Basic Information

Rose-Hulman Course Catalog Description

MA487 is an applied course in design of experiments. Emphasis is placed on designing statistical studies to solve problems in engineering and science. A variety of designs are presented, including the full factorial, screening, response surface, and split plot. It is demonstrated how constraints on the randomization process due to the design are related to the appropriate analysis method and meaning of the results. Statistical software is used for data analysis throughout.

Topics We Will Cover

One-, Two-, and K-way ANOVA; Factorial Designs; Multiple Comparisons; Fractional Factorial Designs; Response Surface Methodology; Complete Block Designs; Nested Factor Designs; Incomplete Block Designs; Hasse Diagrams

Prerequisite

MA223 (Engineering Statistics) OR MA382 (Introduction to Statistics)

Role of the Prerequisite

An introductory course in statistics is a requirement for this course. We will assume you have experience with statistical inference and terminology. Specifically, we will rely heavily on previous knowledge of hypothesis testing and ANOVA.

No textbook required

The class notes and assignments provided within Moodle are comprehensive for the course. Thus, purchase of a textbook is not required. However, if you prefer to have a formal textbook source as a reference, we loosely follow the textbook by Oehlert.

Oehlert. *A First Course in Design and Analysis of Experiments.* (2010). 1st edition. Online pdf available for free.

Statistical Software

We will exclusively use R for data analysis in this course. Please see the 0: Getting Started in MA487 section.

You will find that this is NOT a typical mathematics course.

A poor statistical analysis may contain completely valid computations. However, an exemplary statistical analysis not only contains correct mathematical computation, but also, a thorough data exploration and interpretation of results in context.

Additionally, most data scientists, mathematicians, and engineers will need to implement a statistical analysis at some point in their career. Due to the breadth of the statistical field, it is unlikely you will need the exact statistical tool covered in an introductory course. We strive to give you the basic skills needed to problem-solve and seek the correct analysis technique.

Hybrid Format

Face-to-Face Class Meetings

Monday and Thursday @ 11am in G220

The face-to-face class meetings will have a similar feel to a traditional lecture (e.g. instructor-led content and activities). The in-person meetings are required and all students need to plan on attending these. However, I encourage students who are ill to stay home and not come to class. If you are sick, please let me know as soon as possible. Unfortunately I do not have videos for every single face-to-face class day. With enough advance notice, there are some days where I might be able to record class and provide video access afterwards.

Some of our face-to-face days will be associated with real study design and data collection. On those days, there won't be lecture; you will work together as a class to complete the data collection task.

Online Days

Tuesday and Friday, asynchronous

The online days will contain a mixture of new content, example data analyses, and activities. Students may need to fill in notes packets, follow along to complete an example data analysis in R, or produce a set of results using simulations in R. You may want to print off notes packets that are provided during these sessions.

Important: Although we will not meet at a specific time, it is expected that students work through the provided material at some point during the specified day. The face-to-face meetings will operate under the assumption that the previous days' online material was completed.

All course notes packets will contain a set of objectives that students should be able to complete by the end of the session. These objectives are tied to overall course objectives. The overall course objectives are then assessed through various assignments.

Office Hours

Office hours in DL110-B: 10:00 - 10:50 AND 12:00 - 12:50 on Monday & Thursday

- My office is inside the Engineering Management/Graduate Studies/Lifelong Learning office suite. I'm first door in the hallway on the left. If you've never been there, it is in Moench hall to the right of the "commons" entrance.

Availability other times:

- I try to check email regularly during work hours: 8am-8pm Monday through Friday. *My availability outside of typical hours may be limited*. Although I do use Microsoft Teams, I do not check it as often.
- I attempt to keep my Outlook calendar updated. If you cannot come to in-person office hours or have questions on other days of the week, please do not hesitate to reach out to me over email. We can set up an ad-hoc meeting either in person or on Teams.
- I will make every effort to try to meet with you upon request. I do request your patience and flexibility, as there may be times when I cannot meet with you immediately.

Assessment Structure

This course was created using "backwards design." This implies that lectures, activities, and assessments are created based on course goals and objectives.

