Course Syllabus

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Description

This document outlines how this course operates. Please read it carefully and let me know of any questions you may have regarding the structure of the course. The instructor reserves the right to modify the syllabus at any time during the course; if any modifications are made, you will be notified via email and it will be posed on the ***Course Announcements*** forum. Note: after entering the syllabus, you can print a hard-copy by selecting the *Print Book* link under the *Administration* block on the left-hand side of the course page.

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MA482/BE482 Bioengineering Statistics

Course Description:

The biological sciences often yield datasets which present unique challenges to data analysis. This course introduces these challenges and the statistical methods employed to overcome them. We begin with an introduction to the use of statistical regression models and then explore how such models can be altered to account for various features in the dataset. This could include non-linear or categorical response variables, censored survival (or reliability) data, repeated measurements on the same subject, and missing data. Other topics discussed as time permits include pooling results from multiple studies, study design and power, drawing causal conclusions from observational data, and general modeling techniques. This course will enable students to evaluate the strength of evidence presented in the literature within their field of study.

Learning Objectives:

As in any statistics course, we emphasize statistical literacy (interpretation and clear communication of statistical methods, results, and concepts) and statistical reasoning (modeling variability in a process, defining the need for data to address questions, choosing appropriate methodology, and critiquing an analysis). Specifically, after taking this course, students will be able to accomplish the following tasks:

(A) **Describe** situations for which mulit-predictor regression models are needed to address the research question of interest. Specifically, **describe** the role multi-predictor regression models play in isolating the effect of a variable and investigating the interplay between multiple variables.

(B) Given an analysis situation, **state** the appropriate regression modeling technique (linear, non-linear, survival, or repeated measures) and **justify** your choice.

(C) **Formulate** research questions as measurable statements about parameters in a regression model.

(D) Given a research question from the biological sciences, use appropriate software to **conduct** inference on the corresponding parameters and **interpret** the resulting output in context of the research question.

(E) **Compare** and **contrast** the four primary regression modeling techniques discussed: linear, non-linear, survival, repeated measures.

(F) Clearly **communicate** an analysis and its implications using a variety of media: written paper, scientific poster, scientific abstract, and oral presentation.

(G) **Collaborate** with others to formulate a statistical analysis plan for addressing a research question.

(H) **Appreciate** the value and limitations of regression modeling for addressing research questions in the biological sciences.

(I) **Express** a desire for researchers in the biological sciences to be trained in statistical thinking and literacy.

(J) **Assess** the strength of evidence presented by a scientific publication in addressing a research question and **provide** constructive feedback for improving a study.

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Course Prerequisites

MA223 (Engineering Statistics I) is a prerequisite for this course. In particular, students should be familiar with basic statistical concepts such as confidence intervals and hypothesis testing. Other courses that may be beneficial (but not required) include a background in biology, differential equations, probability theory, mathematical statistics and statistical programming.

Contact Information:

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Office Hours:
I do not have regular office hours dedicated to this class. When you have questions, feel free to email or drop by. A copy of my schedule is available on my office door. Or, you may email me to schedule an appointment.

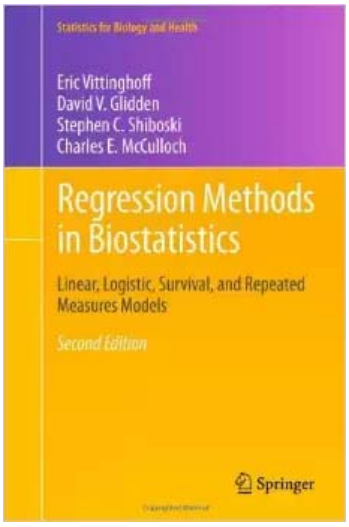
Instructor Biography

After graduating from Rose-Hulman Institute of Technology in 2006 with a degree in Mathematics and Economics, I attended graduate school at North Carolina State University where I earned my Ph.D. in Statistics under the direction of Dr. Dennis Boos and Dr. Len Stefanski. My primary interest is biostatistics - the application of statistical methodology to medical research. As a former participant in the NHLBI Integrated Biostatistical Trainee Program for CVD Research, I spent five years as an intern at the Duke Clinical Research Institute serving as a statistical consultant under the direction of Karen Pieper.

