**UNIVERSITY OF SOUTHERN CALIFORNIA**
**Marshall School of Business**

**DSO 570 – The Analytics Edge: Data, Models, and Effective Decisions**
**(Spring 2017)**

# Syllabus
# (Version: 1/9/17)

## Contact Information


Instructor: **Paat Rusmevichientong**
Office: **BRI 400F**
Tentative Office Hours: **Wednesday 11am – 4pm**


NOTE: **I want to accommodate as many students as possible, so I would be happy to hold additional office hours based on the students' preferences and schedules. Also, I have to attend a department-wide meeting on 1/18. So, on Wednesday 1/18, my office hours will be from 10am – 12pm and 3pm – 4pm.**


Course E-mail: **paat.dso570@gmail.com**


**IMPORTANT:** **0** is the number zero, and **o** is the letter. To ensure a quick response, please send your questions about the course to **paat.dso570@gmail.com**

## Class Schedule:

Section 16298: Tuesday and Thursday 12:30 – 1:50 @ JKP 102
Section 16301: Tuesday and Thursday 5:00 – 6:20 @ JKP 202

## Course Description

Companies routinely collect large volumes of data on customer profiles, point of sales transactions, and operating performance at different units. How can companies use these data to make effective decisions? How do organizations covert these data into business intelligence and insights? This course will give you the tools and methods to answer these questions, providing you with a unique analytics edge in an increasingly data-centric global business environment.

The goal of this course is to teach students how to build sophisticated models from raw data, and how to translate these models to make effective business decisions. Specifically, we will study the following modules:

- Framework for effective decision-making under uncertainty
- Fundamentals of discrete and continuous probability
- From data to models: Linear and logistic regressions
- Putting everything together: Effective decisions through optimization

**Prerequisites:** Students are assumed to have taken a basic course in statistics such as GSBA 524. Every student is assumed to have access to and be able to use regularly, efficiently, and effectively a word processor, e-mail, a web browser, and a spreadsheet software package.

**Textbook:** Much of the class materials will be given in the slides posted on Blackboard. However, case discussion and homework problems will come from the textbook *Data, Models, and Decisions: The Fundamentals of Management Science* by D. Bertsimas and R. M. Freund, 2nd Edition, published by Dynamic

Ideas in 2004 (ISBN-13: 978-0975914601 and ISBN-10: 097591460X). The textbook is available at bookstore, or online at Dynamic Ideas through https://www.dynamic-ideas.com/Order/orderform_sec.html

**Instructional Methods:** The class will consist of lectures and case-based discussion.

**Lectures:** The lecture notes in PowerPoint will summarize all of the theory and concepts needed for this class. The lecture notes will be posted on Blackboard.

**Case Analyses:** During the course we will analyze several case studies. Each team is required to prepare a report that summarizes your finding, with a maximum of 2 pages, with up to 3 pages of appendices. Each team will consist of at most 2 students.

**Homework Assignments:** Students must complete the assigned readings and homework assignments prior to coming to class. Homework assignments are due on the indicated due date and no late assignments will be accepted.

**Grading**:

The course grade, which will be curved, is based on a midterm, a cumulative final exam, homework assignments, case analysis, and class participation according to the following weights:

| | |
|---|---|
| Class Participation | 10% |
| Homework | 20% |
| Case analysis | 20% |
| Midterm | 25% |
| Final Exam | 25% |

**Class Participation**

It is very important for each student to actively participate in the class discussion. Read the assigned material before the class and make sure you are familiar with the main issues to be discussed in class. You will be cold-called. Your participation is evaluated mainly on the quality of your contribution and insights. I will make every effort to call on as many students who wish to speak up as possible.

**Notice on Academic Integrity**

The use of unauthorized material, communication with fellow students during an examination, attempting to benefit from the work of another student, and similar behavior that defeats the intent of an examination or other class work is unacceptable to the University. It is often difficult to distinguish between a culpable act and inadvertent behavior resulting from the nervous tensions accompanying examinations. Where a clear violation has occurred, however, the instructor may disqualify the student's work as unacceptable and assign a failing mark on the paper. There may be additional penalties, including failing the course, in accordance to the university policies, as listed in the SCampus.

