COURSE DESCRIPTION

Risk management is a multidisciplinary field involving finance, economics, mathematics, and computer science. This course covers an introduction to the theory and practice of risk management with an emphasis on techniques and applications. We consider FMEA (Failure Mode Effect Analysis), FTA (Fault Tree Analysis), HACCP (Hazard Analysis and Critical Point Control), simulation, portfolio optimization, value at risk, and coherent risk measures. This course emphasizes the use of mathematical models to analyze risk phenomena and the implementation of risk-aware solutions.

In this course, we follow a mathematical modeling approach to analyze and solve real-life applications in the context of risk. Our main tools are probability and mathematical optimization. The course develops the student's ability to analyze risk-related issues in a wide range of applications central to today’s risk theory and practice. The skills developed in this course can be applied to a broad range of business problems. The examples and student exercises will focus on the following areas: real options, supply chain management, shop floor operation scheduling, project management, and portfolio analysis and optimization.

PREREQUISITES (Recommended course 22:960:575 - Data Analysis & Decision Making)

Students taking this course must have proficiency in topics that include numerical methods of descriptive statistics, elements of basic probability theory, discrete probability distributions, continuous probability distributions, point estimation, sample size determination, hypothesis testing, inferences about the difference between population means, tests of independence of two categorical variables, simple linear regression, and multiple regression.

COURSE MATERIALS

Teaching materials will be drawn from many sources including the Internet, professional articles, academic articles, and books. Each lecture will have a set of associated slides, and some will include videos.

Textbook:
The course is based on class notes and presentations provided online.

Supplemental Text:
Readings:

Materials and Tools:
1. Readings: available online.
2. Microsoft Excel
3. DecisionTools suite with @RISK by Palisade: http://www.palisade.com
   - Can be purchased at: http://www.palisade.com/cart/products_EN.asp?cat=51&panel=0
   - DecisionTools is compatible with PC Excel 2003 and higher and PC Windows XP and higher.
   - DecisionTools is not compatible with Mac OS or iOS.
4. Python Programming Language (preferred distribution: Anaconda)

LEARNING GOALS AND OBJECTIVES

After completing this course, you should understand:
- Basic financial risk management models and techniques.
- Representative collection of examples and applications that covers the breadth of current risk management.
- Modeling and simulation of risk-averse decision-making problems on operations management.
- Development of models and methods based on the Value at Risk and coherent risk measures.
- Ability to apply risk models to quantify and analyze the supply chain Bullwhip Effect, project management scheduling with risk, and shop floor scheduling problems.
- The state of the art in the optimization of risk-averse multistage stochastic problems.

SUPPORT SERVICES


If you are a military veteran or are on active military duty, you can obtain support through the Office of Veteran and Military Programs and Services. http://veterans.rutgers.edu/

If you need mental health services, please use our readily available services. Rutgers Counseling and Psychological Services – New Brunswick: http://rhscaps.rutgers.edu/

If you need physical health services, please use our readily available services. Rutgers Health Services – New Brunswick: http://health.rutgers.edu/
If you need legal services, please use our readily available services: http://rusls.rutgers.edu/

If you need additional academic assistance, please use our readily available services. Rutgers University-New Brunswick Learning Center: https://rlc.rutgers.edu/

ACADEMIC INTEGRITY

I do NOT tolerate cheating. Students are responsible for understanding the RU Academic Integrity Policy (http://academicintegrity.rutgers.edu/files/documents/AI_Policy_2013.pdf). I will strongly enforce this Policy and pursue all violations. On all examinations and assignments, students must sign the RU Honor Pledge, which states, “On my honor, I have neither received nor given any unauthorized assistance on this examination or assignment.” [I will screen all written assignments through Safe Assign or Turn it in, plagiarism detection services that compare the work against a large database of past work. Don’t let cheating destroy your hard-earned opportunity to learn. See business.rutgers.edu/ai for more details.

GRADING POLICY

The evaluations of your class participation, assignments, course project, and final exam will be the basis for the course grade. There is no extra credit for this course.

- Class participation/attendance 10%
- Assignments 20%
- Course project 30%
- Final exam 40%

Attendance:
Attendance will be taken at the start of every class period. Class participation is necessary to facilitate a free-flowing and open dialogue.

Assignments:
There will be four individual assignments throughout the semester. These assignments are designed to examine your ability to implement and understand some of the systems that we have discussed in class. The distribution and due dates are listed in the course schedule below. Each assignment has equal weight in deciding your final assignments grade. You must prepare your answer using a word processor and hand it in at the start of class. Some assignments will require computer programming. In these cases, you will be required to submit the code for your program. If you submit your answers after the due date and have no valid excuse, you will receive zero score for that assignment.

Course Project:
Each team should complete a course project. A course project details a practical application case study with risk management. It is essential to prepare the project as soon as possible. Every team should prepare a one-page proposal for the project and submit this proposal for the instructor’s evaluation by (Midpoint of the semester). In this proposal, students need to clarify what the outline of the project is. The project is designed to provide each student with a more detailed analysis of an application of Risk Analytics in real-world business use cases. Students should take the approach of examining how companies have adopted Risk Management into their functionality. This would involve a case study(s) examining how a business(es)
have integrated risks and their impacts on the business. Finally, the class project should be prepared in the form of a project report as well as PowerPoint slides and presented on the assigned date. The presentations will be evaluated based on content, organization, presentation and originality.