My research interests include methods for variable selection (the process of discerning which variables are useful for predicting a response) and statistics education (how to teach my discipline in a way that optimizes the student learning experience).

I was hired into the math department to teach primarily statistics. I developed the Bioengineering Statistics course from scratch based on my experience at Duke Clinical Research Institute and working with the Biology and Biomedical Engineering departments at Rose-Hulman. Applying statistics to research in the biological sciences is definitely a passion, and I love teaching this particular course. In addition to teaching statistics, I am the faculty adviser for the InterVarsity Christian Fellowship chapter on campus.

Textbook (Optional):



- **Title:** Regression Methods in Biostatistics: Linear, Logistic, Survival, and Repeated Measures Models, 2nd Edition
- **Author:** Vittinghoff, Glidden, Shiboski, McCulloch
- **ISBN-10:** 1461413524 **ISBN-13:** 978-1461413523

You can view this text for free through the Rose-Hulman library; **click here**.

Note: this textbook is optional. This text was chosen because it provides an excellent reference for learning more about the methods covered during the duration of the course. However, homework problems and reading assignments are not assigned directly from the text. The course schedule does let you know which sections are covered in case you are following along in the text.

Course Notes:

Each module in the course includes a guided course note packet. There is one guided note packet per module and accompanies all lectures for the corresponding module. The guided notes highlight the key ideas but are not meant to replace a textbook. The notes allow you to focus on the content of the course instead of scrambling to copy every word of each class example. Additional comments made during the term, especially in response to student questions, should be added to your course notes.

Software:

- **R:** This is a freely available statistical software package used widely in academia and becoming more popular among various corporate sectors. R is a programming language (not point-and-click), but students in the past have found it to be fairly easy to grasp.
- **RStudio:** This freely available front-end to R provides a nice environment for programming in R and provides a nice way (via rmarkdown) to integrate R code and output with your homework and reports while avoiding cut-and-paste.

Note: While the use of R and RStudio will be demonstrated throughout the course, this software is not required. You are free to use any statistical software package with which you are familiar. I will provide support where possible, but I am particularly familiar with Minitab, SAS, and R. Also, be aware that not all methods we discussed can be implemented in other programs (Minitab, in particular, is very limited in its capabilities).

Additional Technology Requirements:

All materials for this course are placed online and therefore the course requires some additional technology requirements. At a minimum, you should be able to perform the following tasks *prior* to beginning the course:

- Navigate Moodle and interact with activities posted in Moodle (such as discussion forums and quizzes).
- Typeset mathematical equations using Latex, Microsoft Word, or Maple.
- Have access to a high-speed internet connection for viewing instructional videos, downloading course note packets and datasets, and submitting course assignments.

Working in the biological sciences (indeed, this is true of many disciplines) provides you an opportunity to create real change in the world. You might develop a medication, procedure, or device that significantly improves the quality of life for a particular population or even rids them of a debilitating condition altogether. Substandard work can have significant consequences. This course is designed to reflect this practice; I want to encourage you to perform at your best throughout the term. As a benefit, when you leave this course you will have high-quality examples to showcase your proficiency in analyzing data from biological studies. This goes a lot further with potential employers than a line item on your resume stating you took a specific course.

In order to help you achieve the objectives of the course, I will be implementing "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 requirements you choose to complete (described below). Each assignment is graded pass/fail (meaning no partial credit is awarded). In order to help you achieve a passing score, very clear expectations will be provided on every assignment. You have complete control over your grade in the course; I will provide you with the necessary tools and feedback to help you achieve that grade.

Grading Structure:

The course consists of four modules (or units), each covering a different statistical procedure used in the biological sciences. Your grade in the course will be tied to the level proficiency with each module; the scale below (adapted from the **NIH Competencies Proficiency Scale**) applies within each module of the course.

