Colorado State University
Department of Civil and Environmental Engineering

CIVE 622: RISK ANALYSIS OF WATER/ENVIRONMENTAL SYSTEMS

CREDITS: **3**
SEMESTER: **Fall 2010**
DATE AND TIME: **MWF 3:00 - 3:50 PM**
PRE-REQUISITES: **ST 301 or ST 309, CE 322, (or equivalent)**
INSTRUCTOR: **J.D. Salas, B208 Engr. Bldg., 491-6057, jsalas@engr.colostate.edu**

Many problems related to the analysis, design, and management of water resources and environmental engineering systems deal with a number of uncertainties arising from the random nature of the underlying physical phenomena (e.g. precipitation and streamflow), the errors in measuring the relevant variables of interest, the models used to analyze the systems, and the parameters associated with the models. This course is intended to quantify the various sources of uncertainty and to study approaches for minimizing such uncertainties by using probability theory, statistical analysis, and elementary concepts of time series analysis. This course will provide the tools for estimating the risk of failure and the reliability of water resources and environmental engineering systems based on probability and statistical methods as well as stochastic simulation techniques.

COURSE OUTLINE

1. **Introduction**
2. **Concepts of Uncertainty and Risk in Civil and Environmental Engineering**
   - Uncertainty and risk
   - Sources of uncertainty
   - Quantifying and modeling uncertainties
   - Risk of failure, reliability, and vulnerability
   - Uncertainty of risk of failure
3. **Statistical Analysis of Empirical Data Used in Civil and Environmental Engineering**
   - Basic statistical characteristics of empirical data.
   - Empirical frequency analysis based on plotting position formulas
     - Complete samples, samples with missing data, and samples with historical-paleo data
     - Flow duration curves
     - Low-flow and high-flow frequency analysis
     - Low-flow-duration frequency curves
     - Intensity-duration frequency curves
     - Frequency analysis of hydrologic, sediment, TMDL's, etc.
   - Empirical frequency analysis based on class intervals
     - Empirical PDF and CDF
4. **Brief Review of Random Phenomena, Random Events, and Random Variables**
   - Review of basic concepts: sample space, events, union and intersection of events, probability of events, dependent and independent events, mutually exclusive events, mutually exhaustive events, theorem of total probabilities, continuous, discrete, and mixed random variables. PDF's and CDF's.
5. **Distribution of Functions of Random Variables (Derived Distributions)**
   - Basic Concepts, Procedures, and Examples in Water Resources and Environmental Engineering.
6. **Population Moments**
   - Moments of Single Variables. Probability Weighted Moments (L-moments)
   - Moment Generating Function and Characteristic Function.
   - Moments of Two or More Variables. Conditional Moments.
   - Applications in Water Resources, Environmental Engineering.
7. **First Order Analysis of Uncertainty for Civil and Environmental Engineering Problems**
   - Theory and Applications in Water Resources and Environmental Engineering. Typical examples include:
     - Design of canals and pipes under uncertainty
     - Uncertainty of water and sediment rating curves
     - Uncertainty of sediment and water quality loadings
     - Design of drainages systems.

8. **Risk Analysis of Civil and Environmental Engineering Systems Based on Probability Models**
   - Risk Analysis Based on Probability Models
     - Normal, Gamma (Pearson), General Extreme Value, Logistic
     - Lognormal, Log-Pearson, Log-GEV (e.g. Log-Gumbel)
     - Mixed Distributions
     - Binomial, Geometric, Poisson
     - Examples and applications
   - Basic Concepts: Risk, Reliability, Safety Margin, Safety Factor, Time to Failure, Performance Function, Vulnerability.
   - Applications in Designing Hydraulic Structures and applications in Environmental Engineering
9. **Uncertainty Analysis of Civil and Environmental Engineering Problems**
   - Uncertainty of Basic Statistics
   - Parameter Uncertainty. Uncertainty of Quantiles
   - Applications:
     Design of Water Quantity and Water Quality Monitoring Networks.
     Frequency Analysis of Water Quantity and Quality Variables
   - Model Uncertainty
     Tests of Goodness of Fit. AIC.
     Robustness Analysis. Bayesian Analysis.
     Other Criteria (physically based probability models, etc.)
10. **Regression and Correlation Analysis**
    - Basic concepts
    - Simple Linear regression
    - Multiple linear regression
    - Applications
11. **Detection and Estimation of Changes of Water Quantity and Water Quality Variables**
    - Examples of Changes in Water Resources and Environmental Engineering
    - Exploratory Analysis for Detecting Changes
    - Tests for Shifts in the Mean, Variance, and other Statistics
    - Tests for Trends
12. **Filling in of Missing Data and Record Extension in Water Resources and Environmental Systems**
    - Typical cases (single site & multisite, stationary & periodic data, non-intermittent & intermittent data, etc.)
    - Statistical criteria and procedures for various cases commonly encountered in practice
13. **Regional Analysis of Civil and Environmental Engineering Data**
    - Regional Extreme Precipitation Analysis
    - Regional Flood Frequency Analysis
    - Spatial Interpolation: Applications in Surface and Subsurface Hydrology, & Environmental Engineering.
14. **Uncertainty and Risk Analysis of Civil and Environmental Engineering Systems by Stochastic Simulation**
    - Stochastic modeling and simulation of streamflows: single and multiple sites, annual and seasonal time scales, temporal and spatial disaggregation techniques, nonparametric techniques.
    - Stochastic modeling and simulation of precipitation
    - Applications: Design of the Storage Capacity of Reservoirs, Evaluating Reservoir Operating Rules, etc.

References: "Statistical Computing Techniques in Water Resources and Environmental Engineering", draft by J.D. Salas, R.A. Smith, G. Tabios and J.H. Heo

"Analysis and Modeling of Hydrologic Time Series", by J.D. Salas, chapter 19 of the McGraw Hill Handbook of Hydrology, D. Maidment, Editor, 1994.

Papers

Grading:	Homework:	30%
	Midterm Exam:	30%
	Final Exam:	40%