ISE 610 Advanced Design of Experiments and Quality Engineering
FALL 2017

ISE 610
Fall 2016
Lecture: MW 10:00-11:20pm
Room: KAP 163
Web site: blackboard.usc.edu

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PREREQUISITE: ISE 225 Engineering Statistics I (or equivalent)

COURSE OBJECTIVE: This course will present the advanced topics in engineering statistics involving Design of Experiments and Advanced Quality Engineering.

TEXT: FOLLOWING REFERENCE BOOKS WILL BE USED

1. Wu & Hamada, *Experiments: Planning, Analysis and Optimization*, 2009, John Wiley, ***Second edition***.
2. SUPPLEMENTAL READING MATERIALS

SOFTWARE: Using statistical software is mandatory in your class project and some of your homework assignments. At your convenience, you could choose R, Minitab, Matlab, or Excel. A powerful statistical software R, which is free for download at www.r-project.org, will be demonstrated for problem solving in the class. PhD students are strongly recommended to use R.

TA & OFFICE HOURS: TBD

SEMESTER CALENDAR

August 21, first day of class
September 4, Labor Day
Monday, October 23, Midterm Exam
November 22-26: Thanksgiving
December 1, last day of class
Monday, December 11th, Final Exam, 8:00-10am

TOPICS:

1. *Basic principles and introduction to regression analysis (Chapter 1)*
   - Lecture 1: Introduction of course policy, DOE & brief introduction of ***R***
   - Lecture 2: Introduction of ***R***, example of using ***R*** to fit a linear model
   - Lecture 3: ***R*** reference card, introduction of linear model and simple linear regression. Show examples of hand calculation.
   - Lecture 4: Brief review of variance, hypothesis testing, *t*-test and confidence interval, and Multiple regression. Show examples of hand calculation.

- Lecture 5: Multiple regression, *F* test, examples of using ***R***. Show examples of hand calculation.

2. *Experiments with a single factor, analysis of variance (Chapter 2)*
   - Lecture 6: One-way ANOVA (introduction, ANOVA decomposition)
   - Lecture 7: One-way ANOVA (Multiple comparison, Linear quadratic effects, residual analysis). Show two examples of doing ANOVA by ***R***.

3. *Experiments with more than one factor (Chapter 3)*
   - Lecture 8: Paired comparison & randomized block design
   - Lecture 9: Two-way layout, Latin square design, balanced incomplete block designs, using ***R*** to do analysis

4. *Full factorial experiments at two levels (Chapter 4)*
   - Lecture 10, Transformation of response, factorial design at two levels
   - Lecture 11: Factorial effects and plots, effect estimation, regression model, half-normal plot, two-step procedure
   - Lecture 12: Show examples of using ***R*** to compute factorial effects, to plot half-normal and interaction plots. Design of 2^k factorial experiments in 2^q blocks, ANOVA vs. factorial designs

5. *Fractional factorial experiments at two levels (Chapter 5)*
   - Lecture 13: Effect aliasing, resolution, and minimum aberration
   - Lecture 14: Analysis of fractional factorial experiments, follow-up experiments
   - Lecture 15: Design of 2^{k-p} fractional factorial design, blocking effects

6. *Factorial experiments at three levels (Chapter 6)*
   - Lecture 16: Two-step procedure, 3^k full factorial designs, orthogonal component decomposition
   - Lecture 17: 3^{k-p} fractional factorial designs, defining relation, aliasing groups, minimum aberration
   - Lecture 18: Simple analysis methods, linear-quadratic decomposition, variable selection

7. *Response Surface methodology (Chapter 10)*
   - Lecture 19: Introduction to response modeling (sequential principles), steepest ascent search
   - Lecture 20: Curvature check, central composite designs

8. *Robust parameter design for product and process improvement (Chapter 11&12)*
   - Lecture 21: Robust parameter design perspective, noise factors, control-by-noise interaction
   - Lecture 22: Experimentation strategies (cross array vs. single array), modeling strategies (location and dispersion modeling vs. response modeling), Taguchi's signal-to-noise ratio

9. *(**Week 14-15**) Advanced topics in Quality Control (Supplementary materials)*
   - Lecture 23 & 24: Time series modeling, multivariate statistical quality control
   - Lecture 25 & 25: Advanced Topics in Shape Engineering and Nanomanufacturing

GRADING POLICY

Homework: 30%

Midterm exam on (in class): 30%
Final exam on : 30%
Class project: 10%

Project proposal and final project will be presented in class. Den students could involve by upload to video to blackboard.

