

# Course Syllabus

Davood Tofighi, Ph.D.

Department of Mathematics and Statistics, University of New Mexico

January 6, 2025

## Course Information

- **Instructor:** Dr. Davood Tofighi
- **Location:** Science Math Learning Center 120
- **Time:** Tuesday & Thursday, 2:00 pm - 3:15 pm
- **Office Hours:** Thursday, 3:30 pm - 4:30 pm
- **Course Website:**
  - UNM Canvas
  - <https://Data-Wise.github.io/doe/>.

## Course Description

This course provides a rigorous introduction to experimental design and analysis of variance (ANOVA) methodologies, with an emphasis on their integration into linear modeling frameworks. Topics include fundamental principles of experimental design (randomization, replication, and blocking), handling unbalanced data, diagnostics for model assumptions, and advanced designs such as split-plot, nested, and mixed-effects models. Students will develop skills in designing experiments, selecting appropriate statistical approaches, analyzing data using R, and communicating findings effectively.

## Learning Outcomes

By the end of this course, students will be able to:

1. Design experiments using principles of randomization, replication, and blocking.
2. Implement one-way, two-way, and higher-order factorial ANOVA techniques.
3. Analyze unbalanced data using modern statistical methods.
4. Conduct residual analysis, transformations, and diagnostics for model assumptions.
5. Perform multiple comparisons and construct contrasts for treatment effect interpretation.
6. Incorporate covariates into ANOVA frameworks through analysis of covariance (ANCOVA).
7. Apply advanced designs like row-column, nested, and split-plot experiments.
8. Utilize statistical software (e.g., R) to perform experimental analyses and generate reproducible workflows.

## Prerequisite

A prior course in statistics, such as STAT 440/550, is strongly recommended. Students without this background must meet with the instructor to discuss their preparation.

## Textbook And Software

- **Primary Textbook:** Dean, A., Voss, D., & Draguljić, D. (2017). *Design and Analysis of Experiments*. Springer.
  - Available as a free eBook for UNM students through the UNM Library. Use your UNM credentials to access it. The eBook formats are in PDF and EPUB.
- **Supplemental Textbooks**
- Libre Textbook from Penn State University: Analysis of Variance and Design of Experiments
  - This book provides an accessible introduction to the principles of experimental design and ANOVA. If you find the primary textbook challenging, this resource may offer additional support.
- First version of Prof. Christensen's book from his UNM website
  - Note that this is an older (first) version of the book from Prod. Christensen's website. The book is available in PDF format.
  - An excellent R companion, which is freely available, to the book is R Companion to Applied Regression.
- **Software:**
  - Wickham, H., Çetinkaya-Rundel, M., & Grolemund, G. (2023). *R for data science: Import, tidy, transform, visualize, and model data* (2nd edition). O'Reilly.
  - This book is available online for free and provides a comprehensive guide to using R for data analysis and visualization.
  - R (version 4.2 or higher), paired with RStudio, VS Code, or Positron, along with Quarto for reproducible workflows.
  - Key R packages: `lm`, `emmeans`, `pwr`, `multcomp`, `lme4`, and others as introduced during the course.
  - Cran Task View: Experimental Design and Analysis
    - This resource provides an overview of R packages for experimental design and analysis, including links to package documentation and tutorials.
  - Package `daewr` accompanies the book *Design and Analysis of Experiments with R* by Lawson (2014) and does not only provide data sets from the book but also some standalone functionality that is not available elsewhere in R, e.g. definitive screening designs.
  - Package `agricolae` is a package for statistical analysis of experimental designs.

## Course Resources

### 1. Lecture Notes and Online Resources

- Lecture notes and online tutorials will be made available in **HTML/PDF format** on the dedicated **GitHub Pages** website for this course. This platform ensures easy access to interactive and organized course materials.
- **GitHub Pages Website Address:** <https://Data-Wise.github.io/doe/>.

