STAT 441

Approval for this course is undergoing a fast-track review. Attached is the description for STAT 526, which will be a co-convened graduate course offered with the proposed undergrad STAT 441.
Graduate Course Change  
Changes Listing in Catalog  
Montana State University

| Mathematical Sciences L&S Stat Course Number |
|---------------------------------------------|-------------------------------------------------|
| Dept. College Rubric Course Number |

In the spaces below, please indicate only the changes for the current on-line catalog at www.montana.edu/wwwcat/courses/courses2.html. Please attach a separate sheet or any accompanying request forms (i.e. New Course Request Form, Delete Form) indicating the reasons for any substantive (i.e., non-editorial) changes and clarifying anything that might be unclear from this cover sheet.

Which semester and year should this change begin in? Spring 2013

Course Title (for catalog)

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<th>EXPERIMENTAL DESIGN</th>
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Course Title (for schedule – maximum of 22 characters)

Frequency Offered: ☐ Annual ☐ Alternate Years if alternate, starting year:______

Semesters(s) Offered: ☐ Sum ☐ Fall ☐ Spring

Credits by Mode of Instruction: Lecture: 3 Seminar:______
Independent Study:______ Lab/Studio:______
Recitation/Discussion:______

Total Credits: 3

Prerequisite course(s) (When listing multiple prerequisites, please be clear about whether the courses are all required (separated by ‘and’) or if only one is required (separated by ‘or’):

| Stat 410 and Math 221 or Math 333 or Math 441 |

Co-requisite Courses:

| None |

Course Description (40 word limit): If there is a change in the course description, please attach the typed edited copy in which deletions are shown with a strikethrough (or highlighted in red) and additions are in bold (or highlighted in yellow).

An introduction to the design and analysis of experiments: topics include analysis of variance methods, matrix forms, multiple comparisons, fixed and random effects, factorial designs, balanced complete and incomplete blocking designs, designs with nested effects, and split plot designs.

Person Initiating This Request: John Borkowski  
Phone: 994-4606  
e-mail: jobo@math.montana.edu

Approval

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<td>John Borkowski 9/20/12</td>
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Stat 426/526  Experimental Design  Spring 2013

Instructor: John Borkowski  Email: jobo@math.montana.edu
Office: Wilson 2-263  Office Phone: 994-4606

Prerequisites: Stat 426: Stat 410 and (Stat 221 or Stat 333 or Stat 441)
Stat 536: Same as Stat 426 plus the consent of the instructor

Course Description:

An introduction to the design and analysis of experiments: topics include the analysis of variance (ANOVA), matrix forms, multiple comparisons and contrasts, models with fixed and random effects, factorial designs, balanced complete and incomplete blocking designs, designs with nested effects, split-plot and split-split plot designs.

Required Text:

- The students will be given an extensive set of course notes in pdf format.

Schedule: MWF 2:10 - 3:00 in Wilson 1-153

Course Evaluation:

There will be approximately 8 homework assignments, two exams, and a final project

Midterm Exam  20%
Final Exam  20%
Final Project  20%
Homework Assignments  40%

Differences between Stat 426 and Stat 526:

Although the MWF lectures are the same, the expectations on the homework assignments, the exams, and the project will differ depending on your level of enrollment. Specifically, for each homework assignment and for each exam, additional questions will be included for students enrolled in Stat 526. These questions will be more theoretical in nature requiring more advanced math/stat skills to complete. Thus, due to the differences in difficulty levels of the homework assignments and the exams, the grading rubrics will differ between these co-convened courses.
Learning Objectives:

Success of the course will be judged based on training students to
- Identify the type of experimental design from a description of the experiment.
- State the appropriate research scenario for implementing each design.
- Perform a sound statistical analysis for data arising from each design.
- Summarize results from a data analysis in report form.

Assessment of these learning objectives will be documented via the homework assignments, exams, and the final DOE project.

Additional Background for the Course Offering:

This course has not yet been offered at the 400-level, but has been offered for the 20+ years I have taught it as the graduate level Stat 526 course. The enrollment in Stat 526 has typically been around 5 to 10 graduate students. By modifying the course requirements, the new Stat 426 will enable undergraduate mathematics majors under the statistics option to now take a course devoted entirely to the design and analysis of experiments. The proposed enrollment cap of 20 students is based on the maximum allowable number of students who can feasibly present final design of experiments projects. The instructor, Professor John Borkowski, has been a member of the Department of Mathematical Sciences since 1991.