Proficiency Level	Description	Requirements
Fundamental Awareness (basic knowledge)	You have a common knowledge or an understanding of basic techniques and concepts.	1. Successfully complete **all** *Homework Assignments* for the module. 2. ~~Successfully complete the *Article Review* for the module.~~
Novice (limited experience)	You have the level of experience gained in a classroom setting and/or experimental scenarios. You are expected to need help when performing this skill.	1. Successfully complete **all** *Homework Assignments* for the module. 2. ~~Successfully complete the *Article Review* for the module.~~ 3. Successfully complete the *Concept Check* for the module.
Intermediate (practical application)	You are able to successfully complete tasks in this competency as requested. Help from an expert may be required from time to time, but you can usually perform the skill independently.	1. Successfully complete **all** *Homework Assignments* for the module. 2. ~~Successfully complete the *Article Review* for the module.~~ 3. Successfully complete the *Concept Check* for the module. 4. Successfully complete the *Module Quiz* for the module.

Advanced (applied theory)	You can perform the actions associated with this skill without assistance. You are certainly recognized within your immediate organization as "a person to ask" regarding this skill	1. Successfully complete **all** *Homework Assignments* for the module. 2. ~~Successfully complete the *Article Review* for the module.~~ 3. Successfully complete the *Concept Check* for the module. 4. Successfully complete the *Module Quiz* for the module. 5. Successfully complete the *Analysis Task* for the module.

Grades in the course are earned by obtaining a certain degree of proficiency in each of the four modules according to the following definitions:

Grade	Requirements
A	• You must achieve *Advanced* proficiency in all **4** modules • Successfully complete the ***Case Study***. • Successfully complete the *Article Review* • Successfully complete the *Capstone Project*.
B	• You must achieve *Advanced* proficiency in **3** modules ~~and *Intermediate* proficiency in the **remaining** module.~~ • Successfully complete the *Article Review* • Successfully complete the *Capstone Project*.
C	• ~~You must achieve *Advanced* proficiency in **1** module and *Intermediate* proficiency in **2** modules, and *Novice* proficiency in the **remaining** modules.~~ • You must achieve *Advanced* proficiency in **2** modules • Successfully complete the *Article Review* • Successfully complete the *Capstone Project*.
D	• ~~You must achieve *Intermediate* proficiency in **1** module, *Novice* proficiency in **2** modules, and *Fundamental Awareness* in the **remaining** module.~~ • You must achieve *Advanced* proficiency in **1** module • Successfully complete the *Article Review* • Successfully complete the *Capstone Project*.
F	Fail to meet the requirements for a D.

A plus grade is obtained at the discretion of the instructor for making significant progress toward the next grade in the course.

Description of Course Assignments:

In addition to lectures and reading assignments, each module will have several opportunities to assess your progress toward the course learning objectives. Each assessment item is described below.

Homework:

Three homework assignments will be given within each module. You are allowed (and encouraged) to work in groups (of your own choosing) on each assignment; there should be no more than 3 students per group. Only one submission is required per group. See the **Criteria for Successfully Completing a Homework Assignment**. These assignments are meant to spur discussion and encourage you to engage with concepts in the material which are essential to obtaining a fundamental awareness of the subject. Each assignment is expected to take approximately 50 minutes.

Article Review:

~~Each module the instructor will select a journal article to be discussed in class~~. The journal article will describe a study conducted in the biological sciences; no previous knowledge is assumed for the article. An article review consists of a guided critique (via a rubric provided by the instructor) of the article completed prior to the class discussion; this enables the discussion to be a bit richer. The provided rubric helps you to assess the strength of the article in both analyzing and presenting the results with clarity. An Article Review is completed individually, though you may discuss your ideas with others. See the **Criteria for Successfully Completing an Article Review**.

Concept Check:

Each module will have a single writing assignment that asks students to explain a key modeling concept from the module. This assignment provides an opportunity to communicate, in non-technical and non-theoretical language, an important modeling technique discussed during the class. These are meant to simulate conversations you might face in your professional career in an interdisciplinary scenario. This assignment will be completed as an individual, but you may discuss it with another individual. See the **Criteria for Successfully Completing a Concept Check**.