- The GitHub Pages website will be regularly updated with new materials. However, please note that:
  - Some supplemental readings may not be available on the website due to copyright restrictions.
  - Only **supplemental readings in the public domain or with proper permissions** will be provided on GitHub Pages.

### Important Note about GitHub Pages and Browser Caching

- GitHub Pages occasionally caches content, which may result in outdated materials being displayed. To ensure you are viewing the latest updates:
- **Refresh your browser:** Press Ctrl + F5 (Windows) or Cmd + Shift + R (Mac) for a hard refresh.
- **Clear your browser cache:** If refreshing doesn't work, clear your browser's cache in your browser's settings and revisit the website.

### 2. Canvas Course Platform

- All other course materials, such as:
  - **Homework assignments** (on both Canvas and GitHub Pages)
  - **Assignments Submission portals**
  - **Supplemental readings not in the public domain**
  - **Announcements**
  - **Discussion boards** will be hosted on **Canvas**.
- Students are responsible for checking **Canvas regularly** for important updates, announcements, and access to restricted course materials.

### 3. Supplemental Readings

- Supplemental readings will be provided through Canvas whenever possible. However:
- Readings under copyright or without appropriate permissions will **not** be distributed directly.
- Where applicable, references or external links will be shared for you to access materials through **UNM's library system** or other authorized platforms.

### Contact for Technical Issues

- If you encounter persistent issues accessing materials on GitHub Pages or Canvas, please notify the instructor or TA immediately for assistance.

## Communication Guidelines

- **Announcements:** All important course announcements will be posted on **Canvas**. It is your **responsibility** to regularly check Canvas to stay updated. Missing important information due to not checking Canvas will not be considered an acceptable excuse.
- **Discussion/Questions:** For course-related questions, post them on the **Canvas discussion board**. Do **not** email me or the TA directly for general questions about the course. Before posting, review the syllabus to ensure your question hasn't already been addressed. Questions that are already answered in the syllabus will **not** receive a response.

- **Email: All email communication must be sent through Canvas.** Direct emails to my university or personal email address will **not** receive a response. Please ensure that all personal or sensitive matters requiring email communication are sent via Canvas.
- **Personal Matters:** For personal concerns, contact me **only through Canvas email** or visit during office hours.
- **Office Hours (by Appointment):** Please feel free to schedule an appointment with me or the TA if you need additional help or clarification. Office hours are a great opportunity to discuss your questions and ensure your understanding of the material.

**Reminder:** Checking Canvas regularly is essential for staying informed and up-to-date with the course.

## Grading And Assessments

The final grade in this course will be determined by the following components and their respective weights:

Component	Weight
Homework Assignments	50%
Midterm Exam	20%
Final Exam	30%
Extra Credit	Up to 4%

## Grading Scale

The following cut-off values will be used to assign final letter grades:

Percentage	Letter Grade
98-100	A+
93-97.99	A
90-92.99	A-
87-89.99	B+
83-86.99	B
80-82.99	B-
77-79.99	C+
73-76.99	C
70-72.99	C-
67-69.99	D+
63-66.99	D

Percentage	Letter Grade
60-62.99	D-
Below 60	F

## Homework (50%)

### Homework Submission Guidelines

#### 1. Format and Template:

All homework assignments must be completed using the **Quarto template** provided on the course website. You are required to submit the **rendered PDF version** of the Quarto document. Failure to use the provided template or submit the correct format will result in point deductions.

#### 2. Submission Platform:

Submit your completed assignments **electronically** through **Canvas**. Navigate to the “Assignments” folder, click on the appropriate homework assignment, and attach your rendered PDF file.

#### 3. Plagiarism Check:

All submitted assignments will be **automatically checked for plagiarism** by Canvas. Any instances of plagiarism or academic dishonesty will be handled in accordance with **UNM’s Student Code of Conduct** and the **Support in Receiving Help and Doing What is Right** section outlined in this syllabus. Please familiarize yourself with the academic integrity policies detailed in the syllabus and on the UNM website. Ignorance of the policy is not an excuse for violations.

