OPNS 450: Analytical Decision Modeling

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Course Overview

This course focuses on modeling, analyzing, and ultimately solving business decision problems on Excel spreadsheets. We will address problems involving **optimal resource allocation** (how to best utilize the available resources), **risk analysis** (how to incorporate uncertainty in problem parameters) and **sequential decision analysis** (how to make sequential decisions under uncertainty with information). In each area, we will consider a variety of business problems, build models to structure them on spreadsheets, analyze and solve them using the available Excel commands, tools and add-ins and study their economic interpretation.

The focus of the course will be on **modeling, analysis and interpretation** rather than the underlying mathematical theory or computational algorithms. This practical approach to problem solving will not only complement the theoretical one, but is also more readily accessible to managers, who find spreadsheets a natural, intuitive, and user friendly platform for organizing information and performing “what if” calculations, which has made them indispensable tools of modern business analysis.

**The emphasis of the course will be on systematic, logical thinking, and problem solving, not on learning spreadsheet skills.** Good working knowledge of basic Excel will be assumed so that we can focus on the problem solving aspects of the course. For example, knowing how to write and copy formulas involving relative and absolute cell addresses, and how to insert and edit charts in Excel will be essential. However, a typical Excel user may not be familiar with more advanced tools, techniques and add-ins that have significantly increased the power of spreadsheet analysis. This course will introduce and apply these, thereby furthering the spreadsheet knowledge base of even an expert Excel user. In particular, we will use Excel’s **Solver** tool, **Solver Table** and **Open Solver** add-ins for decision optimization, **SimulationSupplement** and **@Risk** add-ins for Monte Carlo simulation, and **Precision Tree** add-in for sequential decision analysis. We will also learn **time series analysis** for forecasting. Thus, the spreadsheet modeling and analysis experience in this course should enhance your analytical problem solving capabilities as well as Excel spreadsheet skills.
Class Setup

The course involves a hands-on, in-class learning, so **attending each class, on time, and actively participating in problem solving on laptops in class are absolutely essential.** Course requirements consist of developing, analyzing, and solving spreadsheet models of assigned problems and cases, and exams.


**Case Packet:** Cases, exercises and supplementary readings.

**Required Software**

1. **You are responsible for installing the necessary software used for each class and making sure that the software is running properly before the class.** Depending on the specific configuration on your computer, the problems with the software installation may vary and a generic solution may not be readily available so I recommend that you install a software and check its functionality **at least a couple of days before** the first class you need to use that particular software.


3. The Palisade Corporation product Decision Tools Suite. This includes the Excel add-ins: Precision Tree, @RISK, and RiskOptimizer.

4. Please download the Excel add-ins OpenSolver and Simulation Supplement from Canvas.

5. Please download the Excel add-in Solver Table from Prof. Chris Albright’s website:

   [http://www.kelley.iu.edu/albrightbooks/Free_downloads.htm](http://www.kelley.iu.edu/albrightbooks/Free_downloads.htm)

**Hardware Requirements**

1. You must bring your laptop to every class.

2. **This class is designed for PCs. I recommend that you use a PC for the purposes of this class.** If you choose to use a Mac, you must find a way to be “*Windows compatible*” because the DecisionTools Suite will not work in Mac. I recommend installing and using a Windows emulator, e.g., VMWare Fusion or Parallels Desktop. Note that using a Mac with a Windows emulator can slow down your computer significantly, especially while running simulations.

**Course Outline**

I. **Introduction:** Modeling and analysis of business decision problems on Excel spreadsheets. Review of basic Excel, including *Goal Seek, Data Tables* and *Solver*. Applications to new product introduction, monopoly pricing and buy vs. lease decisions.
II. **Optimal Resource Allocation**: Constrained optimization models of problems involving best utilization of available resources – equipment, personnel, materials, time, space, capital – to optimize some measure of performance such as profit, cost, sales, return on investment. Model formulation, solution by Solver, sensitivity analysis, and economic interpretation. Applications to optimal product mix, blending, portfolio planning, project selection, work assignment, budget allocation, asset-liability matching, workforce scheduling, production planning, and portfolio optimization.

III. **Risk Analysis**: Monte Carlo simulation of uncertain environmental variables, using the Rand() function, data tables, SimulationSupplement, and @Risk. Applications to performance evaluation, inventory planning, yield management, competitive bidding, project valuation, cash flow analysis, stock option prices, optimal job search and portfolio optimization.

IV. **Sequential Decision Analysis**: Modeling and analysis of multiple stage decision problems under uncertainty, using Precision Tree. Applications to valuing real options, oil drilling, process selection, and capacity planning. Multi-period Inventory Planning Using Dynamic Programming.

