edu/sashtml>. For **Version 9.1.3** the URL to visit is

<http://support.sas.com/onlinedoc/913/docMainpage.jsp>. All computer system inquiries may be addressed to the CBA computer consultants who should be well equipped in this regard. Two useful resources are the SAS Statistics manual and the **SAS/IML Guide** (all available on-line). The IML guide provides details on a very powerful matrix-based language with which programs for analyzing data from many designed experiments can be written. **SAS/STAT**, the SAS statistics manual contains documentation for the procedures such as PROC GLM and PROC MIXED that we will be using extensively. You can find paper copies of some of these SAS manuals in the computer consultants' office in the CBA or in other computer facilities around campus. But as I mentioned, the Blackboard site has all of the manuals you will need in .pdf format. Please to not try to print out the manuals. There are thousands of pages. While it is not necessary, some of may wish to purchase your own copy, if you will use this stuff as a professional or advanced graduate student.

#### Course Syllabus:

##### Introduction

Comparing several treatments-one factor experiments

Completely randomized design

Analysis of fixed effects model

Matrix approach to the analysis

Analysis of heteroscedastic data

Simultaneous inferences and multiple comparisons

\*Trend analysis using orthogonal polynomials (intro. to response surface methods)

Analysis of random effects model

Selecting the sample size

Analysis of covariance - one factor treatment structure in a completely randomized design

Factorial experiments

Two factor experiment in a completely randomized design

Meaning and importance of interaction

Meaning and importance of estimability

Meaningful contrasts  
 \*Using orthogonal polynomials to detect trends  
 Three factor experiments- fixed, mixed, and random effects  
 Importance of the expected mean square  
 'Manufactured' F-tests  
 Randomized block and related designs  
 Randomized complete block experiment  
 Latin square design  
 Efficiency of blocked designs  
 Analysis of contrasts in blocked designs  
 Incomplete block designs  
 \*Least squares means explained  
 Nested designs  
 Split plot designs  
 Split-split plot designs  
 Repeated measures designs

\* No lectures on these topics, only notes.

AIMS: The goals of this course are to introduce the students to the terminology, use and some underlying statistical principles of experimental design with particular emphasis on the correct analysis of data arising from designed experiments. We will discuss several experimental designs, their advantages and disadvantages, estimation of treatment effects, and significance testing. Computer examples and assignments using SAS procedures will complement the lectures. We will emphasize the data analytic and statistical aspects of the design of experiments in this course rather than the philosophy of science. The topics covered should be useful to students at the Masters and Ph.D. level who might be involved in the design of experiments or the collection, analysis and interpretation of data from designed experiments. This includes student in business, economics, the life and health sciences, engineering, social sciences, mathematics, and statistics. A good statistical methods course is a prerequisite and a course in applied regression is very strongly recommended as a prerequisite.

### APPROXIMATE CORRESPONDENCE BETWEEN SYLLABUS AND TEXT

The material to be covered in class corresponds very roughly to the following pages in the text. In addition, material in the notes will be covered which has no direct correspondence with pages in the text. This latter material has been synthesized by the instructor from various sources including, the primary reference text, **Analysis of Messy Data**, Milliken and Johnson, Vol. 1, SAS manuals, and his own notes. The first two chapters will not be covered by chapter 1 is recommended reading, while the material in chapter 2 is prerequisite, and should have been covered in your statistical methods course (a firm prerequisite for entry into this course). The order of the lectures will not correspond to the order of the chapters in the text. For example, the material on blocked experiments will follow material on factorial designs.

<u>CHAPTER</u>	<u>PAGES</u>
1(Reading only)	1-22
2(Prerequisite stuff)	23-55
3	60-118 the supplemental stuff is recommended. Some is in my notes.
4	119-159 "efficiency" in supplement is recommended...in notes too.
5	160-202 leaving out section 5-5
13	484-524
14	525-558
15	559-562, 574-592