#### 4. No Late Submissions Accepted:

All homework assignments are due by the specified deadline on Canvas. **Late submissions will not be accepted under any circumstances.** This policy is strict and applies to all students without exceptions.

#### 5. Extra Credit Opportunity:

If you miss an assignment, you may compensate for it by earning extra credit as outlined in the syllabus. This provides an opportunity to recover points without requiring extensions or exceptions for missed deadlines.

#### 6. Do Not Email About Late Assignments:

Please **do not email me or the TA** regarding missed or late homework submissions. We cannot make exceptions or accept late assignments under any conditions. Instead, focus on utilizing the extra credit opportunities provided in the syllabus.

#### 7. Content Requirements:

- All responses must be typed within the Quarto document.
- If you include hand-written calculations or derivations, they must be scanned and appended to the Quarto document as an appendix before rendering the final PDF.

#### 8. Independence:

All homework assignments must be completed **independently**. While collaboration in studying is encouraged, your final submission must reflect your own work.

#### 9. Grading and Feedback:

Assignments will be graded and feedback will be provided through Canvas. Be sure to review comments and feedback promptly to address any misunderstandings before the next assignment.

**Important Note:** To avoid missing deadlines, plan your work carefully and submit your assignments early. If you are unfamiliar with Quarto or need assistance using the template, refer to the “Resources” section on Canvas for tutorials or contact me during office hours.

### Exams (50%)

#### Midterm Exam (20%)

- **Date:** Thursday, March 6, 2025 (during class time)
- **Location:** Classroom (as specified in the syllabus)
- **Content:** Covers topics from Weeks 1-7.

#### Final Exam (30%)

- **Date:** Tuesday, May 13, 2025, from 10:00 a.m. to 12:00 p.m.
- **Location:** Classroom (as specified in the syllabus)
- **Content:** Comprehensive, covering the entire course.

#### Exam Guidelines

- **Format:** Exams are **closed book** but you may bring up to **three double-sided cheat sheets** (US Letter size) and a calculator. No other electronics or materials (e.g., books, lecture notes) are allowed.
- **Question Types:** Includes a combination of short-answer questions, computations, and application-based problems.

#### No Make-Up Exams Policy

- Make-up exams will only be granted in **cases of proven emergency** that meet the criteria set forth by the **Department of Mathematics and Statistics** and **UNM policies** (e.g., documented medical emergencies, official university-sponsored activities, or other unavoidable situations as defined by university guidelines).
- If you anticipate a potential conflict or emergency, you **must notify the instructor in advance of the exam date whenever possible**. Failure to do so will result in forfeiture of the opportunity to take a make-up exam.

- For non-emergency situations, personal conflicts, or reasons outside of those outlined in this document (e.g., vacation, workload, or personal oversight), **make-up exams will not be permitted.**

### **Proven Emergency Requirements:**

1. **Medical emergencies:** Provide a signed note from a licensed healthcare provider explaining the need for absence.
2. **University-sponsored activities:** Submit official documentation from the relevant department.
3. **Other emergencies:** Submit verifiable proof (e.g., legal documentation, official notifications).

In all cases, documentation must be provided as soon as possible and must align with UNM's student policies on academic integrity and attendance. For more information, consult the UNM Student Handbook.

### **Importance of Timely Notification**

If you foresee a conflict or are unable to attend an exam due to an emergency, **notify the instructor as early as possible.** While advance notice does not guarantee a make-up exam, failing to provide notice will disqualify you from consideration for a make-up opportunity.

By adhering to this policy, we ensure fairness and consistency for all students while maintaining compliance with university guidelines. If you have further questions or concerns, please contact the instructor before the exam dates.

### **Extra Credit Opportunities**

Students have the opportunity to earn **up to 4% extra credit** toward their final grade by completing the following tasks:

#### **1. End-of-Semester Course Evaluation (Up to 3%)**

- Students who complete the **end-of-semester course evaluation** will receive **up to 3% extra credit.**
- To receive the extra credit, students must:
- Submit the course evaluation through the university's designated system (e.g., UNM's course evaluation platform).
- Post a **screenshot or copy of the receipt of submission** (no personal information visible) to the **"Course Evaluation" discussion board** on Canvas.
- Deadline for posting the receipt will be announced during the final week of class.

