# ISyE 4803-GEB / ISyE 6805: Manufacturing Reliability

## Instructor Information

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## Course Description

The primary objective of this course is to introduce students to reliability analysis and engineering. Reliability is the science of modeling failures of engineering systems to better understand how they can be prevented. Formally, reliability is the probability that a component or system will perform its function for a designated time when used under specified operating and environmental conditions. Probability and statistics are essential components of the study of reliability. Prior knowledge of probability and statistics is helpful. Students with no prior background in probability and statistics will be expected to do some extra reading independently.

In this course, students will learn the basis of general probabilistic failure laws. Using these laws, we will introduce important concepts that include the reliability function, hazard rate, and mean time to failure. Students will learn how to determine the reliability of complex systems given knowledge of the reliabilities of their components and their configuration within the system. Students will learn how to model and analyze state-dependent systems using Markovian methods. Different kinds of physical reliability models will also be covered, including covariate methods such as proportional hazards, static and dynamic models, and some examples of physics-of-failure models. The course will also cover maintenance management and equipment availability. Techniques for statistical data analysis for modeling failure and repair data will be taught, with an emphasis on analyzing censored data. The course will conclude with a basic overview of popular condition-monitoring techniques and how they can be leveraged to establish a predictive maintenance program.

**Course Outcomes** Upon successful completion of this course, students should be able to:

- Apply fundamental probability concepts to reliability problems, including probability distributions, conditional probability, and expectation.
- Define and compute key reliability metrics: the reliability function, cumulative distribution function, hazard rate function, and mean time to failure.
- Model component failures using standard lifetime distributions, including the exponential, Weibull, normal, and lognormal distributions, and select appropriate models for a given failure mechanism.
- Construct and interpret the bathtub curve, and relate its regions to infant mortality, useful life, and wearout failure behavior.

- Determine the reliability of complex systems from component reliabilities and system structure, including series, parallel, k-out-of-n, and mixed configurations.
- Model and analyze state-dependent systems using continuous-time Markov chain methods and evaluate their steady-state and transient behavior.
- Apply physical reliability models, including proportional hazards models, static and dynamic covariate models, and physics-of-failure models.
- Formulate and evaluate maintenance and replacement policies, including age replacement, block replacement, and preventive maintenance strategies.
- Compute and interpret system availability measures for repairable systems, distinguishing between inherent, achieved, and operational availability.
- Perform statistical estimation of reliability parameters from both complete and censored life data using maximum likelihood and least-squares methods.
- Apply empirical methods for failure data analysis, including probability plotting and goodness-of-fit testing.
- Describe common condition-monitoring techniques (e.g., vibration analysis, oil analysis, thermal monitoring) and explain how sensor data and degradation signals can be leveraged to support predictive maintenance programs.

## Required Course Materials

**Required Textbook** The *required* textbook for the class is:

C. E. Ebeling, *An Introduction to Reliability and Maintainability Engineering*, 3rd Edition.

The instructor may deviate at times from the textbook, but reading assignments will be provided. This textbook is a valuable resource, and you are expected to read it.

## Grading Policy

Your course grade will be based upon my assessment of your understanding of the material covered throughout the semester. The weights used for grade assignment will be:

| Assessment | Weight |
|---|---|
| **Assignments:** | 10% (weekly) |
| **Test 1:** | 30% |
| **Test 2:** | 30% |
| **Test 3:** | 30% |

Test dates will be announced in class and posted on Canvas.

Thresholds for letter grade assignment are as follows.

| Letter Grade | Percentage Range |
|---|---|
| **A:** | $90\% \leq$ total grade $\leq 100\%$ |
| **B:** | $80\% \leq$ total grade $< 90\%$ |
| **C:** | $70\% \leq$ total grade $< 80\%$ |
| **D:** | $60\% \leq$ total grade $< 70\%$ |
| **F:** | $0\% \leq$ total grade $< 60\%$ |

**Assignments** There will be a homework assignment approximately every week. Homework is meant to build both basic knowledge of the course material and deeper understanding, so it is likely that some additional work beyond attending lectures will be required.

**Tests** Three tests will be given during the semester. All tests will require a laptop, so please bring your laptops to class on test days. Tests are graded for correctness, with partial credit awarded for partial answers (e.g., work shown) or to account for minor errors.

## Course policies

**Attendance** Attendance is mandatory and will be checked with an ungraded short quiz or roll call. You are allowed up to three non-excused absences without questions asked.

**Academic Integrity** Georgia Tech aims to cultivate a community based on trust, academic integrity, and honor. Students are expected to act according to the highest ethical standards. Review Georgia Tech's Honor Code and the student Code of Conduct. Any student suspected of cheating or plagiarism on a quiz, exam, or assignment will be reported to the Office of Student Integrity, who will investigate the incident and identify the appropriate penalty for violations.

**Core IMPACTS** https://www.usg.edu/curriculum/core-impacts/ is the University System of Georgia's General Education curriculum. If you are teaching a course that counts towards Core IMPACTS, you should include a syllabus statement about the Core area and associated career competencies. This resource developed by the Center for Excellence in Teaching and Learning and Online Education at Georgia State University includes template syllabus statements for each of the Core IMPACTS areas that you may adapt for your course.

**Accommodations for Students with Disabilities** If you are a student with learning needs that require special accommodation, contact the Office of Disability Services (404-894-2563) as soon as possible to make an appointment to discuss your special needs and to obtain an accommodations letter. Please also e-mail me as soon as possible in order to set up a time to discuss your learning needs.

**Student-Faculty Expectations Agreement** At Georgia Tech, we believe that it is important to strive for an atmosphere of mutual respect, acknowledgement, and responsibility between faculty members and the student body. The Student-Faculty Expectations articulate some basic expectations that you can have of me and that I have of you. In the end, simple respect for knowledge, hard work, and cordial interactions will help build the environment we seek. Therefore, I encourage you to remain committed to the ideals of Georgia Tech while in this class.

**Collaboration, Group Work, and Use of Generative AI** You are allowed to work in groups on all homework and out-of-class assignments (and you may use my solutions), but any work you turn in must be written in your own hand. In-class tests and exams are to be your own work. All in-class tests and exams will be closed book and notes.

**Generative AI** In general, use of Generative AI and of any previous semester course materials, such as homework, projects, and any other coursework, are prohibited in this course. Using these materials will be considered a direct violation of academic policy and will be dealt with in accordance with the GT Academic

Honor Code. **When in doubt regarding what constitutes a violation, do not guess the answer and post on Piazza for clarifications**.

**Extensions, late assignments, and re-scheduled/missed exams** Late homework will be not be accepted.