This course has never been offered previously as Stat 280 or Stat 480. Prior to 2008, however, the curriculum for the statistics option for students majoring in mathematics included Stat 41C (Regression) and Stat 412 (Design of Experiments and Analysis of Variance). The contents of these courses were then changed and offered as co-convened courses Stat 410/511 (Methods of Data Analysis I) and Stat 412/512 (Methods of Data Analysis II). These courses were designed to meet both the needs for training our own majors as well as the needs of graduate student researchers from other disciplines. Although these courses have been well-received with continually increasing demand each year, there is no longer a 400-level statistics course devoted exclusively to the design of experiments for the students in mathematics under the statistics option as well as students with strong mathematics or statistics backgrounds.

The proposed Stat 426 course will fill the need for a mathematically and statistically rigorous undergraduate applied statistics course in the design and analysis of experiments. It will also become a required course for mathematics majors under the undergraduate statistics option. It will not require any additional resources.

The following is a draft of content to be included in the proposed syllabus.
Review Information for Stat 426 (Experimental Design):

Experiments are performed by researchers in all areas of scientific inquiry with the goal of gaining knowledge of the relationship between experimental treatments and responses of interest. The first and most important step in an experimental strategy is to state clearly the objective of the experiment. The objective of the experiment can be thought of as a very precise answer to the question "What do you want to know when the experiment is complete?" Once this question is best answered, the likelihood of selecting the best design will be maximized.

Unfortunately, experimenters who devote insufficient time to this step often discover only after the experiment is run that the data are also insufficient to meet their research objectives. Only after such a frustrating experience will most researchers consider the importance of the experimental design before running their next experiment. This course will provide an introduction to methods for the design and analysis of experimental data.

The introduction to the course will include a review of the basic principles considered in properly designed experiments: random selection, random assignment, randomized run order, replication, and blocking. During the rest of the course we will cover a variety of experimental designs and techniques to be used in an analysis of the results. For each design we will:

- Define the corresponding mathematical model.
- Discuss the partitioning of the total sum of squares.
- Relate expected mean squares to F-statistics.
- State and test hypotheses and find estimates of effects.
- Check model adequacy with diagnostics.

The focus throughout Stat 426 will be on the application of designed experiments. That is, emphasis will be on design selection, statistical methodology, and interpretation of statistical analyses of experimental data. There will also be coverage (albeit limited) of the relevant underlying theory commensurate with the course prerequisites. Students enrolled in the co-convening Stat 536 will be required to engage in a more in-depth study of the related theory as additional components to homework assignments, exams, and the final project.

Students will be evaluated based on homework assignments, two exams and a final design of experiments (DOE) project. The SAS and R statistical packages will be used extensively. For the DOE project, the student will

- Propose and run an experiment. This proposal will include a description of the experimental factors and response(s) of interest and the objectives of the experiment. Once the student is informed that his/her proposal is acceptable, the student will do the following.
- Run the experiment, analyze the data, and present and interpret results in a report.
- Give a class presentation of the results.

The following Course Outline lists the major topics to be covered in Stat 426.
Course Outline:

1. Introduction to Experimental Design Principles Experiments with a Single Factor
   1.1 The Statistical Model and Parameter Estimation
   1.2 Residual Diagnostics for Checking Model Adequacy
   1.3 Decomposition of Total Sum of Squares, Expected Mean Squares
   1.4 Matrix Forms
   1.5 Contrasts and Multiple Comparison Tests
   1.6 The Random Effects Model

2. Further Topics On Single Factor Experiments
   2.1 Tests for Homogeneity of Variance and Normality.
   2.3 Transformations
   2.4 Simple Repeated Measures Design
   2.5 Sample Size Determination

3. Designs Involving Blocking
   3.1 Randomized Complete Block Designs
   3.2 Latin Square Designs
   3.3 Balanced Incomplete Block Designs
   3.4 Design Efficiency
   3.5 Sample Size Determination

4. Factorial Designs with Fixed Effects Only
   4.1 Dealing with Significant Interactions Among Factors
   4.2 Residual Diagnostics for Checking Model Adequacy
   4.3 Sample Size Determination
   4.4 One Observation Per Cell Designs
   4.5 Unbalanced Designs

5. Factorial Experiments with Random Effects
   5.1 Random and Mixed Effects Models
   5.2 Expected Means Squares
   5.3 Exact and Approximate F-tests
   5.4 Estimation of Variance Components

6. Nested and Split-Plot Designs
   6.1 Multi-Stage Nested Designs
   6.2 Designs with Nested and Crossed Factors
   6.3 Designs with Split-plotting.
   6.4 Replicated Latin Square Designs

The required text will be Design and Analysis of Experiments, 8th Edition (2010), by Douglas Montgomery, Wiley. The students will also be given an extensive set of course notes in pdf format that I have prepared and routinely revised for the past 20 years.