#### **2. Background and Syllabus Quiz (1%)**

- A **"Background and Syllabus Quiz"** will be available on the course website during the **first week of class.**
- This quiz will assess familiarity with the syllabus and the course's policies and expectations. Completing the quiz will earn **1% extra credit.**
- **Note:** The availability of this quiz may vary by semester and will be announced at the start of the course.

### Important Notes:

- These extra credit opportunities are designed to encourage engagement with the course policies and participation in university processes.
- Extra credit is **optional** and cannot replace or make up for missed assignments, exams, or other coursework.
- The **maximum total extra credit available** is 4%, which will be applied to your final grade at the end of the semester.
- Students are encouraged to review the “Grading and Assessments” section of the syllabus to understand how extra credit impacts their overall grade.

Please take advantage of these opportunities to improve your final grade while reinforcing your understanding of the course and contributing to constructive course feedback.

## What to Expect and How to Study and Be Successful in This Course

This course is designed to be both rigorous and rewarding, equipping you with essential skills in experimental design and analysis of variance (ANOVA). Success in this course requires preparation, consistent effort, and active engagement with the material. Below are some key recommendations and expectations to help you succeed:

### 1. Expect to Invest Significant Time

- Mastery of the material requires **dedicated study time** each week. Plan to spend **at least 8-10 hours per week** outside of class on:
  - Reading assigned materials.
  - Completing homework assignments.
  - Practicing statistical techniques in R.
  - Reviewing notes and working through practice problems.

### 2. Prioritize Class Attendance

- Attendance is critical to your success in this course.
- Classes are designed to build upon each other, with cumulative content.
- Discussions, group activities, and real-time problem-solving in class will reinforce your understanding.
- Historical data has shown that students who miss class sessions struggle to keep up with the material.
- If you must miss a class, review the lecture notes and course materials promptly, and reach out to classmates for additional support.

### 3. Come Prepared for Every Class

- **Read the assigned materials before class:**
  - Familiarize yourself with the key topics to be covered.
  - Jot down questions or areas of confusion to bring to class discussions.
  - Engage with supplemental materials like videos, tutorials, or examples provided on Canvas.



- Stay organized by keeping track of due dates, reading assignments, and planned lectures using the course schedule.

#### **4. Stay Active During Class**

- Take detailed notes during lectures and participate in discussions.
- Actively engage in group activities. Collaborating with classmates helps deepen your understanding and clarifies difficult concepts.
- Ask questions during class or post them on Canvas if you need further clarification.

#### **5. Utilize Office Hours and Discussion Boards**

- Office hours are an excellent opportunity for one-on-one assistance with:
- Understanding difficult concepts.
- Reviewing homework problems.
- Discussing your specific challenges with course material.
- Use the **Canvas Discussion Boards** for peer-to-peer support and quick clarifications from the instructor or TA.

#### **6. Practice Regularly**

- Mastery of statistical methods requires consistent practice.
- Work through **examples provided in class** and additional exercises from the textbook.
- Attempt problems in R to solidify your understanding of statistical tools and software.

#### **7. Review and Revise**

- After each class, set aside time to:
- Review your notes.
- Summarize key concepts in your own words.
- Attempt practice problems to apply what you've learned.

#### **8. Focus on Understanding, Not Memorization**

- This course emphasizes application and critical thinking.
- Strive to understand the “why” behind statistical techniques and experimental designs.
- Apply concepts to real-world scenarios or examples from your own field of study.

#### **9. Manage Your Time Wisely**

- Start assignments early to avoid last-minute stress.
- Break down large tasks into smaller steps and set achievable goals for each study session.
- Use tools like planners or digital calendars to track deadlines and manage your workload effectively.

