CHEN/SEENG 430, Risk Analysis in Safety Engineering

Syllabus

Instructor: William J. Rogers, CHEN, JEB-426, <wjrogers@tamu.edu>

Class Sessions: JEB –104; Tue, Thu, 12:45 – 2:00 pm

Office Hours: Wed, Fri, 1:30 – 2:30 pm or by arrangement in JEB-426

Teaching Assist: TBA

Office Hours: TBA

Required Text: Norman Fenton and Martin Neil, *Risk Assessment and Decision Analysis with Bayesian Networks*, CRC Press, 2012 (RDBN)

Required Text: Charles E. Ebeling, *An Introduction to Reliability and Maintainability Engineering, 2nd ed.*, Waveland Press, Inc., 2010 (IRME)

Resources: Materials from M. Modarres, *Risk Analysis in Engineering*, Taylor & Francis, 2006, and from other sources will be placed on the course website. Class PowerPoint presentations, solutions to exercises, quizzes, and tests, tables, figures, articles on the course website.
Risk in the News articles with current applications of risk analysis
Risk Reminder messages sent via Howdy each weekend

Prerequisite: Senior or Junior UG status in engineering or science

Exams:

I	Tuesday, September 30, 12:45-2:00 pm, JEB-104
II	Thursday, October 30, 12:45-2:00 pm, JEB-104
Final	Wednesday, Dec 17, 8:00 – 10:00 am JEB-104

Project dates: Project papers due date: November 11, 2014, JEB-104
Project presentations: November 17 –19, 5:30-8:30 pm, JEB-104

Grading:

Exam 1	15%	increasing weight
Exam II	17.5%	
Final	22.5%	
Quizzes	10%	Solutions on website
Homework	15%	Solutions on website
Project	20%	

Objectives: Learn the fundamentals of risk analysis and risk-informed decision making with an emphasis on engineering applications.

Materials: Exams will be based on all materials covered in class and practiced on assigned homework and quizzes. The course exams are weighted based on the concepts covered up to each exam.

Exams will test knowledge and ability to use methods practiced on homework to analyze industrial risk applications. Complex expressions and statistical tables will be provided on handout sheets to be used during exams.

Homework: Problems for work in teams and submitted as a team product with a team self evaluation will be assigned each week and will be due in class the following week for full credit. Solutions to problems will be posted on the course website.

Project: All students on each team will perform a term project based on applications of risk analysis as discussed and practiced in this course.

Class sessions: Attendance for each class session is expected except for excused absences for which makeup quizzes will be given.

Quizzes are given about 1/week, often on the homework due date, to help students keep up to date with the class materials and to be better prepared for the exams. Solutions to quiz problems will be posted on the course website. Quiz credit is also given for occasional questions and comments based on material discussed in class.

Success in this course is achieved through consistent work to keep up with the class materials and discussion, assigned homework problems, and assigned reading. This approach is designed to help each student and each team understand the concepts and apply to class discussion and applications. Class and homework exercises are especially important for learning and reinforcing probability models used to represent uncertainty in real systems and to support engineering decision-making under uncertainty and risk management involving uncertain events in real-life engineering applications.

Course Outline

Topic	***Discussed and used throughout the course**	**Classes**
Introduction		1
	Hazards, risk, risk analysis, decisions, probability, reliability	
Risk Assessment (RA) structure and methods		9
	*Decision analysis, value of information, value of control, pre-posterior analysis	
	*Probabilistic modeling of uncertain events for optimum decision-making	
	*Bayes discrete models and Bayesian networks (BNs), for probability updating and identifying causal effects	
	Statistical correlations and cause/effect analysis	
	*Data engineering: confidence interval analysis and amount of data	

*Traditional statistics compared with Bayesian statistics
Near misses, unusual occurrences, precursor events
Logic modeling, fault trees, event trees
Bayesian network construction, software calculation, analysis
Diagnostic, predictive, inter-causal, and abductive reasoning
Dependent failures: β-model of common cause failure

