Group Workshop Syllabus

1. Overview

Title	**Decision and Risk Analysis**		
Mode	**Online instructor sessions and teaching fellow sessions**		
Hours	**4*2 hours instructor sessions + 2*2 hours review session+ 1*2 hours final presentation session+ 6*1.5 hours teaching fellow sessions (conducted by mentor)**		
Targeted Students	*High School Students*: students with interest in engineering, mathematics or statistics with a good calculus background *College Students*: students in engineering with an interest in probabilistic methods and risk analysis		
Prerequisites	**High School Students**	Required course/Knowledge	Fundamental knowledge of calculus and familiarity with common software packages (e.g., Excel and MATLAB).
	College Students	Required course/Knowledge	Fundamental knowledge of calculus and familiarity with common software packages (e.g., Excel and MATLAB).

2. Program Introduction and Objectives

Introduction	**Background** Structural engineers need to make decisions on complex systems and problems. Such decisions are complicated by the uncertainties in the possible outcomes and performance of such systems. For a full probabilistic assessment of an engineering problem, engineers must fully understand the corresponding deterministic problem, and be aware of the effect of uncertainties on their results. Similar considerations apply to every field of engineering. Consequently, it is essential for engineering students to learn techniques in decision and risk analysis. **Aim** This course first introduces students to deterministic methods and principles of structural analysis applied to trusses, beams, and frames. Then, the course expands to probabilistic analyses. The students are first introduced to concepts of risk and probability such as events, random variables, and probability distributions. Then, such concepts are applied to the field of reliability analysis and structural assessment. The methods for reliability covered in this course can be extended to other fields of engineering. **Description** The course covers the following topics: forces and moments, free body diagrams, static analyses for trusses, beams, and frames, set theory and fundamental elements of probability theory, random variables, probabilistic modeling, formulation of the reliability problem, and Monte Carlo Methods for simulations.
Course Objectives	For high school and undergraduate students, this course provides a solid base in static analysis, applied probability and Bayesian statistics as used by engineers. It introduces them to the increasingly important topic of engineering risk analysis. For graduate students, in addition, this course provides a strong background for pursuing more advanced courses on non-deterministic methods.
Software/Tools	Common software packages (e.g., Excel and MATLAB).

3. Program Schedule

Week		Lecture	Mentor Session (lab/case study, etc.)	Assignment	Reading Materials
1	**Topic**	Principle of statics and application to trusses		Homework 1 Project 1st part: deterministic analysis of a truss	Notes will be provided
	Detail	• Force and moments • Free body diagram • Equilibrium and determinacy • Truss analysis • Planar trusses	Example problems		
2	**Topic**	Shear and moment curves and application to beams and frames		Homework 2 Project 2nd part: deterministic analysis of a beam	Notes will be provided
	Detail	• Shear curves • Moment curves • Beam analyses • Frame analyses	Example problems		
3	**Topic**	Fundamental concepts of risk and probability		Homework 3	Notes will be provided
	Detail	• Events • Axioms of probability • Elementary rules of probability • Conditional probability and statistical independence • Bayes' rule • Theorem of total probability • Discrete, continuous, and mixed random variables • Probability distributions	• Partial descriptors of a random variable – Median, Mean, Mode – Variance, Standard Deviation, Coefficient of Variation – Coefficient of Skewness • Common distribution models		
4	**Topic**	Reliability analysis		Homework 4 Project 3rd part: fragility analysis of truss and beam	Notes will be provided
	Detail	• Elements of fragility analysis • Limit-state functions • Capacity and demand safety format • Component vs. system reliability problems	Example problems		
5 - 6	**Final Project (probabilistic assessment of a full structure) - Review Weeks**				
7	**Final Written Reporting and Oral Presentation**				

4. Problem Sets/Written Assignments/Quizzes

Total Number of Assignments	**5 times**	
Submission Deadline	7 Days after an assignment has been assigned	
Is Mentor needed to review and grade assignment?	Yes (x)	No ( )
Will a standard answer be provided?	Yes (x)	No ( )
Will there be Quizzes? How often/how many?	No	
Other Requirements (if any)	No	

5. Final Oral and Written Project

Each student is required to complete an individual term project. The topic will be a probabilistic analysis of a full structure. The students will be asked to complete parts of the project as weekly assignments. The project focuses on implementing techniques learned in this program to solve a realistic risk analysis and decision making problem.

5.1 Final Written Report

A final project report should be in a typed form and in sufficient detail to allow evaluation of its merits (a template will be provided during the program).

5.2 Final Oral Presentation

In addition to a detailed report, each student will also present the work performed for the project in an oral presentation. The presentation should start with a clear description of the problem/structure of interest. Then, it should describe the approach used to solve the selected, and end with a description of the results. More detailed instructions will be provided during the course of the program.

6 Suggested Future Research Fields/Direction/Topics

After completing this program, students will be able to work on more advanced topics in probability and statistics, reliability analysis, random vibrations, and stochastic processes.

7 Suggested Reading Materials

Leet, K., Uang, C-M., and J. Lanning (2008). *Fundamentals of Structural Analysis*. McGraw-Hill Higher Education, New York, NY

Ang, A. H-S., and W-H Tang (2007). *Probability Concepts in Engineering: Emphasis on Applications to Civil and Environmental Engineering*. John Wiley, New York, NY

8 Instructor Introduction

10.1 Instructor Title

Alfredo H. Ang Family Professor and Excellence Faculty Scholar in the Department of Civil and Environmental Engineering at the University of Illinois at Urbana-Champaign

10.2 Instructor Bio

Paolo Gardoni is the Alfredo H. Ang Family Professor and an Excellence Faculty Scholar in the Department of Civil and Environmental Engineering in the Grainger College of Engineering at the University of Illinois at Urbana-Champaign. He also has several courtesy appointments including at Loughborough University in the UK, and the Harbin Institute of Technology and Jianghan University both in China.

Prof. Gardoni is the Director of the MAE Center, which focuses on creating a Multi-hazard Approach to Engineering, the Editor-in-Chief of the international journal *Reliability Engineering and System Safety*, and the founder and former Editor-in-Chief of the international journal *Sustainable and Resilient Infrastructure*.

Prof. Gardoni is a member of the Board of Governors of the Engineering Mechanics Institute (EMI) of the American Society of Civil Engineering (ASCE), the Probabilistic Methods Committee (PMC) of the EMI, the Board of Directors of the International Civil Engineering Risk and Reliability Association (CERRA), the Advisory Council of the International Forum on Engineering Decision Making (IFED), and several national and international committees and associations that focus on risk, reliability, and resilience analysis.

His research interests include probabilistic mechanics; sustainable and resilient infrastructure; reliability, risk and life cycle analysis; decision-making under uncertainty; performance assessment of deteriorating systems; modeling of natural hazards and societal impact; ethical, social and legal dimensions of risk; optimal strategies for natural hazard mitigation and disaster recovery; impact of climate change; and engineering ethics.

Prof. Gardoni is the author of over 200 refereed journal papers, 28 book chapters, and 9 edited volumes, and has delivered over 60 invited, plenary, and keynote lectures. He has received over $50 million in research funding from multiple national and international agencies.

Prof. Gardoni is the 2021 recipient of the prestigious *Alfredo Ang Award on Risk Analysis and Management of Civil Infrastructure* from the American Society of Civil Engineers. The award was given for his contributions to risk, reliability, and resilience analysis, and his leadership in these fields. Prof. Gardoni has graduated 26 PhD students and 33 Master students. Several of his former students now hold faculty positions in the USA and around the world.

10.3 Instructor Profile Photo