**Turnitin Technologies**

USC is committed to the general principles of academic honesty that include and incorporate the concept of respect for the intellectual property of others, the expectation that individual work will be submitted unless otherwise allowed by an instructor, and the obligations both to protect one's own academic work from misuse by others as well as to avoid using another's work as one's own. By taking this course, students are expected to understand and abide by these principles. All submitted work for this course may be subject to an originality review as performed by Turnitin technologies (http://www.turnitin.com) to find textual similarities with other Internet content or previously submitted student work. Students of this course retain the copyright of their own original work, and Turnitin is not permitted to use student-submitted work for any other purpose than (a)

performing an originality review of the work, and (b) including that work in the database against which it checks other student-submitted work.

**For Students with Disabilities**

Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to your instructor as early in the semester as possible. DSP is located in STU 301 and is open 8:30 a.m. - 5:00 p.m., Monday through Friday. The phone number for DSP is (213) 740-0776.

**Course Disclaimer**

This syllabus is an invitation to students to engage in an exciting and interactive study of operations management. The intention of the instructor is to provide you with information, offer practice with skill sets, and enhance your capacity to use fundamental concepts to build your repertoire of analytics tools and make sound decisions. The learning environment will be collaborative and supportive; we will learn from one another both in and out of the classroom. To that end, modifications to this syllabus might be warranted as determined by the instructors as we assess the learning needs of this particular class of students.

# COURSE OUTLINE

**Module 1: Framework for Effective Decision-Making Under Uncertainty**

**Session 1 – 1/10/17 (Tuesday)**: Introduction to the analytics edge and decision-making under uncertainty
***Question:*** What is the Analytics Edge? Why do we need it?
***Learning Outcomes:*** You will discover the broad range of applications that can be applied using the tools and methodologies learned in this class. We will also introduce a framework for effective decision-making under uncertainty.

- Define and recognize opportunities for business analytics in real-world situations
- Understand how we can use data to develop good models that drive effective decision-making
- Recognize and formulate decision problems

**Optional Text Reading:** Chapters 1.1 - 1.3.

**Session 2 – 1/12/17 (Thursday)**: Bayes' rule and its role in information decision-making
***Question:*** What is the framework for effective decision-making under uncertainty? What is Bayes' Rule? How do we use them in structuring decision tree?
***Learning Outcomes:*** You will learn how to structure and analyze a decision problem using decision trees

- Structure an decision problem using decision trees with properly chosen probabilities
- Compute the expected value of a decision and identify the optimal strategy
- Understand Bayes' Rule and apply it to decision tree problems

**Optional Text Reading:** Chapter 2.1

**Session 3 – 1/17/17 (Tuesday)**: Graphic Corporation Case
***Question:*** How to use Bayes' Rule? What is sensitivity analysis? How to apply the decision analysis framework to an actual business case?

***Learning Outcomes:*** The Graphic Corporation Case is a nice application of the Bayes' Rule and the concept of value of information. It is also an opportunity to apply sensitivity analysis techniques. You will have the opportunity to apply the decision analysis framework and the Bayes' Rule to actual business problems.

- Learn how to translate business case to decision-tree
- Apply the decision analysis and Bayes' Rule to actual business problems
- Understand how sensitivity analysis can be used to assess the robustness of your proposed strategy.

**Case Description:** The Graphic Corporation case on pages 99 – 100 of the textbook.

## Module 2: Fundamentals of Discrete and Continuous Probability

**Session 4 – 1/19/17 (Thursday)**: Modeling uncertainty
***Question:*** How do we model uncertainty? What is the difference between continuous and discrete random variables? What are the summary statistics of a random variable?
***Learning Outcomes:*** You will learn to basic concept of random variables and probability distributions. You will also understand and compute basic summary statistics for random variables.