Performance assessment	6
Reliability, Maintainability, and Availability analysis Time independent and time dependent hazard rates Covariate models and physical models Markov analysis, State dependent systems Reliability testing and model parameters updating	
Human reliability modeling, SHARP method with quantitative models and BNs. Human factors	1
Uncertainty analysis	1
Uncertainty propagation methods and comparisons	
Consequence analysis on projects	
Aloha, Phast, Probit, Multi-Energy, Baker-Strehlow models	
Risk contributors	1
Risk metrics Risk ranking	
Risk values, risk acceptance criteria	1
Individual and societal criteria, ethics, citizen engineer	
Risk Management	4
System approach of continual monitoring and measurement of the engineering system, its organization, and its safety climate by aggregation of indicators (lagging and leading) and BNs to identify trends and actions for support of optimum decisions to manage risk within acceptable limits Risk-informed multi-criteria decisions Dynamic predictive management with monitoring and testing of earlier forecasts with continual updating of model parameters	
Risk communication with personal and stakeholders	1
Risk perception; risk conversion factors	
Guest Lecture on risk analysis topics	1
Exams and reviews	2
Two exams	
Total Class Sessions, 75 minutes each	28

Classroom Attendance

Students are expected to arrive in the classroom for the class session to begin on time as is required for professional assignments. Late arrivals or missing class sessions can result in a low quiz grade average. If, due to circumstance, a student is not able to arrive on time, late arrival to class is better than missing the entire class. Students missing class time should consult their team members, other class students, and the course website to obtain current classroom materials. Students who missed class time also are urged to consult the instructor and the teaching assistant to collect missed materials.

Classroom Participation

Participation and questions in class discussion are encouraged. We will all learn more effectively from each other if we exercise what we encounter and analyze from different points of view and from a variety of experiences.

Laptops and Cell Phones

The use of cell phones and laptops during class is generally a distraction from class participation and is not acceptable. See your instructor if you have a special need for laptop use during class.

Classroom Decorum

As stated in Section 21 of the **TAMU Student Rules**, “Texas A&M University supports the principle of freedom of expression for both instructors and students. The university respects the rights of instructors to teach and students to learn. Maintenance of these rights requires classroom conditions that do not impede their exercise. Classroom behavior that seriously interferes with either (1) the instructor’s ability to conduct the class or (2) the ability of other students to profit from the instructional program will not be tolerated. An individual engaging in disruptive classroom behavior may be subject to disciplinary action. See 24.3.12.”

If you experience issues concerning classroom behavior, please discuss with the instructor or with the teaching assistant. Also, you are encouraged to bring concerns about the course to the attention of the instructor or the teaching assistant. Thank you for your consideration and dedication to help make the classroom environment respectful, stimulating, and comfortable for all students.

Americans with Disabilities Act (ADA) Policy Statement

The Americans with Disabilities Act (ADA) is a federal anti-discrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other items, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring an accommodation, please contact Disability

Services, in Cain Hall, Room B118, or call 845-1637. Additional information is available at http://disability.tamu.edu.

Academic Integrity Statement and Aggie Honor Code

"An Aggie does not lie, cheat, or steal or tolerate those who do."

Please consult the Honor Council Rules and Procedures on the web at http://aggiehonor.tamu.edu.

Plagiarism

Use of another person's ideas, processes, results, or words requires appropriate credit or references to the author or authors. Plagiarism is forbidden, because it weakens trust in safe communication of research among authors and scholars. For questions about plagiarism, consult the TAMU Student Rules under "Scholastic Dishonesty" or "Academic Misconduct" at http://aggiehonor.tamu.edu/Student%20Rules/definitions.html

Team Objectives and Guidelines

Students will work on and submit homework assignments and team projects in teams of 3 - 5 students. Three objectives of working in teams are:

1. To practice and gain experience in working with others, because this is the most common mode of operation in professional engineering.
2. To learn from each other in a dynamic work environment, to expand individual perspectives, to pool individual knowledge to maximize the utility and quality of individual work, and to promote continual and cumulative benefits from a variety of learning modes.
3. To benefit from the insight, analysis, and evaluation of each team member together with the dynamics of team interaction, communication, and leadership.

The greater the interaction among your team members, the more effectively these objectives will be achieved. An objective is not just to divide up the work, so that each team member has less to do. This approach would defeat the primary advantages of interactive teamwork and will result in poor performance on exams.

Each team will have a team leader. For maximum benefit and experience, the team leader position should rotate frequently at the discretion of the team. You should decide at your first team meeting who will be the leader and for how long.