**Final Exam**
The final exam will be an open-book, open-internet exam and last for three hours. All students are expected to take the final exam at the same time on the scheduled day. If a student has a valid excuse not to take the final exam on the exam day, one that complies with University regulations, the student must contact me and obtain permission to take the exam on another day. Failure to obtain the necessary permission will result in a zero grade.

Students are expected to learn how to mine and organize and utilize the knowledge gained through the Internet. Please do NOT copy/paste from websites! Use your own words and make sure that you cite the materials from the Internet or from other sources appropriately.

**PRELIMINARY COURSE SCHEDULE**

<table>
<thead>
<tr>
<th>Lecture</th>
<th>Topic(s)</th>
<th>Item(s) due/Reading assignment</th>
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<tbody>
<tr>
<td>1</td>
<td>Introduction to Risk Management</td>
<td>Quality risk management paper Q9</td>
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<tr>
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<td>• Risk fundamentals</td>
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<td>• Risk assessment tools</td>
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<td>• Pharma risk management</td>
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<td>Other general risk management techniques (FMEA, FTA, HACCP)</td>
<td>Quality risk management principles and industry case studies</td>
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<td></td>
<td>• FMEA (Failure Mode Effect Analysis)</td>
<td>T. Frank1, S. Brooks2, R. Creekmore3, B. Hasselbalch4, K. Murray5, K. Obeng6, S. Reich5, E. Sanchez7,</td>
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<td>• HACCP (Hazard Analysis and Critical Point Control)</td>
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<td>• Building a decision tree</td>
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<td>3</td>
<td>Risk assessment and probability estimation</td>
<td>Assignment 1 is due</td>
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<td></td>
<td>• Numerical methods based on mathematical models</td>
<td>Assessing risk probability:</td>
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<td></td>
<td>• Finding the theoretical probability distribution that best represents a data set</td>
<td>Alternative approaches, Dr. David A. Hillson PMP FAPM FIRM, Director, Risk Doctor &amp; Partners,</td>
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<td></td>
<td>• Alternative methods: based on qualitative judgment</td>
<td><a href="mailto:david@risk-doctor.com">david@risk-doctor.com</a></td>
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<td>• Maximum-likelihood estimators (MLEs)</td>
<td><a href="http://www.projectrisk.com/white_papers/Assessing_Risk_Probability--Alternative_Approaches.pdf">http://www.projectrisk.com/white_papers/Assessing_Risk_Probability--Alternative_Approaches.pdf</a></td>
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<tr>
<td>4</td>
<td>Risk acceptability and control</td>
<td>Quality risk management –</td>
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<th>5</th>
<th>Modeling risk using @RISK</th>
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<td>6</td>
<td>Simulation of discrete events and Analysis @Risk</td>
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<tr>
<td>7</td>
<td>Bootstrap application in financial and insurance industry.</td>
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<td>8</td>
<td>Financial risk analytics use cases</td>
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<td>9</td>
<td>Capital Budgeting with risk use cases</td>
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<tr>
<td>10</td>
<td>Supply chain risk analytics use cases</td>
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### Modeling risk using @RISK
- Monte Carlo simulation of basic models
- Viewing results summary
- @Risk reports
- @Risk Analysis
- Sharing simulation results
- Sharing model information

### Simulation of discrete events and Analysis @Risk
- Selecting Distributions
- Goodness of fit tests (Akaike, Bayesian AIC, BIC, chi-square)
- Correlation and interdependence
- Stochastic model with Risk Optimizer

### Bootstrap application in financial and insurance industry.
- Bootstrap resampling
- Validity of bootstrapping
- R & Python codes introduction for bootstrapping.
- Jackknife resampling for bias and variance estimation.

### Financial risk analytics use cases
- Financial statement forecasting modeling uncertainly hands on @RISK
- Value at Risk (VAR)
- Valuing stock options @RISK
- Valuation via Option Theory

### Capital Budgeting with risk use cases
- Models with @Risk on capital budgeting NPV (net present value)
- Modeling options and introduction to Copula
- Capital Asset Pricing Model

### Supply chain risk analytics use cases
- Modeling Supply chain risk
- Inventory risk and allocation model
- Operations management and Supply

### References
- Understanding and control the risk in pharmaceutical manufacturing industry, Joymalya Bhattacharya. [http://www.ijpsi.org/Papers/Vol4(1)/E041029041.pdf](http://www.ijpsi.org/Papers/Vol4(1)/E041029041.pdf)
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<tr>
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<th>Required readings will be provided</th>
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| 11 | Project Management risk analytics use cases with @RISK  
   • Project cost with delays and failures  
   • Optimal timing of projects  
   • Crashing the project and optimizing cost @RISOPTIMIZER  
   • New product profitability: advanced sensitivity analysis |
| 12 | Risk preferences and simulation (case study: Wastewater) |
| 13 | Project presentations |
| 14 | Final Exam |