Assessments are mapped to overall course goals and objectives.
This course has three overarching goals. Each type of assessment has one or more associated goals. (For example, Quizzes are associated with Goal #1.) Thus, the importance or use of any graded assignment in this class should be clear, since the assignments directly assess valuable objectives.

Each module has 3 assignments.
Students can work together but submit their own solutions to complete the Quiz and Analysis assignments. After both module assignments pass, you unlock your Module Exam. The Module Exam is completed individually.

The class will work together to design a study, implement it to collect data, and analyze the resulting dataset.
This will occur through 4 class experiment days. Students will then submit a report containing the data analysis. The final project report will also be similar.

Quiz

Quiz assignments are written to align with the following course goal and objectives.

Goal #1: Students will demonstrate literacy in the area of statistical experimental design.

In order to achieve this goal, you will...

- 1.a <u>Define</u> and <u>recognize</u> statistical terminology correctly and in context.
- 1.b <u>Identify</u> design components based on a stated scenario.
- 1.c <u>Describe</u> procedures for implementing specific experimental designs.
- 1.d <u>Recognize</u> statistical designs based on a stated scenario.
- 1.e <u>Identify</u> relevant components of output produced by statistical software.

What to expect with quizzes

There will be 9 quiz assignments, occurring weekly during the first 9 weeks.
- Each quiz will consist of 5 multiple choice, true/false, or matching questions and will be implemented using Moodle.
- The material on the quiz is from the associated module. If you have completed all 4 class days, you should be able to complete the quiz.
- You may consider quizzes as low-stakes "practice" with the new material.

In order to pass the quiz, you must receive a 100% on the quiz.
- You may attempt the quiz as many times as needed to receive the 100% prior to the assignment deadline (typically, 11:59pm Eastern time, Friday of the module).
- There is no time limit on any quiz attempt.
- You may use any course materials as reference when working on the quiz.
- The quiz assignment is available for you to work on throughout the entire module week.

You are encouraged to work individually on the quiz assignments to help you gauge your comfort with the material. However, there is technically nothing that prohibits students from collaborating on these assignments.

There are no resubmissions for quizzes since you have unlimited attempts on the quiz during the entire module week.

Analysis

Analysis assignments are written to align with the following goal and objectives.

Goal #2: Students will know how to perform statistical analyses on data from controlled experiments.

In order to achieve this goal, you will...

2.a Use statistical software to create visual displays of data and create reproducible statistical analyses.
2.b Support the use of a statistical method based upon the underlying reasonable assumptions.
2.c Implement an appropriate statistical analysis based on the implemented study design and available data.
2.d Make a decision for a question of interest that is supported by the statistical analysis result and practical constraints.
2.e Interpret relevant information from the statistical analysis output.
2.f Describe what the employed statistical analysis technique is doing and how it works.
2.g Use statistical terminology correctly and in context.

What to expect with Analyses

There will be 9 Analysis assignments, occurring weekly during the first 9 weeks.
- Students will need to use R to complete these assignments.
- Analysis assignments will be collected using Moodle.
- The material on the assignment is from the associated module. If you have completed all 4 class days, you should be able to complete the assignment.

In order to pass the Analysis, you need to meet all listed rubric criteria.
- There is no time limit on the assignment, but you should plan to submit the assignment by the end of each module (typically, 11:59pm Eastern time, Sunday after the module completes).
- You may use any course materials as reference when working on the assignment.
- The assignment will be available for you to view and work on throughout the entire module week.

Each student should complete their own assignment.
- It is permissible to work with other students. However, any of the following may be considered academic misconduct:
  - utilizing or copying another students' code
  - utilizing or copying another students' discussion
  - utilizing or copying another students' collected data
- Students engaging in academic misconduct will receive a 0 for the entire assignment for the offense and will not be allowed to resubmit the assignment. Academic Affairs will also be notified.

Students may resubmit any Analysis assignments that are unsuccessful on the first attempt. Please see the "Resubmissions" section for more information.

Module Exam

Module Exam assignments are written to assess the same goals and objectives as the Quiz and Analysis assignments.