Team Leader - is responsible for insuring that everything gets done. He or she will coordinate teamwork and insure that everyone contributes. Coordination includes:

> Scheduling Team Meetings - The team should meet together at least once and preferably twice each week to discuss the assignments, compare and check work. Additional communications can be by e-mail or telephone.

Assigning Specific Tasks to Team Members –Task assignments may include doing calculations, explaining principles, or checking someone else's calculations. Assign responsibilities and tasks for the semester project.

Setting Schedules - The leader must set deadlines and insure that they are met. Schedules include time for every team member to review and check all the work done on every assignment with feedback and corrections prior to submission.

Evaluating Team Activities - The team leader for a given week will evaluate the team performance in completing the homework on an included Team Evaluation form that will be the basis for 20% of the homework grade.

Obtaining Signatures - Each student will sign the teamwork evaluation form to confirm that that each problem has been understood and performed or reviewed.

Team Members – will perform a variety of tasks relative to the assignments and term projects including researching a topic, setting up or solving a problem, checking calculations, or looking up references or data. Every member of the team must contribute in some way to every assignment and every major component of the term project, even if it involves only checking the work that others have done. Every student is expected to understand every problem on every assignment, and will demonstrate that understanding individually on quizzes and exams.

Communication and persistence are the keys to effective teamwork!

Course Goals and Learning Outcomes

Learn a system approach methods to perform risk assessment, make more accurate predictions of system and component behavior, reduce risk cost effectively within acceptable ranges, manage risk, and improve system performance and reliability, make risk/gain-informed decisions to benefit the organization and the community, and communicate decisions that affect the organization personnel and the public, which benefits from and supports the products of your company.

Course Objectives

This course provides the opportunity to learn about risk, learn probability methods needed for a system approach, learn to think in distributions to represent ranges of outcomes of critical variables, and learn the applications of risk involved with industrial activities, and how to practice risk-informed decision-making and risk management. Because engineering is a systems decision-making enterprise, a systems decision-making way of thinking is used throughout the course.

Risk analysis consists of identifying, characterizing, reducing, managing, and informing others about the nature, magnitude, probability, and uncertainty of possible events, which are represented in distributions. Therefore, an understanding of methods and tools to represent and quantify uncertain events is essential. These tools include the models and methods of probability to model uncertain events and statistics to evaluate data, estimate how many data are required, develop cost effective strategies such as how often to test critical components, and calculate model parameters for up-to-date system reliability forecasts. Quantification of risk and forecasts of potential failure occurrences are essential for all risk analysis applications.

Risk assessment and good decision-making for increasingly complex systems is increasingly needed for design, manufacturing, operation, management, and regulations. The risk analysis approach facilitates evaluation of calculations and results so that the benefits and costs of each decision alternative can be weighed and balanced. Open discussion and analysis of decisions can help to improve the organization safety culture based on good risk management and also to increase public confidence in plant leadership.

This course will analyze how uncertainties and risk levels can be reduced and managed at tolerable levels. Zero risk results in no activities, and some risk is always necessary, so a systematic method is needed to provide the basis for controlling risk within acceptable levels. This needed approach is provided by risk assessment. Another approach still used in design and management of systems, however, is to reduce risk through over design and defense in depth using, for example, large ad hoc safety margins that can result in excessive costs or with risk insufficiently reduced or with risk transferred elsewhere in the system or the organization. Risk analysis and optimum engineering decisions result from the fundamentals to analyze and predict overall system behavior under industrial conditions.

The course topics follow those listed on the course syllabus, and homework assignments are based on lecture topics and materials. Applications of class materials are to be consistently practiced and reinforced by class exercises, homework problems, and student projects, which culminate in written reports and class presentations. In addition to applications of engineering principles, concepts of management and individual responsibility are stressed, as well as teamwork and the appreciation for measurement or estimation and the significance of calculated values.

Students in Teams fulfill the homework assignments and perform a major project as a team product. Homework papers and projects are therefore submitted as team products, and the teamwork dynamics of each team are self-evaluated weekly to promote continual and cumulative benefits from team learning. The main purpose of working in teams is to enable each student to learn from the experience, knowledge, and the ideas of the other team members and to learn through the dynamics of team interaction, communication, and leadership.

