



UNIVERSITY OF PUERTO RICO
MAYAGÜEZ CAMPUS
COLLEGE OF ENGINEERING
INDUSTRIAL ENGINEERING DEPARTMENT



COURSE SYLLABUS

General Information

Course Number: ININ 4027
Course Title: **Design and Analysis of Engineering Experiments**
Credit-Hours: Three

Course Description

Fundamental principles in the design and analysis of engineering experiments: randomized blocks, latin squares, split plots, factorial experiments; fractional factorials; confounding and response surface methodology.

Prerequisites

ININ 4020 - Applied Industrial Statistics

Textbook and References

- Montgomery, D. C., 2004, **Design and Analysis of Experiments**, 6th Edition, John Wiley and Sons.
- Hicks, C. R., 1999, Fundamental Concepts in the Design of Experiments, 5th Edition, Holt, Rinehart & Winston.
- Box, G. E. P., Hunter, W. G. J., and Hunter, S., 1978, Statistics for Experimenters, John Wiley and Sons.
- Anderson & McLean, 1974, Design of Experiments & Realistic Approach, Marcel Decker, New York.

Course Goals

- The student should learn the main principles of analysis of variance. Such as hypothesis testing, confidence interval, and sampling errors.
- The student should learn and understand the basic principles of experimental design such as factors, levels, sample size, randomization, replication, confounding, blocking, folding over, and composite design.
- The student should recognize when a problem can be solve using statistical experiments.
- The student should select and conduct the appropriate experimental design for a particular problem.
- The student should be able to analyze and interpret the experimental results.
- The student should apply experiments design and analysis to identify the source of variability and tune means on target values.
- The student should learn how to use computer software to design an experiment and analyze experimental data (SAS, Stat graphics, Minitab, or S plus)

- The student must use the fundamental concepts of designing an experiment and performing data analysis to a practical application. The student should develop a final report that describes problem definition, design of experiment, data collection, data analysis, identify principal factors, search for the optimal levels, validation of results, conclusions and recommendations.

Department/Campus Policies

Class attendance: Class attendance is compulsory. The University of Puerto Rico, Mayagüez Campus, reserves the right to deal at any time with individual cases of non-attendance. Professors are expected to record the absences of their students. Frequent absences affect the final grade, and may even result in total loss of credits. Arranging to make up work missed because of legitimate class absence is the responsibility of the student (Bulletin of Information Undergraduate Studies)

Absence from examinations: Students are required to attend all examinations. If a student is absent from an examination for a justifiable reason acceptable to the professor, he or she will be given a special examination. Otherwise, he or she will receive a grade of zero or "F" in the examination missed (Bulletin of Information Undergraduate Studies).

Final examinations: Final written examinations must be given in all courses unless, in the judgment of the Dean, the nature of the subject makes it impracticable. Final examinations scheduled by arrangements must be given during the examination period prescribed in the Academic Calendar, including Saturdays (see Bulletin of Information Undergraduate Studies).

Partial withdrawals: A student may withdraw from individual courses at any time during the term, but before the deadline established in the University Academic Calendar (see Bulletin of Information Undergraduate Studies).

Complete withdrawals: A student may completely withdraw from the University of Puerto Rico, Mayagüez Campus, at any time up to the last day of classes (see Bulletin of Information Undergraduate Studies).

Disabilities: All the reasonable accommodations according to the Americans with Disability Act (ADA) Law will be coordinated with the Dean of Students and in accordance with the particular needs of the student.

Ethics: Any academic fraud is subject to the disciplinary sanctions described in article 14 and 16 of the revised General Student Bylaws of the University of Puerto Rico contained in Certification 018-1997-98 of the Board of Trustees. The professor will follow the norms established in articles 1-5 of the Bylaws.

Sexual Harassment: Certification 130-2014-2015 states: Sexual harassment in the workplace and in the study environment is an illegal and discriminatory act and is against the best interests of the University of Puerto Rico. All persons who understand they have been subject to acts of sexual

harassment at the University of Puerto Rico may file a complaint and request that the institution investigate, where necessary, and assume the corresponding action by the university authorities. If the complainant is a student, he or she must refer his or her complaint to the Office of the Student Ombudsperson or that of the Dean of Students.

Hostigamiento Sexual: La Certificación 130-2014-2015, indica: El hostigamiento sexual en el empleo y en el ambiente de estudio es una práctica ilegal y discriminatoria, ajena a los mejores intereses de la Universidad de Puerto Rico. Toda persona que entienda ha sido objeto de actuaciones constitutiva de hostigamiento sexual en la Universidad de Puerto Rico podrá quejarse para que se investigue, de ser necesario, y se tome la correspondiente acción por parte de las autoridades universitarias. Si quien reclama fuera estudiante, deberá referir su queja a la Oficina de la Procuradora Estudiantil o al Decanato de Estudiantes.