Quiz:

Each module will have a single quiz associated with it. The quiz consists of questions similar in nature to those appearing on the homework as well as questions requiring you to integrate two or more concepts from the course. These questions will be a mix of multiple choice questions and numerical computations. These questions test the full range of analytical skills discussed in the module; therefore, you may be expected to interpret provided computer output, make computations, or perform an analysis on a provided dataset. You will have up to **3 attempts** to successfully complete the quiz prior to the due date. A quiz is to be completed individually, though you may ask another individual for help. See the **Criteria for Successfully Completing a Module Quiz**.

Analysis Task:

Each module will have a single Analysis Task associated with it. The task consists of five questions meant to guide you through addressing a particular scientific question of interest given a dataset, as well as assess key concepts addressed in the module. Unlike a quiz, the emphasis of the Analysis Task is the communication of the results and key concepts. An Analysis Task is to be completed individually. **You should not discuss this assignment with anyone (other than the instructor) for any reason.** See the **Criteria for Successfully Completing an Analysis Task**.

Case Study:

The **Case Study** is only for those students seeking an A in the course. Students will find a published study (or internal study on which the student has not directly collaborated before) and reproduce the primary results of the article. Students will also discuss any improvements they feel are warranted to the analysis. The **case study** goes beyond a simple analysis; your final product will resemble an academic journal article and should be written in a very professional tone. See the **Criteria for Successfully Completing the Case Study**.

Capstone Project:

The Capstone Project is the backbone of the course and is required for all students. This assignment will be conducted as a class, though individuals may have unique tasks throughout the term. Students will collaborate (alongside the instructor) on conducting original research on a question somewhat related to the biological sciences. It will require students to consult the literature, design a study, collect data, conduct an analysis, and report on the results. The final product will consist of a written report and a visual (poster or PowerPoint) presentation. See the **Criteria for Successfully Completing the Capstone Project**.

Revisions:

I recognize that life happens. We each have our individual priorities, and these may not align with the course schedule. In those moments, the pass/fail nature of the course may be overwhelming. The best way to prevent this is to start assignments early; waiting until the last minute to begin an assignment will often result in work that does not meet the **criteria for successful completion**. Additionally, there will be opportunities for revisions. Specifically, students will be able to revise a Concept Check or an Analysis Task, provided the initial submission demonstrated a good-faith effort and was submitted by the original deadline. A revision is a chance to learn from mistakes; it is not a license to submit sub-standard work in hopes of being given the correct answer. Revisions are costly to both you as a student as well as to the instructor. As a result, you are limited to submitting 4 revisions during the term.

A revision on an assignment can be claimed by resubmitting the assignment to the same dropbox at any point during the term; all revisions must be submitted by 11:59 PM on Friday of 10th week.

Academic Misconduct Penalty

Expectations for upholding academic integrity, and the importance of academic integrity within the institution, as well as the departmental policy on academic integrity, can be located in the last chapter of the course syllabus (Institute Policies). In this section, we simply outline the penalty for academic misconduct. If a student commits academic misconduct on an assignment, the following action will be taken by the instructor:

- A letter will be sent to the student, the student's academic advisor, the Head of the Department of Mathematics, and the Dean of Students outlining the incident.

- The corresponding assignment will be considered unsuccessful, and the student will not have the opportunity to revise or submit this assignment. Note that based on the course structure, failing certain assignments can be extremely detrimental to your course grade.

This policy is consistent with the **Mathematics Department's Academic Integrity Policy**. To ensure you are not found in violation of the standards of academic integrity, you are encouraged to read the **Student Handbook**.

Expectations for Professionalism within a Group

Whether working in industry or academia, engineers and scientists will primarily make use of statistical ideas in a collaborative setting. Further, we believe learning some of the abstract ideas in this course is best done within a group setting. As a result, a significant portion of this course requires collaborative work. I expect each student to act professionally within their group. Group members will have different levels of mastery of the course content and different skill sets. As a result, a healthy group does not necessarily mean "equal participation" of group members. However, every group member is responsible for the work submitted by the group; therefore, every group member is expected to act professionally - which includes active participation in meetings and aiding in the construction of final documents.