- Distinguish between discrete and continuous random variables
- Understand probability distributions and histograms
- Compute summary statistics for random variables such as mean, variance, and standard deviation

**Optional Text Readings:** Chapters 2.1 – 2.5, 2.7, and 2.8

**Session 5 – 1/24/17 (Tuesday)**: Dealing with multiple uncertainties
***Question:*** How do we model situations with many uncertainties? What are summary statistics to use in this situation?
***Learning Outcomes:*** You will learn how to model multiple uncertainties using a joint probability distribution. We will discuss the concept of risk pooling and its application to asset diversification in investing.

- Describe the binomial distribution and its modeling applications
- Compute the covariance and correlation between two random variables
- Under the concept of risk pooling and its application to asset diversification

**Optional Text Readings:** Chapters 2.6 and 2.9 – 2.11

**** 1/26/17: Homework #1 is due in-class. ****

**Session 6 – 1/26/17 (Thursday)**: Having fun with probabilities!
***Question:*** How can we model arrivals of customers to the store? How to compute probabilities of complex events?
***Learning Outcomes:*** We will discuss applications of probability in various domains. The session will contain extensive hand-on practice on solving probability problems.

- Understand Poisson distribution and its applications
- Derive alternate formulas for variance computation
- Understand applications of probability to the Monty Hall problem

**Optional Text Readings:** Chapter 2.12

**Session 7 – 1/31/17 (Tuesday)**: Dealing with continuous uncertainties and normal distributions
***Question:*** Many uncertainties in real-world problems take values in a continuum. How should we model these uncertainties? What is the corresponding representation?
***Learning Outcomes:*** You will learn about continuous random variables and their properties. Examples of continuous distribution will also be given.

- Understand the probability density and distribution functions for normal distribution
- Compute summary statistics associated with the normal distribution
- Understand and apply the Central Limit Theorem

**Optional Text Readings:** Chapters 3.1 – 3.7

**Module 3: From Data to Models**

**Session 8 – 2/2/17 (Thursday)**: Review of linear regression
***Question:*** What is linear regression? How to assess the quality of regression models?
***Learning Outcomes:*** Review of linear regression. The OILPLUS and Executive Compensation cases demonstrate a nice application of the linear regression modeling techniques. In addition to fitting the regression models, we will learn how to interpret the results of the model in business applications

- Understand the process for building a linear regression model
- Assess the quality of the resulting models
- Understand the statistics associated with the regression model

**Case Description:** Read the OILPLUS and Executive Compensation cases on pages 295 – 299 in the textbook.

**Session 9 – 2/7/16 (Tuesday)**: Introduction to logistic regressions
***Question:*** What is logistic regression? How is it different from linear regression? How to use logistic regression for target marketing? How to fit the logistic regression model in Excel? How to interpret the results?
***Learning Outcomes:*** Logistic regression is a powerful tool for predicting categorical dependent variables.

- Understand the underlying model for logistic regression
- Recognize business application where these tools can be applied
- Learn how to fit the logistic regression using Excel and interpret the results

**** 2/9/17: Homework #2 is due in-class. ****

**Session 10 – 2/9/17 (Thursday)**: Advanced logistic regressions
***Question:*** How to compute the confidence intervals and p-values for logistic regression?
***Learning Outcomes:*** Advanced analysis of logistic regression

- Understand how to construct the confidence intervals and p-values for multiple logistic regressions
- Understand the asymptotic normality of the maximum likelihood estimates

**Session 11 – 2/14/17 (Tuesday)**: Regression with binomial data
***Question:*** How to extend logistic regression methods to binomial data?
***Learning Outcomes:*** You will learn about how to extend logistic regression models for dealing with binomial data. You will understand how to use Excel to fit these models.

- Understand binomial data and how to model them
- Applications to binomial data

**Session 12 – 2/16/17 (Thursday)**: Modeling customer choice
***Question:*** How to model choice behavior when customers choose from more than two options?
***Learning Outcomes:*** You will learn about the multinomial logit model, which is a widely used model for customer choice behavior. You will understand how to use Excel to fit these models.