Certification 36 (2018-2019): Discrimination by Sex and Gender on Modality of Sexual Violence: "The University of Puerto Rico prohibits discrimination based on sex, sexual orientation, and gender identity in any of its forms, including that of sexual harassment. According to the Institutional Policy Against Sexual Harassment at the University of Puerto Rico, Certification Num. 130, 2014-2015 from the Board of Governors, any student subjected to acts constituting sexual harassment, may turn to the Office of the Student Ombudsperson, the Office of the Dean of Students, and/or the Coordinator of the Office of Compliance with Title IX for an orientation and/or formal complaint."

Certification 06-43 of the Academic Senate states, "The academic guidelines for offering online courses," defines: Traditional face-to-face courses are those that have less than 25% of the course's regular contact hours via the Internet. Therefore, a three-credit course will be considered "face to face" if, of the 45 hours of regular contact, 11 or less are taught via the Internet. According to certification 16-43 of the Academic Senate, a course may include up to 25% of its total contact hours via the Internet. The objective of this is so that all professors have this alternative in the case of any unscheduled eventuality.

Law 51: The Comprehensive Educational Services Act for People with disabilities states that after identifying with the instructor and the institution, the student with disabilities will receive reasonable accommodation in their courses and evaluations. For more information contact the Department of Counseling and Psychological services at the Office of the Dean of Students (Office DE 21) or call 787-265-3864 or 787-832-4040 x 3772, 2040 and 3864.

General Topics

| Lecture | Topic | Reading |
|----------|--|-------------------------|
| 1 | Introduction | 1,2 |
| 2-3 | Basic Definition in experimental design: factor, levels, responses, treatments, randomization, blocking... | 3 |
| 4-6 | Experiments with a single factor. ANOVA (fixed model) | 3.1,3.2,3.3 |
| 7 | Comparison of individual treatment, LSD. | 3.5.7 |
| 8-9 | Model Adequacy Checking. Barlett=s test Transformation. | 3.4, 3.5.8, 14.1 |
| 10-11 | Choice of Sample Size. Kruskal-Wallis Test. Repeated measures. | 3.7, 3.10.1, 14.4 |
| 12 | The regression approach to ANOVA. | 3.9 |
| 13-15 | Randomized Complete Block Design. The Latin Square Design. The Greco-Latin Square Design. | 4 |
| 16-17 | Factorial design, advantages, definitions, fitting models, choices sample size. | 5.1, 5.2, 5.3,5.5 |
| 18-19-20 | The 2^k factorial designs. 2^3 design, single replication. | 6.1, 6.3, 6.4, 6.5, 6.6 |
| 21-22 | Confounding in the 2^k factorial. Partial confounding. | 7 |
| 23-24-25 | Two-level fractional factorial designs. | 8 |
| 26-27 | The 3^k factorial designs. | 9.1, 9.3 |
| 28-29 | Random and mixed models. Expected means squares. | 12.1, 12.2, 12.3 |
| 30-31 | Two-stage nested design. | 13.1 |
| 32-33 | The split-plot design. | 13.4 |
| 34 | Response Surface Methods. | 11.1 |
| 35 | The method of steepest ascent. | 11.2 |
| 36-37 | Analysis of a second order model. | 11.3 |
| 38 | Experimental designs for fitting response surfaces- Box - Behnken design. | 11.4 |
| 39 | Mixture Experiments | 11.5 |
| 40 | Taguchis Philosophy. | 11.7 |

*All readings from Montgomery, 2000.
Coordinator: Dr. Nazario Ramírez

ABET Outcomes

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|---|---|---|---|---|---|---|---|---|---|---|
| A | B | C | D | E | F | G | H | I | J | K |
| X | X | X | | X | | | | | | X |

IE Program Outcome

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|---|---|---|---|---|---|---|---|---|----|----|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| | | | | | X | | X | | | |

ABET Outcomes:

- A: Knowledge of mathematics, science, and engineering.
- B: Design and conduct experiments and data analysis.
- C: Design a system, components, or process to meet desired needs.
- E: Identify, formulate and solve engineering problems.
- K: Use techniques, skills, and modern engineering tools.

IE Outcomes:

- 6: Develop models to experiment, evaluate, or solve a problem.
- 8: Use modern telecommunication and computer technology.