CLASS POLICY

- For **on-campus** students, assigned homework will be collected **in class**. Homework is due one week after it was assigned. ***No late homework will be accepted in general.***
- Midterm exam can be taken on or before the scheduled exam date.
- Per instructions of USC final examinations schedule (http://classes.usc.edu/term-20163/finals/), ***final exam*** can only be given on .
- Both exams will be closed book, closed notes. One page (8 ½ x 11) formula sheet can be used. Be sure to bring your calculator. There will be ABSOLUTELY NO SHARING among students of books, formula sheets, or calculators.
- Please show steps in your work in order to gain partial or full credits.
- If you believe there was an error in the grading of an exam, then you can submit the entire exam to the instructor requesting to re-grade. This must be done ***within one week*** from the date the exam was returned. The entire exam will be re-graded, so that you may gain, or lose, points by resubmitting.
- During class time, please ***turn off*** all cell phones, beepers and pagers.
- Students are responsible for all information conveyed during class and on Blackboard (www.uscden.net). It is the student's responsibility to make sure they are receiving their emails related to the class.
- Always bring your textbook to class! Also bring your calculator, notebook, pencils/pens, eraser, and course syllabus.
- If there is any discrepancy between class policy and DEN or USC policy, we will follow DEN/USC policy.

PROJECT GUIDELINE

Please form a team of two or three students. In the final project report, all team members should sign and state that they contribute to their project roughly equally. Every member will receive the same grade on the project.

All reports should be typewritten and printed out for handing in. The report should not exceed 20 pages. (12 point, double space, Appendix does not count to 20 pages.) The report must have a professional appearance. Clarity and thoroughness of the analysis, and good use of the English language, including grammar, spelling and punctuation, are considered in grading the project.

Final project report includes project objective, problem statement, solutions, conclusions, and appendix if needed. The report should describe the background, any assumptions made, the analysis used to analyze the data, and the appropriate results. Explanation, interpretation, and justifications are required. Computer output should be included in an appendix and the description of the outcome/results included in the text of the report.

SAMPLE CLASS PROJECT

- **Example 1 on 3D printing experiments**: Optimization of surface roughness for Fused Deposition Modeling: Fused Deposition Modeling (FDM) is a popular 3D printing process to produce 3D objects directly from CAD models. One drawback of FDM is the seam lines between layers will impact on the surface roughness of printed parts. The team selects the lifting gap of extrusion head in the vertical direction, speed of extrusion head in the horizontal direction, heating temperature of the nozzle orifice, feeding speed of materials and environment humidity as experimental factors. The team will identify the significant factors and the optimal settings to minimize surface roughness.
- **Example 2 on Aluminum Pre-heating to identify ideal furnace loading procedures**: The project aims to identify the furnace loading factor levels that result in the greatest aluminum heating throughput for a metal forging facility. Aluminum parts need to be heated prior to forging. Heating capacity is limiting throughput and revenue. Insufficient heating causes delays in forging, further impacting revenue. Heating capacity is affected by environmental factors, equipment specifications, and loading strategy. The team identifies the optimal loading procedure that results in 19.6% improved heating rate/ throughput and $39.2M annual revenue.
- **Example three on microwave popcorn experiments:** The team aims to find the significant factors and their settings (recipe) to make popcorns.

Academic Conduct

Plagiarism – presenting someone else's ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in *SCampus* in Section 11, *Behavior Violating University Standards* https://scampus.usc.edu/1100-behavior-violating-university-standards-and-appropriate-sanctions. Other forms of academic dishonesty are equally unacceptable. See additional information in *SCampus* and university policies on scientific misconduct, http://policy.usc.edu/scientific-misconduct.

Discrimination, sexual assault, and harassment are not tolerated by the university. You are encouraged to report any incidents to the *Office of Equity and Diversity* http://equity.usc.edu or to the *Department of Public Safety* http://capsnet.usc.edu/department/department-public-safety/online-forms/contact-us. This is important for the safety of the whole USC community. Another member of the university community – such as a friend, classmate, advisor, or faculty member – can help initiate the report, or can initiate the report on behalf of another person. *The Center for Women and Men* http://www.usc.edu/student-affairs/cwm/ provides 24/7 confidential support, and the sexual assault resource center webpage http://sarc.usc.edu describes reporting options and other resources.

Support Systems

A number of USC's schools provide support for students who need help with scholarly writing. Check with your advisor or program staff to find out more. Students whose primary language is not English should check with the *American Language Institute* http://dornsife.usc.edu/ali, which sponsors courses and workshops specifically for international graduate students. *The Office of Disability Services and Programs* http://sait.usc.edu/academicsupport/centerprograms/dsp/home_index.html provides certification for students with disabilities and helps arrange the relevant accommodations. If an officially declared emergency makes travel to campus infeasible, *USC Emergency Information* *http://emergency.usc.edu* will provide safety and other updates, including ways in which instruction will be continued by means of blackboard, teleconferencing, and other technology.