V. **Forecasting**: Forecasting by time series analysis with trend and seasonality. *Moving average* and *exponential smoothing*.

**Course Requirements and Guidelines**

♦ **Prerequisites**: Everyone is expected to know the basics of working with Excel spreadsheets. These include developing and copying formulas with relative and absolute cell addresses, and drawing and editing charts in Excel.

♦ **Class Work**: A detailed class schedule showing topics, classroom examples, homework assignments, and readings appear at the end of this syllabus. Preparation for each class involves reading and preparing the case(s) to be covered in that class. Excel files of the case data should be downloaded from Canvas **before** (not during) the class. They will be used in class to build models, analyze them, and interpret solutions. This problem solving process seems *deceptively* simple when watching someone else do it, or reading the solution. The only way to learn this important and difficult skill is by practicing it yourself. Given the in-class learning involved, everyone is expected to attend all classes, on time, and actively contribute to the class discussion, sharing ideas, experiences and insights.

♦ **Grading**: The course grade will be based on the homework assignments (35%), an in-class midterm (25%), a take-home final exam (30%), and class participation (10%), which includes class attendance as an essential component. Each group member must fill out the peer evaluation form that reflects individual members’ contribution to the group output.

♦ **Assignments**: The homework problems and cases are designed to enhance your understanding of the process of modeling and analysis learned in class. Some assignments are to be completed individually, while others may be done in groups of three. The individual and group assignments are specified in the schedule at the end of this syllabus. Grading will be based on demonstrated comprehension of the case, logic of the model, and application of concepts, methods and tools learned in class. An ideal homework should include:
♦ a write-up explaining the problem, model, analysis and results,
♦ a well-organized spreadsheet with clear explanations and documentation including formulas, gridlines, row and column headings, color coding, shading, etc. For conciseness, do not repeat similar formulas. Add explanations, comments and text boxes to help the reader understand your spreadsheet.

Although many assignments are to be submitted as a group, everyone is expected to work on each assignment individually first, and then combine the individual effort to produce the best group output. Each group should submit one report per assignment electronically (through Canvas) of their model, analysis and solution. There will be some individual assignments as well. All assignment solutions will be distributed in class when they are due, so late submissions will not be accepted or graded.

♦ **Guidelines:** Each submission should include (a) a short write-up explaining your model (1-2 pages), analysis and conclusions, and (b) supporting exhibits such as spreadsheets, charts, formulas, figures, etc. Think of your submission as a business report that you will present to your client or superior, who does not have time or patience to try to understand your work. So it is in your best interest to explain your work – the thought process in structuring the problem, step-by-step development of the spreadsheet model, its analysis, and final results – as clearly as possible. It is very critical that you communicate your work as clearly and effectively as possible so the reader can follow it instantly and effortlessly. A concise, logically organized, well documented and aesthetically pleasing report will improve your chances of getting the client’s business, your next promotion, or a high course grade! Here are some guidelines:

♦ **Write-up:** This should be a clear and concise explanation of your approach to the problem, model, analysis, and conclusions. Use a presentation format with outlines, bullets and tables, rather than long verbose essays. The write-up should include:

  ♦ **Executive Summary:** Brief overview of the problem addressed, key issues involved, and your solution, clearly demonstrating your understanding of the problem and results.
  ♦ **Model:** Explanation of the logical structure of your model, outlining its step-by-step development, which summarizes your thought process in approaching the problem. State the objective, decisions and tradeoffs involved, as well as the key structural assumptions you made to simplify the analysis. Do not just restate the problem data as assumptions. Explain key formulas in words, such as: Cash Receipts this month = 0.2*Sales 2 months ago + 0.8*Last Month’s Sales + 0.2*This month’s sales.
  ♦ **Analysis:** Summarize the key spreadsheet functions, commands and tools used to analyze your model and how. (Do not simply list them.)
  ♦ **Conclusions:** Provide concrete answers to the specific questions asked. Highlight the key results, and provide an intuitive economic interpretation. Make references to the exhibits attached, but do not just state “See Exhibit 1 for answer to part (a)”.

♦ **Spreadsheets:** Spreadsheets are notoriously difficult to understand, trace the logic of, and debug, even for the person who creates them, let alone for an unfamiliar reader. It is your responsibility to make your spreadsheets absolutely clear and easy to follow. For
tractability, try to organize your model and results on one page. If it will not fit on one page, determine logical break point(s) and provide sufficient documentation to guide the reader from one page to the next. The goal is to help the reader follow your work effortlessly. Each spreadsheet should be self-contained and well documented to show:

- The title of the exhibit that is descriptive of its content
- Careful, logical layout, with data separated from the model and its analysis
- **Key cell formulas displayed using the Formula List add-in.** Try to place the formula text close to the cells containing the formulas. For conciseness, do not repeat similar formulas; manually type instead “copied to..”. Make sure to print the *gridlines, and row and column headings*, without which formula lists are useless. Add explanations, comments and text boxes to help the reader understand your spreadsheet.
- Color coding and shading to highlight contents of key cells and results, with a legend.