- Understand the multinomial logit and its application
- Under the data needed to calibrate such model
- Applications of the multinomial logit to sales data

**Module 4: Putting everything together: Effective Decisions Through Optimization**

**Session 13 – 2/21/17 (Tuesday)**: Introduction to linear programming
***Question:*** How do we find the optimal solution? What is a linear program? How can we use Excel to solve a linear program?
***Learning Outcomes:*** Optimization gives business a critical edge. In this class, you will learn that optimization is a powerful tool that can be applied to various business problems not limited to operations management. You will be able to formulate a linear program (LP) and solve small LP problems using Excel Solver.

- Recognize linear program as a special optimization tool
- Understand the components of a linear program
- Formulate linear programs and solve it using Excel solver
- Make decisions by utilizing optimization tools to allocate resources effectively

**Optional Text Reading:** Chapters 7.1 – 7.4

**** 2/23/17: Homework #3 is due in-class. ****

**Session 14 – 2/23/17 (Thursday)**: Shadow price and sensitivity analysis
***Question:*** Can we use the LP techniques to solve real business problems? What are the typical business problems where LP techniques can be applied? How can we interpret sensitivity analysis reports?
***Learning Outcomes:*** You will practice more advanced linear program formulation in Excel. You will appreciate the value of the Excel reports, which help you understand how the solutions change if the conditions vary.

- Solve linear program using Solver
- Understand the impact of changes in the problem's parameters
- Interpret the Excel reports for business insights

**Optional Text Reading:** Chapters 7.5 – 7.6

**Session 15 – 2/28/17 (Tuesday)**: Review for midterm

**NOTE: In addition to my regular office hours on Wednesday 3/1 from 11am – 4pm, I will have extra office hours on Thursday morning (3/2) to help with the midterm preparation.**

**Session 16 – 3/2/17 (Thursday)**: Midterm

**** 3/7/17: Case Assignment #1 is due.** A write-up on the Filtoi Riuniti case is due on Tuesday (3/7) at the beginning of class. You can work alone, or with a partner. Each team can have at most 2 students. **

**NOTE: I will have extra office hours on Monday (3/6) and Tuesday morning (3/7) to help with the case assignment.**

**Session 17 – 3/7/17 (Tuesday)**: Linear optimization under uncertainty
***Question:*** How to formulate LP when there is an underlying uncertainty? How to extend LP to allow multi-period decision-making?

***Learning Outcomes:*** You will learn how to formulate a two-stage LP, and apply the formulation to multi-stage decision-making problems. You will see how to concept of probability distributions from Module #2 can be incorporated into a linear optimization problem.

- Recognize linear optimization problems where there is an underlying uncertainty
- Understand the two-stage LP formulation. Formulate multi-period decision-making as a two-stage LP

**Optional Text Reading:** Chapter 7.7

**Session 18 – 3/9/17 (Thursday)**: Additional applications of linear program

***Question:*** What are additional applications of linear program? How to set up the spreadsheet to handle large LP applications?

***Learning Outcomes:*** The Sytech International Case is a nice application of linear programming in production scheduling. It demonstrates the value optimization in quantifying the complex trade-offs in large-scaled applications. You will have an opportunity to apply linear programming to actual business problems.

- Learn about production scheduling using linear programming
- Set up the spreadsheet for complex linear programming problems
- Develop a deeper understanding of the impact of changes in the problem's parameters

**Case Description:** The Sytech International Case on pages 380 – 389 in the textbook.

3/13/17 – 3/17/17: Spring Break. No Class.

**Session 19 – 3/21/17 (Tuesday)**: Introduction to nonlinear optimization

***Question:*** What is a non-linear optimization problem? What are potential applications?

***Learning Outcomes:*** You will learn how about non-linear optimization and its applications. We will discuss graphical analysis of nonlinear optimization problem, and review solution methods based on Excel Solver.

