Iowa State University
Department of Industrial and Manufacturing Systems Engineering
IE 560: Engineering Risk Analysis
Fall 2019

Class Time and Location: Mon Wed Fri 1:10-2:00 pm, 1344 Howe

Instructor: Dr. Cameron MacKenzie
Office: 3029 Black Engineering
Office Hours: Mon Wed 2:10-3 pm, Tues Thur 1-1:45 pm, or by appointment
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This course focuses on building mathematical models to assess and quantify risk principally by following the methodologies of probabilistic risk analysis. We will examine different models to help us quantify risks and explore how to solve these models both analytically and through simulation. Because many risk problems involve societal and human behavioral issues, the course will also explore how humans naturally perceive risk, communicating risk issues to a non-technical public, and accounting for intelligent adversaries. Ultimately, risk analysis is used to make better risk management decisions, and the course will teach how to incorporate analysis into good decision making, while accounting for a decision maker's risk attitude. Examples from business, engineering systems, critical infrastructure, defense and security, cybersecurity, and health systems will be discussed.

Educational objectives:

1. Ability to quantify risk as a function of probability and consequences
2. Ability to build and apply probabilistic models to complex problems even when little data is available
3. Make sound decisions that account for uncertainty
4. Make good risk management decisions that incorporate the multi-faceted nature of many risk problems and account for how people perceive risk

Prerequisites: Coursework in probability and basic statistics

Textbook (required):
1. Hubbard, D. W. *The Failure of Risk Management: Why It's Broken and How to Fix It*. Hoboken, N.J.: John Wiley & Sons, 2009. [on reserve at the library]

Another book that provides more technical material on subjects discussed in class but is not required: Bedford, T. and Cooke, R. *Probabilistic Risk Analysis: Foundations and Methods*. Cambridge: Cambridge University Press, 2001. [also on reserve at the library]

Grading:

Reading quizzes	5%
Homework	12%
Topic quizzes	13%
Case studies	35%
Term paper	35%

Grading scale:

Grade	Percent range	Grade	Percent range
A	94 – 100	C	73 – 76
A-	90 – 93	C-	70 – 72
B+	87 – 89	D+	67 – 69
B	83 – 86	D	63 – 66
B-	80 – 82	D-	60 – 62
C+	77 – 79	F	< 60

This scale represents the worst possible grading scale I will use, and the grades may be rounded up to benefit the students.

Reading quizzes: There will be approximately six reading assignments that will consist of either individual topics or chapters taken from the Hubbard book. In order to verify that a student is reading the material, a quiz will be posted on Canvas that will be graded. The reading quizzes will have fixed due date and time. Failure to complete the quiz before that due date and time will result in a 0 for that quiz. Students are forbidden from helping one another on a reading quiz.

Homework: There will be four to five homework assignments during the semester. Since the topic quizzes will focus on numerical answers, the homework assignments will focus on interpretation and short answers. Students can work together on the homework, but each student must hand in his or her own work. Each homework will have a due date, but the TA and I will be flexible on many of the due dates. It is the student's responsibility to ask the TA for an extension (preferably before the due date), and it is the TA's discretion to grant an extension. No homework will be accepted after solutions to that homework are posted. A short homework assignment will be due during dead week on Friday, December 13.

Topic quizzes: There will be four topic quizzes posted on Canvas during the semester. The topic quizzes are designed to reinforce knowledge about how to solve particular problems dealing with uncertainty and risk. Each topic quiz can be taken as many times as the student wishes until the due date of the topic quiz. There will be specific rules about the type of help that a student is allowed to receive on topic quizzes.

Case studies: There will be three case studies during the semester, which will require each student to individually put together a PowerPoint presentation. For each case study, one-third of the students will be randomly chosen to present his or her presentation to me (either in person or online). If a student is not selected to present his or her presentation, the student will need to submit a PowerPoint presentation. The case studies will serve as a sort of examination, and students are forbidden from discussing the case study with other students.

Term paper: Each student will be required to submit a term paper analyzing a risk derived from his or her research or professional experience. The term paper will be written in three sections during the semester with opportunities to receive feedback from each section. The final version of the term paper will be due on Thursday, December 19.