**Honor Code:** We will strictly follow the Kellogg honor code as described at [http://www.kellogg.northwestern.edu/stu_aff/policies/honorcode.htm](http://www.kellogg.northwestern.edu/stu_aff/policies/honorcode.htm). The honor code requires that you must not obtain solutions to the assignments, cases or projects from other students in the past or present classes. **Also, you must not include your name on a group report if you have not contributed substantially to the group work.** You must also fill out peer evaluations that accurately reflect all group members’ contribution to the group submissions.

**Class Room:** We will adhere to the Kellogg classroom etiquette as described at [http://www.kellogg.northwestern.edu/stu_aff/policies/etiquette.htm](http://www.kellogg.northwestern.edu/stu_aff/policies/etiquette.htm). Everyone is expected to attend all classes, and on time. To minimize delays and disruptions, please come to the class early and set up your laptop, so that the class can start on time, and then stay in your seats until the end of the class. In the interest of minimizing distraction to your fellow students, you must not browse the internet or use e-mail during class. You should also report any violation of this standard classroom etiquette, so an appropriate action can be taken.

**Re-grading Policy:** If a student wishes to contest a grade given, s/he should adhere to the following procedure:

1. Students have up to 5 working days after graded written work has been made available to them to submit it for re-grading. If the work is returned to students at the end of the term, they have 10 days in the next registered term to resubmit the work for re-grading. In contesting a grade, students should be informed that the entire work will be reviewed, not only the sections in question, and the final grade adjusted accordingly.

2. Submissions for re-grading must be done in writing, with the student outlining the specific areas of the work that s/he feels were incorrectly graded. All submissions should be signed and dated by the student.

3. The professor will re-grade the work being contested and provide a response to the student within 20 working days, explaining the results of the review and indicating whether the student’s grade has changed. Oral or written responses may be provided.
4. If a student remains dissatisfied with the grade, s/he has 5 working days after receiving the re-graded work to submit it a second time for re-grading, as outlined in Step 2.

5. The professor will re-grade the work within 20 working days of receiving it, as outlined in Step 3. This concludes the grading appeal process.

The professor’s judgments on second submissions of written work will be final. There are no provisions for student appeal to outside parties in resolving grading disputes.
Peer Evaluation

Please evaluate all members of your group (including yourself) in terms of their contribution to the group assignments and the final project, and record the scores on the spreadsheet on the back page. Highlight your own name and grade each member of your group on each assignment. Allocate a total of 10 points among all group members (including yourself) to reflect their relative contributions to the group effort on each assignment and the term project. At the end of the quarter, compute the average scores for all of your group members in the last column and return this evaluation form with your final project report. Please fill these forms carefully, as time progresses. It will be one of the important inputs used in deciding the individual course grades. Submission of the peer evaluation forms is mandatory; your grade may be withheld for failure to submit it. These evaluations will be guarded with utmost confidentiality, and will be used only by me, and that too only for grading purposes.

During this peer evaluation process, please keep in mind the following criteria in terms of each individual group member’s contribution.

♦ **Communication:** Does the group member listen to and consider others’ points of view? Communicate ideas well? Adhere to the group meeting schedule? Is open to feedback?

♦ **Innovation:** Does he/she generate ideas on how to achieve group goals? Apply past knowledge and experience to the current project? Offer alternative approaches to current ways of thinking? Challenge the status quo when necessary? Encourage innovative thinking among the group members?

♦ **Initiative:** Does the member help move ahead efficiently? Go beyond the requirements of the task? Look for opportunities to improve? Help others in the group’s understand the background material?

♦ **Team Orientation:** Does the member work well with the group? Acknowledge and pay attention to the group and individual activities? Treat all members as colleagues? Complete individual task requirements to achieve group goals? Give other members credit for their ideas? Consider the group goals as the top priority? Attend all group meetings or provide advance notice when absent? Informs the group of his/her task so that it can be completed when absent?
Analytical Decision Modeling

Peer Evaluation Form

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<th>Assignment</th>
<th>#4</th>
<th>#5</th>
<th>#8</th>
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<th>#11</th>
<th>Project</th>
<th>Average</th>
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Group Member / Score