#### **10. Maintain a Growth Mindset**

- Statistics can be challenging, but persistence is key.
- Embrace mistakes as part of the learning process.
- Reach out for help early if you're struggling with a concept or assignment.

### 11. Make Use of the Resources Provided

- The course provides several resources to support your learning:
- A Quarto template for homework submissions.
- Supplemental readings, videos, and tutorials.
- Access to the course textbook through UNM's library system.
- R and VS Code or RStudio (or equivalent IDEs) for conducting statistical analyses.

### 12. Avoid Falling Behind

- Given the cumulative nature of this course, falling behind on one topic will make subsequent topics more difficult to grasp.
- Stay on top of assignments and make reviewing previous material part of your weekly routine.

### 13. Academic Honesty and Collaboration

- While collaboration is encouraged during study sessions or discussions, ensure all submitted work reflects your own understanding.
- Familiarize yourself with the **Support In Receiving Help and Doing What is Right** section of the syllabus to avoid issues related to academic dishonesty.

By following these recommendations, staying engaged, and managing your time wisely, you'll position yourself for success in this course. Remember, learning statistics is a journey that requires consistent effort and a positive attitude. I am here to support you every step of the way, so don't hesitate to reach out for assistance.

## Accommodation

In accordance with **University Policy 2310** and the **Americans with Disabilities Act (ADA)**, academic accommodations will be provided for students who notify the instructor of their need. It is the student's responsibility to inform the instructor promptly so accommodations can be arranged. Instructors are not legally permitted to inquire about disabilities or the need for accommodations. For assistance in arranging accommodations, contact the **Accessibility Resource Center (ARC)**:

- Phone: **277-3506**
- Email: [arcsrvs@unm.edu](mailto:arcsrvs@unm.edu)
- Website: Accessibility Resource Center

Students who may require assistance in emergency evacuations should also contact the instructor to discuss the most appropriate procedures to follow.

UNM is dedicated to fostering an inclusive, accessible, and supportive learning environment for all participants. If you encounter **physical, academic, or mental health barriers**, or concerns related to physical health, **mental health**, or **COVID-19**, you are encouraged to communicate these concerns to the instructor via **Canvas email**, phone, or during office hours. Additional support is available through the Accessibility Resource Center. Let's work together to ensure you have equitable access to this course.

## Title IX

As part of UNM's commitment to a safe and equitable campus environment, faculty, Teaching Assistants (TAs), and Graduate Assistants (GAs) are considered “**responsible employees**” by the **Department of Education**. This means that **any report of gender discrimination**—including sexual harassment, misconduct, or violence—shared with a faculty member, TA, or GA must be reported to the **Title IX Coordinator** at the **Office of Equal Opportunity (OEO)**.

- Office of Equal Opportunity.
- Title IX policy details

For more information on reporting obligations, see the **Title IX Guidelines** Title IX Guidelines. If you prefer to discuss sensitive concerns confidentially, please consider reaching out to the UNM **LoboRESPECT Advocacy Center** or other confidential resources on campus.

## Support In Receiving Help and Doing What is Right

UNM provides a range of services and policies to help students succeed academically and thrive within the university community. If you are unsure where to begin, consult the **UNM Student Services** website or reach out to the instructor for guidance in identifying the right resource.

### Key Policies and Support Resources:

1. **Student Grievances:** Policies D175 and D176 in the Faculty Handbook detail procedures for addressing grievances.
2. **Academic Dishonesty:** Adhere to UNM's policies outlined in the **Faculty Handbook D100**, which address plagiarism and academic misconduct.
3. **Respectful Campus Policy:** Uphold UNM's guidelines for fostering a respectful academic environment (Faculty Handbook C09).

Find these resources in the Student Pathfinder or the Faculty Handbook.

**Plagiarism and Academic Dishonesty:** Violations of academic integrity have serious consequences, including failing an assignment or course, and potential suspension or expulsion. If you have any questions about avoiding plagiarism, please ask the instructor or consult UNM's policies. It is always better to ask for clarification than to risk committing an academic violation.