Use of Canvas: I will be using Canvas to make announcements about the class and to post homework assignments, additional reading, and notes from the class. Students should submit their homework and take the quizzes via Canvas.

If you have a question that is appropriate for the entire class (e.g., questions about homework or lectures), please post that question on Canvas in the discussion section, and I will answer it there. If you have a question that is private (e.g., request for an extension on a homework, questions about grading an assignment), please email me. You can always ask me any type of question in person or via phone.

Use of Python: We will be using Monte Carlo simulation in this class to solve models of risk. I will be explaining how to perform Monte Carlo simulation in Python. In case you have never used Python, there is a reading that provides a tutorial of Python with the basic structure and commands that you will need for this course. If you prefer using another simulation software (e.g., Matlab, R, @Risk, Crystal Ball), you are more than welcome to use that software to solve problems, and the assignments will not require you to submit computer code.

Topics covered in this class (in roughly this order)

- Definition of risk, what is risk analysis?
- Reliability
- Monte Carlo simulation
- Influence diagrams
- Event trees
- Fault trees
- Bayesian probability
- Expert opinion
- Utility theory and risk attitude
- Risk management
- Risk perception
- Risk communication
- Intelligent adversary

Our commitment to you: The TA and I will do my best to respond to your questions quickly, whether you email me, post a question on Canvas, or leave a phone message. You are welcome to contact us by any of these methods. I will also come to class prepared and work to give stimulating lectures while teaching the material that I think is important for you to learn. As the lesson plan changes, I will update you both verbally and via Canvas.

You will have at least a week to complete homework, and you usually will have longer than a week. We will strive to grade homework within two weeks, and we will provide feedback on your

PowerPoint presentations and term papers. In summary, I am committed to helping you learn the material and improve your mathematical modeling, problem-solving, and communication skills.

Academic Dishonesty: The class will follow Iowa State University's policy on academic dishonesty. Anyone suspected of academic dishonesty will be reported to the Dean of Students Office. http://www.dso.iastate.edu/ja/academic/misconduct.html

Note: Copying and pasting from the Internet is considered plagiarism and is academically dishonest. If you do it for an assignment or for the term paper, you will receive a 0 for that assignment. You must write things in your own words!

Accessibility: Iowa State University is committed to assuring that all educational activities are free from discrimination and harassment based on disability status. Students requesting accommodations for a documented disability are required to work directly with staff in Student Accessibility Services (SAS) to establish eligibility and learn about related processes before accommodations will be identified. After eligibility is established, SAS staff will create and issue a Notification Letter for each course listing approved reasonable accommodations. This document will be made available to the student and instructor either electronically or in hard-copy every semester. Students and instructors are encouraged to review contents of the Notification Letters as early in the semester as possible to identify a specific, timely plan to deliver/receive the indicated accommodations. Reasonable accommodations are not retroactive in nature and are not intended to be an unfair advantage. Additional information or assistance is available online at www.sas.dso.iastate.edu, by contacting SAS staff by email at accessibility@iastate.edu, or by calling 515-294-7220. Student Accessibility Services is a unit in the Dean of Students Office located at 1076 Student Services Building.

Dead Week: This class follows the Iowa State University Dead Week policy as noted in section 10.6.4 of the Faculty Handbook http://www.provost.iastate.edu/resources/faculty-handbook. There will be a homework assignment due during dead week.

Harassment and Discrimination: Iowa State University strives to maintain our campus as a place of work and study for faculty, staff, and students that is free of all forms of prohibited discrimination and harassment. Any student who has concerns about such behavior should contact me, Student Assistance at 515-294-1020 or email dso-sas@iastate.edu, or the Office of Equal Opportunity and Compliance at 515-294-7612.

Religious Accommodation: If an academic or work requirement conflicts with your religious practices and/or observances, you may request reasonable accommodations. Your request must be in writing, and I will review the request. You may also seek assistance from the Dean of Students Office or the Office of Equal Opportunity and Compliance.

Contact Information: If you are experiencing, or have experienced, a problem with any of the above issues, email academicissues@iastate.edu.