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Comments:
<table>
<thead>
<tr>
<th>Week</th>
<th>Date</th>
<th>Classwork</th>
<th>Homework</th>
<th>Readings &amp; Textbook Reference</th>
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<tbody>
<tr>
<td>1</td>
<td>April 3rd</td>
<td>I. Introduction: Excel in Modeling</td>
<td>Note: * = individual assignments</td>
<td>“Essential Excel”</td>
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<td></td>
<td>Have 6th</td>
<td>Introduction to Decision Modeling</td>
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<td>Chapters 1 and 2</td>
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<td>Review of Excel: <em>Goal Seek</em> and <em>Data Tables</em></td>
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<td>Case: New Product Profit Projections (A)</td>
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<td>April 6th</td>
<td>Case: Buy Now, Pay Later</td>
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<td>“Principles of Spreadsheet Modeling”</td>
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<td>Case: The Price Is Right</td>
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<td>Chapter 7, Section 3</td>
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<td>April 10th</td>
<td>II. Resource Allocation: Optimization</td>
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<td>Introduction to Resource Allocation</td>
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<td>Linear Optimization: <em>Solver</em></td>
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<td>Case: Producing p-Pads for Profit</td>
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<td>April 13th</td>
<td>Sensitivity Analysis: <em>Shadow Prices</em></td>
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<td>Case: Planning a Proper Portfolio</td>
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<td>April 17th</td>
<td>Optimal Blending</td>
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<td>Have 40th</td>
<td>Case: Make Me Wine (and Wealthy Too!)</td>
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<td>April 13th</td>
<td>Airline Network Revenue Management</td>
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<td>Case: BlueSky Airlines A, B, C</td>
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<td>Integer Optimization</td>
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<td>Case: Picking Peachy Projects</td>
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<td>Case: Planning a Product Promotion</td>
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<td>Case: Matching Fund Flow Fluctuations (time permitting)</td>
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<td>April 27th</td>
<td>Multi-period Planning:</td>
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<td>Case: Production Planning Over Time</td>
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<td>Case: Workforce Planning Over Time (time permitting)</td>
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| Week 5 | May 1st | III. Risk Analysis: Simulation | Financial Risk Management: *Solver Table*  
Case: Risk-Return Relationship (A) | Note: * = individual assignments  
Case Write-up Due: McPherson  
Refrigeration Limited (Assignment #5) | Nonlinear optimization models  
Chapter 7, section 7 |
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| May 4th | Introducing Uncertainty: The *Rand(/) function*  
Case: Pay for Performance | Case Write-up Due: Risk-Return Relationship (B)* (Assignment #6) | Review basic probability  
Chapter 11, sections 1 – 4 |
| Week 6 | May 8th | **IN-CLASS MIDTERM EXAM** |  |  |
| May 11th | Discrete Probability Models: Binomial and Poisson  
Case: Inventory Planning  
Case: Yield Management | Case Write-up Due: Let’s Make a Deal* (Assignment #7) | Review Binomial and Poisson dist.  
Chapter 12, sections 1 and 2  
“Guidelines for Simulation with add-ins”  
Chapter 12, section 4 |
| Week 7 | May 15th | Continuous Prob. Models: Normal and Triangular  
Case: The Best Bid |  |  |
| May 16th | Case: Project Valuation  
Case: Cash Flow Analysis |  | Review Normal distribution  
Chapter 12, section 3 |
| Week 8 | May 18th | Role of Uncertainty over Time  
Case: Pricing Bonds, Stocks and Options  
Case: Waiting for the Right Offer | Case Write-up Due: Confederated Pulp & Paper (Assignment #8)  
Case Write-up Due: Marsh and McLennan (A) (Assignment #9) |  |
| May 22nd | Correlated random variables & Risk Optimizer  
Case: Portfolio Optimization Revisited  
“Decision Analysis” (Time-permitting) |  |  |
| Week 9 | May 25th | **IV. Sequential Decision Analysis** | *Precision Tree* Case: Decision Analysis with Information, Sequential Decisions with Information, Expected value of information | Chapter 10  
Chapter 11, section 6 |
<table>
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<th>V. Forecasting</th>
<th>May 29th</th>
<th>Case: Satisfying Demand for ‘Hot’ Product Mid-Winter (A), (B)</th>
<th>Case Write-up Due: How to Figure Odds in Forecasting Acquisition Results (Assignment #10)</th>
<th>Chapter 16</th>
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<td><strong>Week 10</strong></td>
<td>June 1st</td>
<td><em>Forecasting: Exponential Smoothing</em></td>
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<td><em>Case: Merriwell Bag Co.</em></td>
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<td>June 5th</td>
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<td>Forecasting Cont. &amp; Course Review (Time-permitting)</td>
<td>Case Write-up Due: Hawthorne Plastics (Assignment #11) Peer Evaluations Due</td>
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<td><strong>Week 11</strong></td>
<td>June 12th</td>
<td><strong>TAKE-HOME FINAL EXAM DUE</strong></td>
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