What to expect for Module Exams

There will be 9 Module Exam assignments, occurring weekly during the first 9 weeks.
- Each module exam will contain a combination of short answer questions and data analysis that is conducted using R.
- Module exams will be collected using Moodle.
- The material on the Module Exam is from the associated module. If you have completed all 4 class days, you should be able to complete the Module Exam.

Module Exams only become available after both the Quiz and Analysis for the module pass.
- This is similar to "unlocking" the exam by demonstrating basic knowledge of the module before attempting the exam.
- There is no time limit on the assignment. It is strongly recommended that you attempt to submit it by 11:59pm Eastern time, Wednesday after the module has completed so your coursework does not get too far behind.
- You may use any course materials as reference when working on the exam.

Module Exams are an individual effort. That is, students do not work together to complete these assignments.
- Students engaging with academic misconduct will receive a 0 for the entire assignment for the offense and will not be allowed to resubmit the assignment. Academic Affairs will also be notified.

Students may resubmit Module Exams up to 3 times after the initial attempt. Please see the "Resubmissions" section for more information.

Class Experiment Report

The Class Experiment Report assignments assess some of the analysis objectives, but also the following goal and objectives.

Goal #3: Students will make recommendations regarding experimental design and areas of improvement.

In order to achieve this goal, you will...

    3.a <u>Describe</u> limitations related to the parameter(s) of interest and/or statistical inference technique.
    3.b <u>Recommend</u> improvements for a process (subsequent experimental designs or process settings) based on results from a statistical analysis.
    3.c <u>Recommend</u> a statistical design to incorporate all factors of interest, constraints to the process, and that could produce data to answer a stated question of interest.
    3.d <u>Outline</u> steps of good data collection procedure when presented with a question of interest.
    3.e <u>Justify</u> the choice of a design.
    3.f <u>Criticize</u> an implemented or proposed experimental design.

What to expect with Class Experiment Reports

There will be 4 class experiment reports, occurring approximately every other week during the first 9 weeks of the term.

- Each report will consist of various short answer and data analysis questions.
- The report will be based on a study design and class data collection that occurs approximately 1 week prior to the report due date.
- These assignments will be collected through Moodle.

In order to pass the Class Experiment Report, you need to meet all listed rubric criteria.
- There is no time limit on the assignment, but it must be submitted by the deadline (typically, 11:59pm Eastern time, Sunday of the module following the in-class study design)
- Assignments submitted after the deadline are considered a resubmission.

Students are allowed to collaborate, but each student should complete their own assignment.
- It is permissible to work with other students. However, any of the following may be considered academic misconduct:
    - utilizing or copying another students' code
    - utilizing or copying another students' proof
    - utilizing or copying another students' work
- Students engaging in academic misconduct will receive a 0 for the entire assignment for the offense and will not be allowed to resubmit the assignment. Academic Affairs will also be notified.

Students may resubmit Class Experiment Reports once. Please see the "Resubmissions" section for more information.

Final Project Report

The Final Project Report assesses the same goals and objectives as the class experiment reports.

What to expect with the Final Project Report

There is one Final Project Report, collected 11:59pm Eastern time on Sunday of 10th week.

- The final project information will be presented on Monday of 10th week.
- Students will have the opportunity to work together throughout 10th week (including during our scheduled class sessions) to complete the project
- No new material will be presented during 10th week to allow for adequate work time on the final project.

In order to pass the Final Project Report, you need to meet all listed rubric criteria.
- There is no time limit on the assignment, but it must be submitted by the 11:59pm Sunday of 10th week deadline.
- Late submissions cannot be accepted due to RHIT finals week policy (Instructors collecting work during finals week need to have a scheduled time for that work and we do not have a scheduled time.)

Students are allowed to collaborate, but each student should complete their own assignment.
- It is permissible to work with other students. However, any of the following may be considered academic misconduct:
  - utilizing or copying another students' code
  - utilizing or copying another students' proof
  - utilizing or copying another students' work
- Students engaging in academic misconduct will receive a 0 for the entire assignment for the offense and will not be allowed to resubmit the assignment. Academic Affairs will also be notified.

There are no resubmissions of the Final Project Report.