Course resources

Norman Fenton and Martin Neil, *Risk Assessment and Decision Analysis with Bayesian Networks*, CRC Press, 2012

This recent book provides the mathematics needed for Bayesian networks, which are presented clearly with excellent and interesting examples to build motivation for students to learn how to construct Bayesian networks and use them in risk applications.

Charles E. Ebeling, *An Introduction to Reliability and Maintainability Engineering, 2nd ed.*, Waveland Press, Inc., 2010

This is an engaging and up to date book on reliability and maintainability models needed for risk assessment and management.

Modarres, M., M. Kaminskiy, V. Krivtsov, *Reliability Engineering and Risk Analysis, 2nd ed*, Taylor & Francis, 2010 (Modarres, RERA)

This book focuses on practical methods for evaluating and managing systems within acceptable risk levels with emphasis on reliability of system components.

Jordaan, I., *Decisions under Uncertainty, Probabilistic Analysis for Engineering Decisions*, Cambridge University Press, 2005 (Jordaan, DUU)

This book provides a clear and coherent approach to engineering decision-making and an intuitive approach for understanding and estimating probability values needed for risk assessment and decision-making.

Modarres, M., *Risk Analysis in Engineering*, Taylor&Francis, 2006 (Modarres, RAE)

This book is a comprehensive book on risk analysis to supplement the risk and reliability methods discussed in RERA. Assigned readings will be placed on the course website.

Aven, Terje, *Quantitative Risk Assessment, The Scientific Platform*, Cambridge, 2011

The objective of this excellent book is a unifying scientific platform for evaluating risk assessments with particular focus on the uncertainties on the input information used in the risk calculations.

Ayyub, B.M., *Risk Analysis in Engineering and Economics*, Chapman & Hall/CRC, 2003.

Provides a good introduction to risk, with emphasis on economic applications, and to decision making.

Making Acute Risk Decisions with Chemical Process Safety Applications, CCPS, AIChE, 1995 (AIChE, 1995)

This book concerning risk decision-making has examples and case studies from the chemical industry.

Ang, A.H-S. and Tang, W.H., *Probability Concepts in Engineering, 2nd ed*, Wiley, 2007 (Ang, PCE)

An excellent, practical source for probability methods and probability distributions with engineering examples

Ang, A. H-S. and W.H. Tang, *Probability Concepts in Engineering Planning and Design, Vol 2*, Wiley, Decision, Risk, and Reliability, 1990 (Ang, PCEPD)

An excellent source for decision analysis and value of information as part of the decision process with many decision-making examples from industry

Savage, S.L., *The Flaw of Averages, Why we Underestimate Risk in the Face of Uncertainty*, Wiley, 2009

Uses graphic methods to teach the importance of using distributions instead of only point values, such as mean or median values, for decision-making.

Clemen, R.T. and T. Reilly, *Making Hard Decisions*, Duxbury, 2001

Presents a broad but clear approach to decision making with many examples.

Hammond, J.S., R.L. Kenney, and H. Raiffa, *Smart Choices*, Harvard Business School Press, 1999

An enjoyable and well-founded discussion of how to make better decisions.

Holloway, C. A., *Decision Making Under Uncertainty, Models and Choices*, Prentice-Hall, 1979

A very clear and readable introduction to decision analysis with interesting examples and applications.

Hubbard, D.W., *The Failure of Risk Management*, Wiley, 2009

This engaging book dramatizes current weaknesses of risk management and what could and should be done to improve decision-making and mange risk more effectively.

Hubbard, D.W., *How to Measure Anything, 2nd ed*, Wiley, 2010

Focuses on the importance of measuring significant factors that benefit a system or help to develop a highly effective risk management program.

Christensen, R., W. Johnson, A. Branscum, and T.E. Hanson, *Bayesian Ideas and Data Analysis, An Introduction for Scientists and Statisticians*, Taylor&Francis, 2011

Provides an incisive discussion of the power and applications of Bayesian reasoning and statistical inference to make accurate predictions and fulfill a crucial objective of engineering and science.

Neapolitan, R.E., *Learning Bayesian Networks*, Pearson Prentice Hall, 2004

A comprehensive textbook introduction to applications of Bayesian networks for scientists, engineers, and other practitioners of system behavior understanding and management.