- Recognize nonlinear optimization problems
- Analyze simple nonlinear optimization problems using graphical methods
- Learn how to use Excel Solver to solve general nonlinear optimization problems

**Optional Text Reading:** Chapters 8.1 – 8.3

**Session 20 – 3/23/17 (Thursday)**: Application of nonlinear optimization to portfolio allocation

***Question:*** How can we use nonlinear optimization problem to determine the optimal portfolio allocation?

***Learning Outcomes:*** You will learn about applications of nonlinear optimization in investment management.

- Formulate the portfolio problem as an optimization problem
- Solve the problem using Excel Solver
- Understand the outputs of the Solver and provide appropriate interpretation

**Optional Text Reading:** Chapter 8.5

**Session 21 – 3/28/17 (Tuesday)**: Introduction to discrete optimization

***Question:*** Can we apply optimization tools when the decision variables are not divisible?

***Learning Outcomes:*** Optimization is more than linear and nonlinear programming. The firms cannot hire half of a person or fly a quarter of an airplane. You will be able to formulate an integer program (IP) and solve small IP problems using Excel Solver.

- Understand the components of an integer program
- Formulate integer programs and solve it using Excel solver
- Under how to use binary decision variables to model constraints in integer programming

**Optional Text Reading:** Chapters 9.1 – 9.3

**** 3/30/17: Case Assignment #2 is due.** A write-up on the Endurance Investors is due on Thursday (3/30) at the beginning of class. You can work alone, or with a partner. Each team can have at most 2 students. **

**Session 22 – 3/30/17 (Thursday)**: More applications of discrete optimization.
***Question:*** How to identify problems that can be solved using IP? How to convert business problems so that they fit with the IP framework?
***Learning Outcomes:*** You will learn about additional applications of IP, including locating shelters, matching, and scheduling.

- Identify problems that can be formulated as an IP
- Convert business problems into an IP using appropriate variables
- Create a model for locating earthquake shelters in the San Gabriel Valley using IP

**Session 23 – 4/4/17 (Tuesday)**: Additional applications of discrete optimization and Branch-and-Bound method
***Question:*** How can we convert assortment optimization into a discrete optimization problem? What is a Branch-and-Bound Method? How can we use it to solve discrete optimization problems?
***Learning Outcomes:*** Branch-and-Bound method is one of the most commonly used techniques for solving discrete optimization problems. You will learn the underlying principle of the method.

- Understand how to formulate an assortment optimization problem as a DO.
- Understand the Branch-and-Bound method
- Aware of the pitfalls and issues associated with the method

**Optional Text Reading:** Chapter 9.4

**Session 24 – 4/6/17 (Thursday)**: Case studies in discrete optimization
***Question:*** How can we use discrete optimizations to help with strategic decisions?
***Learning Outcomes:*** The International Industries, Inc. Case is a nice application of discrete optimization in strategic planning. It demonstrates the value of discrete optimization in finding a good investment strategy. You will have an opportunity to apply linear programming to actual business problems.

- Learn how to formulate strategic decisions in terms of discrete optimization problems.
- Set up the spreadsheet for complex integer programs.

**Case Description:** The International Industries, Inc. Case on pages 471 – 473 in the textbook

**Session 25 – 4/11/17 (Tuesday)**: Introduction to dynamic optimization
***Question:*** What is a dynamic optimization? What are the important features of such problems?
***Learning Outcomes:*** Many business problems require a multi-period optimization framework. How to recognize such problems? What are the important features of these problems?

- Recognize a dynamic optimization problem
- Understand the principle for solving such problems.

**** 4/13/17: Case Assignment #3 is due.** A write-up on the Supply Chain Management at Dellmar, Inc is due on Thursday (4/13) at the beginning of class. You can work alone, or with a partner. Each team can have at most 2 students. **

**Session 26 – 4/13/17 (Thursday)**: Dynamic Programming Formulation
***Question:*** What is dynamic programming? How can we use it to solve dynamic optimization problem?
***Learning Outcomes:*** You will learn about value function and how it can be used to solve the dynamic programming equation.

- Understand the concept of value function
- Understand the dynamic programming formulation

**Session 27 – 4/18/17 (Tuesday)**: Solving dynamic optimization using Excel
***Question:*** How do use Excel spreadsheet to implement dynamic programming and solve the dynamic optimization problem?
***Learning Outcomes:*** You will learn about value function and how it can be used to solve the dynamic programming equation. You will also implement dynamic programming on Excel

- Understand the concept of value function
- Solve for the value function in Excel

**Session 28 – 4/20/17 (Thursday)**: Applications of dynamic optimization to retail pricing
***Question:*** How should a retailer set the price of its products over time in face of random demands, in order to maximize the total profit over an entire selling season?
***Learning Outcomes:*** In this session, we will discuss application of dynamic optimization to retail pricing. We will show how to formulate the problem as a dynamic program.