Grades

I want this course to create a strong foundation in statistical experimental design for you. **In order to help you achieve this, I will be implementing a version of "specifications-based grading."** That is, instead of taking a weighted average of points earned on a series of assignments throughout the term, you will earn grades based on the assignments that you successfully complete.

Successfully completed assignments earn credit toward your overall course grade.   Each assignment is graded as pass (1) / fail (0). In order to help you achieve a passing score, very clear expectations will be provided on every assignment, often via a rubric.

You will also notice that I am not expecting perfection. For example, a student may achieve an A in the course without having to pass every single course assignment. However, successfully completed/passing assignments will be based on clear, high standards. You will also have the chance to resubmit some assignments that did not receive credit on the first attempt. This awards you for going back to learn the material, even if it did not "click" the first time through.

In the end, you have complete control over your grade in the course; I will provide you with the necessary tools and feedback to help you achieve your desired grade.

Letter Criteria

Final letter grades in this course will be assigned based on the mastery of course material demonstrated throughout the term.

- **There are a total 9 module exams during the term** (one per module).
- **There are a total of 4 class experiments during the term** (approximately one every other week).
- **There is a quiz and a data analysis associated with each module.** Successful completion of both assignments unlocks the module exam. Passing these and not the associated module exam can be associated with "+" grades.
- **There is one final project** (occurring during week 10).

In order to earn a grade of "D"

You must meet **both** of the criteria listed below:
- Successfully complete 5 module exams
- Successfully complete 2 class experiment reports

In order to earn a grade of "D+"

You must meet **both** of the criteria listed below:
- Complete all criteria associated with D
- {Pass at least one additional module quiz AND analysis. These both of these are associated with the same module.} **OR** *{Pass an additional class experiment report.}* **OR** {Pass the final project}

In order to earn a grade of "C"

You must meet **both** of the criteria listed below:
- Successfully complete 6 module exams
- Successfully complete 3 class experiment reports.

In order to earn a grade of "C+"

You must meet **both** of the criteria below:
- Complete all criteria associated with C
- {Pass at least one additional module quiz AND analysis. These both of these are associated with the same module. } **OR** *{Pass an additional class experiment report.}* **OR** {Pass the final project}

In order to earn a grade of "B"

You must meet **all** of the criteria listed below:
- Successfully complete 7 module exams
- Successfully complete 3 class experiment reports
- Successfully complete the final project

In order to earn a grade of "B+"

You must meet **both** of the criteria below:
- Complete criteria associated with B
- {Pass at least one additional module quiz AND analysis. These both of these are associated with the same module.} **OR** *{Pass an additional class experiment report.}*

In order to earn a grade of "A"

You must meet **all** of the criteria listed below:

- Successfully complete 8 module exams
- Successfully complete 4 class experiment reports
- Successfully complete the final project

An "F" is assigned when the criteria to earn a "D" are not achieved.

Resubmissions

Life happens. We all have different priorities, and at times the priorities may not easily align with the timing for class assignments. I recognize that this happens with the busy schedules that students have at RHIT and want to give every student adequate opportunity to succeed. Moreover, I value the learning experience of re-examining material that was not mastered on the first encounter.

All students will have the opportunity to resubmit most course assignments that were not initially successful. There are many opportunities to resubmit throughout the term.

Here's how resubmissions work

- Each Monday, Thursday, and Friday, Dr. Heyman will grade any assignments that are submitted in Moodle by 8am that day.
  - Dr. Heyman can automatically see when assignments are updated in Moodle. Thus, she does not need email notification of a resubmission. However, if your assignment is resubmitted and you do not see any updated feedback or grade in a timely manner, it is completely fine to check in with Dr. Heyman about this.

- **Analysis assignments that are not successful on the first attempt can be resubmitted any time during the term.**
  - There are 9 analysis assignments possible during the term. You can resubmit these at any time after your initial submission.
  - If you miss the initial submission deadline, you can submit a late attempt as a "resubmit"
  - You can resubmit the analysis assignments as many times as you need until the solution is successful.