You are expected to resolve typical issues of group dynamics; the instructor can help with this as needed. If you feel a member of your group is not acting in a professional manner to the extent that you do not feel comfortable with that individual's name attached to the work submitted, please contact the instructor immediately. If, after investigating, the instructor determines that a student has a pattern of unprofessionalism (negligence) within a group, the following action will be taken by the instructor:

- A letter will be sent to the student and the student's academic advisor outlining the incident.
- The student's final grade in the course will be reduced by a letter grade (A to B, B to C, etc.)

Students with Disabilities

Rose-Hulman is committed to working with students who have special needs or disabilities. Such students may be eligible to receive accommodations that provide equal access to learning, the living and learning environment, and college activities. After being admitted to Rose-Hulman, students must establish their eligibility for accommodations by notifying the Disability Services Coordinator of the disability and providing sufficient documentation. Students must provide as much documentation as possible about the disability and resulting substantial limitations. Documentation less than three years old by a psychiatrist, psychologist, medical doctor, school counselor, licensed clinical social worker, or other licensed health provider is acceptable.

Students with documented disabilities should contact **Student Accessibility Services**, 30 days prior to the course start date, for current regulations and more information and assistance. **Students requiring extended time on an exam should contact the instructor at least 3 days prior to an in-class quiz or exam to arrange a time to take the assessment.**

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.

Student Handbook

This course adheres to all policies described in the **Student Handbook**. A few key sections are briefly outlined below. *Rose-Hulman expects its students to be responsible adults and to behave at all times with honor and integrity. All students are expected to abide by this code and to aid in its enforcement by reporting violations of it.*

Dropping the Course

You are responsible for understanding the university's policies and procedures regarding withdrawing from courses found in the current catalog. You should be aware of the current deadlines according to the **Rose-Hulman Academic Calendar.** More information for Drops and Adds can be found on the **Registrar's site here**.

Academic Integrity

Academic integrity is an integral part of the Rose-Hulman community. It is important that all members of our community learn to properly acknowledge the important contributions of others in our respective fields, both within Rose-Hulman and external to Rose-Hulman. Understanding how to work in collaboration with others and how to incorporate their work into your own, and then appropriately acknowledging them, demonstrates your intellectual maturity and a high degree of professionalism. Academic integrity refers to maintaining a high standard of honesty in academic conduct. All students and faculty are encouraged and required to show academic integrity at all times. On the other hand, academic misconduct is a failure of academic integrity. Specifically, academic misconduct is cheating, plagiarism, or interfering with the academic progress of other students.

The **Academic Rules and Procedures document** provides extensive rules and procedures for academic and other misconduct. The Mathematics Department follows these rules seriously. The minimum penalty for such misconduct is for the instructor to award zero credit for whatever test, exam, project or quiz on which the misconduct occurs, even if it results in a lowered or failing grade. A report of the misconduct will be sent to the Dean of Students, Mathematics Department Head and the student's adviser. Faculty members may exact a higher penalty, up to and including failure in the course if they feel the misconduct warrants such action. Students may appeal the sanctions to the rules and discipline committee, per the cited web page.

Plagiarism is a serious offense, and students are expected to adhere to the Rose-Hulman policy on plagiarism and cheating. Some individuals might say that they did not understand what plagiarism was when they took credit for someone else's ideas, but ignorance is not an excuse for lack of academic integrity. It is each student's responsibility to know the Rose-Hulman policy on academic honesty, including plagiarism, cheating, dishonest conduct, and collusion. This not only includes misrepresenting others' work as your own, but also summarizing, paraphrasing, use of any other material in your work, and incorrect or incomplete citations and references. Using the same work for multiple courses is also dishonest. If you have any questions concerning rules, procedures, or about academic honesty, plagiarism, cheating, dishonest conduct or collusion, please speak with your instructor or with the Associate Dean of the Faculty.

Course Information Copyrights

For further information please refer to **Rose-Hulman Library information on Copyright**.

Statement of Non-**Discrimination**

It is the policy of Rose-Hulman Institute of Technology to admit students on the basis of their academic ability. Rose-Hulman Institute of Technology does not discriminate based on race, religion, color, national origin, sex, age, citizenship status, disability, veteran status or sexual orientation.

The Higher Learning Commission

Rose-Hulman is accredited by the **Higher Learning Commission**, Chicago, IL 60602-2504, 312-263-0456.