If you need assistance understanding the guidelines or accessing these resources, please do not hesitate to reach out.

## Land Acknowledgement

Founded in 1889, the University of New Mexico sits on the traditional homelands of the Pueblo of Sandia. The original peoples of New Mexico Pueblo, Navajo, and Apache since time immemorial, have deep connections to the land and have made significant contributions to the broader community statewide. We honor the land itself and those who remain stewards of this land throughout the generations and also acknowledge our committed relationship to Indigenous peoples. We gratefully recognize our history.

## Course Schedule, Assignment Deadlines, and Exam Dates

The **course schedule**, including **assignment due dates** and the **midterm exam date**, is **subject to change** based on the progress of the class, unforeseen circumstances, or instructor discretion. Students are responsible for regularly checking **Canvas** and **announcements on the course GitHub page** for the most up-to-date information regarding deadlines and schedule adjustments.

However, **the final exam date is not subject to change**, as it is determined and scheduled by the university. Please plan accordingly based on the **final exam schedule provided by UNM**:

- **Final Exam Date: Tuesday, May 13, 2025, 10:00 a.m.-12:00 p.m.**
- **Location:** Classroom (as specified in the syllabus)

Students are strongly encouraged to stay proactive, monitor changes, and ensure they meet all revised deadlines and expectations as announce

### Tentative Course Schedule

Week	Date	Topics	Readings & Homework Assignments
1	Jan. 21 & 23, 2025	Introduction to Experimental Design	Ch. 1 (Sections 1.1-1.1.1), Ch. 2 (Sections 2.1-2.2).
2	Jan. 28 & 30, 2025	Completely Randomized Designs (CRD)	Ch. 3 (Sections 3.1-3.5); Homework 1 (due Feb. 6).
3	Feb. 4 & 6, 2025	Multiple Comparisons	Ch. 4 (Sections 4.1-4.4); Homework 2 (due Feb. 13).
4	Feb. 11 & 13, 2025	Checking Model Assumptions	Ch. 5 (Sections 5.1-5.3); Homework 3 (due Feb. 20).
5	Feb. 18 & 20, 2025	Two-Way Factorial Designs	Ch. 6 (Sections 6.1-6.5); Homework 4 (due Feb. 27).
6	Feb. 25 & 27, 2025	Higher-Order Factorial Designs	Ch. 7 (Sections 7.1-7.6); Homework 5 (due Mar. 6).
7	Mar. 4 & 6, 2025	<b>Midterm Exam</b>	Review all chapters and notes.
8	Mar. 11 & 13, 2025	Blocking & RCBD	Ch. 10 (Sections 10.1-10.4); Homework 6 (due Mar. 25).
9	Mar. 16-20, 2025	<b>Spring Break</b>	No classes.
10	Mar. 25 & 27, 2025	Complete Block Designs	Ch. 10 (Sections 10.6-10.8); Homework 7 (due Apr. 3).
11	Apr. 1 & 3, 2025	Analysis of Covariance (ANCOVA)	Ch. 9 (Sections 9.1-9.4); Homework 8 (due Apr. 10).

Week	Date	Topics	Readings & Homework Assignments
12	Apr. 8 & 10, 2025	Row-Column (Latin square) Designs	Ch. 12 (Sections 12.1-12.4); Homework 9 (due Apr. 17).
13	Apr. 15 & 17, 2025	Random & Mixed Models	Ch. 17 (Sections 17.1-17.8); Homework 10 (due Apr. 24).
14	Apr. 22 & 24, 2025	Nested Models	Ch. 18 (Sections 18.1-18.4); Homework 11 (due May 1).
15	Apr. 29 & May 1, 2025	Split-Plot Designs	Ch. 19 (Sections 19.1-19.5); Homework 12 (due May 6).
16	May 6 & 8, 2025	Catching Up and Review	Comprehensive review and Q&A.
17	May 13	<b>Final Exam</b>	Comprehensive (Weeks 1-15).

## Bibliography