- **Module Exam assignments that are not successful on the first attempt can be resubmitted up to 3 times during the term.**
  - Module Exam assignments are completed as an individual. Students that work together on exams (whether it is the first attempt or any resubmission) will not receive credit for the exam and also be reported under the Mathematics department academic integrity policy.
  - There are 9 module exams possible during the term. You can resubmit these at any time after your initial submission.
  - Module exams become available to you after passing both the Quiz and Analysis from the Module.
  - You can resubmit any Module Exam up to 3 times (thus, any Module Exam would have a maximum of 4 possible attempts)

- **Class Experiment Reports that are not successful on the first attempt can be resubmitted once.**
  - There are a total of 4 experiment reports during the term.
  - You are only allowed a single resubmission per report. If the report is submitted after the deadline, the late submission counts at the resubmission for that report.

- **There are no resubmissions associated with Quizzes and the Final Project.**

Participation

Rose-Hulman Institute of Technology is **committed to being an inclusive community** in which the multiplicity of values, beliefs, intellectual viewpoints, and cultural perspectives enrich learning and inform scholarship. I want our classroom to be an open and safe environment to share and discuss ideas. Thus, it is expected that students and the professor are good citizens during and outside of class, treating each other with mutual respect.

- **Discussion and questions are encouraged during class**. Feel free to speak up at any time during lecture sessions. My classroom is a fairly informal atmosphere.
- If anything occurs during or outside of our class (for example, a microaggression) which makes you feel uncomfortable, please reach out to me. I want all students to feel comfortable in my classroom, and it is my intention to foster both equality and equity.
- If there are any instances where a student continues disrespectful behavior after discussion with me, to the point that the behavior is disrupting our classroom experience, a penalty may be incurred.
- Lecture attendance is integral to success in this course. It is easy to fall behind from missing 1 or 2 class sessions.
  - With the hybrid format, it is especially important to keep on schedule, since we have fewer face-to-face meetings.
- Please do not use your cell phone during class. It is disruptive to other students and the professor. Laptop use should be responsible and appropriate to our class activities.

Institute Policies

Students with Accessibility Needs

Rose-Hulman Institute of Technology strives to make all learning experiences accessible to students. If you anticipate or experience academic barriers based on accessibility issues, please feel free to communicate those needs and register with Student Accessibility Services.

Student Accessibility Services will work with you understand the process and to determine what accommodations are most appropriate for your individual situation. Visit the Accessibility Services website for more information. Please note that accommodations are not retroactive and accommodations cannot be provided until verified.

Please contact Student Accessibility Services for more information at HMU 156, 812-877-8040, or eaton1@rose-hulman.edu.

Please note that it is the student's responsibility to request any approved, documented academic accommodations (such as extra time) at least three days in advance of exams.

Academic Integrity

Plagiarism, offering, and accepting solutions to assessments when a student is required to work individually are cases of academic misconduct. These instances are taken seriously by the professor and university, and will be reported. Anyone found cheating will not be permitted to withdraw and will be (appropriately) heavily penalized in the course. Academic affairs will be informed.

The Student Handbook and Rose-Hulman's Academic Rules and Procedures describe penalties and processes invoked as a consequence if academic misconduct (such as cheating, plagiarizing, or interfering with the academic progress of other students) takes place. It is the responsibility of each student to know and follow Rose-Hulman's rules about academic integrity.

Incompletes

Incompletes are granted only when a student is forced to miss several days of class due to extraordinary circumstances such as a documented confining illness or family emergency. To receive an incomplete grade, students should obtain approval from the professor before the last day of class.

No incompletes will be given unless a prior written agreement with the professor exists, following typical Rose-Hulman policy. In this course, an "I" grade will be given only in cases of extreme hardship. Poor performance in the course is not grounds for an incomplete. An incomplete shall be recorded as an "F" if the work is not completed within the time agreed upon by the professor and student.

Emergency Information

To receive email or text messages regarding emergency situations that may impact campus and, possibly, the delivery of classes, register for RAVE alerts *and/or follow* @Rose-HulmanAlert on Twitter*. Any announcements about the Institute's ability to offer classes will be shared on* Rose-Hulman's website*.*