Advance Fire Risk Modeling

Course Description
This course addresses the fundamentals of fire risk modeling from both theoretical and applied perspectives. A detailed case study on fire risk is presented in the first two modules as an introduction to the different technical topics covered in the course. Subsequent modules will cover modeling techniques for specific elements of fire risk assessment. Throughout the course, students are encouraged to implement the theoretical concepts in the computer to gain a better understanding of the uses and limitations of these techniques.

Course Objectives
Upon completing this course, the student should:
• Develop a fundamental understanding of the technical bases for fire risk elements through the development, implementation and use of computational models;
• Be able to incorporate fire risk concepts to practical engineering problems in order to assist the decision making process.

Required Textbooks
• Course handouts provided by instructor
• SFPE Handbook of Fire Protection Engineering, 3rd or 4th edition

Grading
Successful completion of:
• 2 examinations 40% (20% each)
• Homework assignments/projects 60% (6% each)
• Note: Extra credit will be available in most modules and exams.

A = 90-100; B = 80-89; C = 70-79; D = 60-69; F < 60;

Following Module 5, I will post the midterm exam (the exam will cover modules 1-5) for you to review and complete. This will give time for you to ponder a solution, ask questions to clarify any issues and develop a solution. The exam is to be completed solely by you, without correspondence with your colleagues. The midterm will be assigned on once the fifth module is completed and due in one week. Similarly, the final exam will cover Modules 6-10, will be posted on after completion of the last module and will be due in one week. As with the midterm, the final exam is to be completed solely by you, without correspondence with your group members or any other colleagues.

The assignments are problems that require solutions. I encourage you to submit answers to these assignments via the online drop box (Assignment tool). It will be to your benefit to show your work. Giving me only the answer is the equivalent of putting all your eggs in one basket. If that answer is wrong, there will be no partial credit.

A schedule of due-dates is provided within each module. This is provided so that you “keep pace” and do not try to complete the entire course in the last week of the 12 week term. I appreciate that many of you have busy work schedules and may have difficulty fulfilling all of the course requirements by the noted dates.
If you need additional time to complete an assignment, contact me before the due date and we will work out an agreeable solution.

**Homework Assignments**

A number of problem sets and computer-based homework assignments will be made throughout the term. These assignments will deal with various aspects of fire risk modeling. The purpose of these assignments is two-fold: first, they are intended to reinforce the understanding of the different technical elements in fire risk and second, they are intended to enhance the skills of students in applying computer-based fire risk modeling.

**Student Feedback and Course Evaluations**

I would appreciate any comments about the course, the delivery mechanism, administration or any other issue. Please feel free to send along comments during the term (especially if it is something that could be altered promptly to make an immediate improvement). Otherwise, you are welcome to wait until the end of the term.

In addition to individual comments sent directly to me, a midterm and final evaluation will be available for you to complete online. These surveys are completely anonymous. You will receive a notice in the course when these become available.
Summary of Course Content

The course will be made available at the course web site. They are organized into "modules" under the Course Content icon on the Homepage. You will be able to view the content section by section. A compiled version for each module will also be available from the 'Compiled Modules' in Student Tools. Each module will become available the week it will be covered and will remain available for the rest of the course.

Included within the modules are exercises, assignments and discussion points. The exercises are comparable to what we would discuss in class if this were a classroom presentation of the class. They are intended to help you to understand applications of the material and to foster discussions among you and your fellow students. We encourage students to attempt all of the exercises. Some exercises encourage you to share your results with your fellow students and to discuss the implications of these exercises. The discussions prompted by these exercises and the discussion points will be graded for participation and will constitute 20% of your grade (see Discussions below). The “Graded Assignments” interspersed throughout each module are “homework” problems which you should submit at the end of the Module week (see Assignments). These assignments will be graded and will constitute 30% of the course grade. Solutions will be posted after the end of the module.

Module 1: Quantifying Fire Risk: Frequency, Scenarios & Consequences

The first module covers basic concepts in quantitative fire risk assessment. It is intended to describe in detail the concepts of frequency, scenarios and consequences within the framework of a fire risk assessment. Upon the completion of this module, students should be able to identify frequency, scenario and consequences inputs for particular risk assessment applications. Subsequent modules in the course will describe modeling techniques to quantify them.

Module 2: Example Application

This module provides an overview of quantitative fire risk assessment in nuclear power plants. This introductory module will provide students a practical example of how fire risk is calculated and used in the decision making process in nuclear power plant applications. The objective of this module is to provide students an introductory perspective on different modeling tools and technical area expertise that could be involved in a fire risk assessment.

Module 3: Engineering Economy & Decision Making

This module covers two separate topics: Engineering Economy and Decision Making. Engineering Economy provide fire risk analysts with quantitative tools for comparing alternatives in terms of monetary value over time. However, many decisions are not based only on cost. The technical material on Decision Making provide tools to analyze different factors affecting various alternatives (including monetary value) in a systematic way to assess decisions of complex problems.
Module 4: Uncertainty 1 – Random Variables and Distributions
This module introduces the students to random variables and probability distributions, which are fundamental topics in any risk assessment. The probability distributions commonly used in risk assessment and reliability analysis will be discussed. Typical parameters describing the distributions will be also discussed. Upon completion of this module, students should be able to identify random variables in specific applications, characterize them as probability distributions, and generate random numbers from those distributions.

Module 5: Uncertainty 2 – Uncertainty Propagation
Uncertainty propagation is a very useful application of the material discussed in Module 3. This module will describe two commonly used uncertainty propagation techniques: Taylor expansions, and Monte Carlo simulations. Upon completion of this module, students should be able to propagate the uncertainty from one random variable to another and develop Monte Carlo simulations in Microsoft Excel.

Module 6: Reliability Analysis
Module 6 is the first of three modules focused on reliability, availability and maintainability topics, which are also practical applications of the random variables and probability distributions covered earlier in Module 3. In general terms, reliability analysis deals with equipment or system failures. In fire risk assessment applications, equipment or system failures may refer to fire detection or suppression systems. Therefore, reliability modeling offers a way to incorporate equipment or systems into the risk assessment. Upon completion of this module, students should be able to understand the basic concepts of reliability analysis and determine the reliability of replaceable components such as sprinkler heads and smoke detectors.

Module 6 is also focuses on the reliability of repairable items such as fire pumps. Upon completion of this module, students should be able to understand the concept of trend analysis and predict the number of failure of equipment as a function of time.

Module 7: Maintainability and Availability
This module introduces the concepts of availability and maintainability. In addition, the Module will introduce the students to availability and maintainability modeling through Markoff modeling. Upon completion of this task, students should be able to model the availability of fire protection systems using Markoff in Microsoft Excel or any other mathematical package.

Module 8: System Reliability Modeling
Modules 6 and 7 were focused on component reliability, availability or maintainability. Module 8 provides an introduction on system reliability by presenting fault tree and event tree modeling. Upon completion on this task, students should be able to develop and quantify system models using fault trees and event trees.
Module 9: Human Reliability

Human reliability is an important topic in fire risk assessment. No only from the point of view of human behavior in fire conditions, but also, human response to fire generated accidents scenarios. This module provides an introduction to human reliability analysis. Upon completion of this module, students should be able to identify and analyze human actions in fire scenarios. Simple quantification models will also be discussed.

Module 10: Data Management

This module provides a very general introduction to data structures and data management. This topic is important given the amount of data that sometimes is necessary for conducting a fire risk assessment. The objective of this module is to describe basic principles of data management as applicable to fire risk assessment. The material in this module is presented mostly in the form of examples, as a detailed discussion of data management and data structures is out of the scope of this course.