- Apply dynamic programming framework to a problem in retail industry
- Recognize other applications of dynamic optimization

**Session 29 – 4/25/17 (Tuesday)**: Applications of management science tools to Money Tree Mortgage.
***Question:*** Putting everything together. We will demonstrate how can we use all of the tools in the course to analyze a business case related to mortgage investments.
***Learning Outcomes:*** We will discuss applications of management science models and tools to a business case involving mortgage lending.

- Learn how an actual business problem requires all of the tools and models covered in this class.
- Recognize how to use optimization models in actual business problems.

**** 4/27/17: Homework #4 is due in-class. ****

**Session 30 – 4/27/17 (Thursday)**: Review for final exam

## Following the university schedule, the final exams are given as follows:

## Section 16298: Wednesday, May 10, 2:00 – 4:00pm.

## Section 16301: Thursday, May 4, 4:30 – 6:30pm

## No early finals are allowed by University policy.

## A summary of the class schedule and due dates are given on the next two pages.

# Schedule of Classes

| Session | Date | Topics | Assignments due |
|---|---|---|---|
| 01 | Tu 01/10 | Course introduction and overview | |
| 02 | Th 01/12 | Introduction to Decision Tree | Read the Market Research Problem (available on Blackboard) before class |
| 03 | Tu 01/17 | Bayes' Rule and Its Applications | Read the Graphic Corporation Case before class. |
| 04 | Th 01/19 | Modeling Uncertainty | |
| 05 | Tu 01/24 | Dealing with Multiple Uncertainties | |
| 06 | Th 01/26 | Having Fun with Probabilities | HW #1 is due in class |
| 07 | Tu 01/31 | Dealing with Continuous Uncertainties and Normal Distribution | |
| 08 | Th 02/02 | Review of Regression | |
| 09 | Tu 02/07 | Intro to Logistic Regression | |
| 10 | Th 02/09 | Advanced Logistic Regression | HW #2 is due in class |
| 11 | Tu 02/14 | Regression with Binomial Data | |
| 12 | Th 02/16 | Modeling Customer Choice | |
| 13 | Tu 02/21 | Intro to Linear Programming | |
| 14 | Th 02/23 | Shadow Prices and Sensitivity Analysis | HW #3 is due in class |
| 15 | Tu 02/28 | Review for Midterm | |
| 16 | Th 03/02 | Midterm | |
| 17 | Tu 03/07 | Linear Optimization under Uncertainty | Case #1 (Filtoi Riuniti) is due in class |
| 18 | Th 03/09 | Applications of Linear Programming: Case Studies | Read the Sytech International case before class |
| Spring Break | | | |

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|---|---|---|---|
| 19 | Tu 03/21 | Introduction to Nonlinear Optimization | |
| 20 | Th 03/23 | Applications to Portfolio Optimization | |
| 21 | Tu 03/28 | Discrete Optimization | |
| 22 | Th 03/30 | More Applications of Discrete Optimization | Case #2 (Endurance Investors) is due in class |
| 23 | Tu 04/04 | Branch-and-Bound method | |
| 24 | Th 04/06 | Case Studies in Discrete Optimization | Read the International Industries case before class |
| 25 | Tu 04/11 | Dynamic Optimization | |
| 26 | Th 04/13 | Dynamic Programming | Case #3 (Supply Chain Management at Dellmar) is due in class |
| 27 | Tu 04/18 | Solving Dynamic Program in Excel | |
| 28 | Th 04/20 | Applications of Dynamic Optimization to Retail | |
| 29 | Tu 04/25 | Money Tree Mortgage | |
| 30 | Th 04/27 | Final review | HW #4 is due in class |

**Final Exam (Section 16298): Wednesday, May 10, 2:00 pm – 4:00 pm**
**Final Exam (Section 16301): Thursday, May 4, 4:30 pm – 6:30 pm**