# ISDA 609 - Mathematical Modeling Techniques for Data Analytics Course Project

## Project Team

Team members consists of

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## Project Proposal

For our course project, we have selected two projects from the text, A First Course in Mathematical Modeling by Giordano, Fox, and Horton. These two projects come from different modeling method sections in the text. An additional modeling method will be used for both projects to provide another model to compare against.

## Project Selection

We have decided to select the following two projects for this course:

1. Monte Carlo simulation of craps, the popular casino dice game, to maximize winnings.

2. Investment in 401K and Social Security modeling to maximize savings for a comfortable retirement.

## Project Methodology

For each project selected, we will be using two different modeling methods to solve the problem presented. Both models will be used to determine the desired solution for the problem. Each modeling method and its result will be compared with the other to determine which gives the most accurate results.

## Project Deliverables

1. A 15 minute presentation for both projects will be prepared with a slideshow and presented at the end of the class. Presentation slides due by 12/11/14.
2. A project report will be completed with all the points below addressed. Due by 12/14/14.

* Analysis of the problem
* Methodology used for each problem
* Algorithm and Details for solving each problem
* Results from each project
* Conclusions to be drawn from the results

## Project 1

### Project 5.3.3 (page 201):

Craps - Construct and perform a Monte Carlo simulation of the popular casino game of craps. The rules are as follows:

There are two basic bets in craps, pass and don't pass. In the pass bet, you wager that the shooter (the person throwing the dice) will win; in the don't pass bet, you wager that the shooter will lose. We will play by the rule that on an initial roll of 12 (``boxcars''), both pass and don't pass bets are losers. Both are even-money bets.

Conduct of the game:

* Roll a 7 or 11 on the first roll: Shooter wins (pass bets win and don't pass bets lose).
* Roll a 12 on the first roll: Shooter loses (boxcars; pass and don't pass bets lose).
* Roll a 2 or 3 on the first roll: Shooter loses (pass bets lose, don't pass bets win).
* Roll 4, 5, 6, 8, 9, 10 on the first roll: This becomes the point. The object then becomes to roll the point again before rolling a 7.
* The shooter continues to roll the dice until the point or a 7 appears. Pass bettors win if the shooter rolls the point again before rolling a 7. Don't pass bettors win if the shooter rolls a 7 before rolling the point again.

Write an algorithm and code it in the computer language of your choice. Run the simulation to estimate the probability of winning a pass bet and the probability of winning a don't pass bet. Which is the better bet? As the number of trials increases, to what do the probabilities converge?

**Problem Statement**:

The purpose of this project is to create a Monte Carlo simulation for craps and utilize the results of the simulation to determine which bet to make to maximize the chance of winning.

**Analysis of the Problem**:

The craps dice game is base on a pair of dice and wagering if the shooter either wins or loses. A simulation of dice rolls will be needed to determine the probability of the shooter winning/losing. This simulation will provide the best choice in placing a bet.

**Dataset Description**:

All data used in this project been provided for. The rules of the game give rise to probabilities to be used. Simulation of the dice throws will be done to determine how to wager. No data collection from external sources would be necessary.

**Methodologies**:

1. Simulation of Probabilistic Behavior

The R language will be used in the Monte Carlo simulation. A probability will be generated for whether a shooter wins or loses.

1. Sequential Decisions and Conditional Probabilities

A decision tree with expected value of winning on each roll will be generated to determine the best course of action.

**Results To Be Obtained**:

The result from the Monte Carlo simulation and the path with the highest expected value in the decision tree will be compared for selection of the best wager. Show if either modeling method is better suited for this type of problem.

## Project 2

### Project 9.4.2 (page 376):

Retirement and Social Security. Should US citizens build their own retirement through 401Ks or use the current Social Security program? Build models to be able to compare these systems and provide decisions that can help someone to plan a better retirement.

**Problem Statement**:

This purpose of this project is to determine the best way to maximize savings for retirement. 401K investment returns and Social Security payout from contributions will be analyzed and compared.

**Analysis of the Problem**:

401K investment accounts provide a mix of securities that can be withdrawn later in life without penalty. The Social Security program is funded by taxes that are contributed by every worker in America. We will take the amount that is contributed to Social Security program as working capital and try to maximize the returns until the start of retirement.

**Dataset Description**:

Data collection from external sources will be necessary. The main source will be from data.gov for the Social Security system. We will need the amount that is contributed by workers and the payout amount upon retirement.

Data will also need to be collected for 401K return information. Return rates for various investment profiles will be needed. The amount that can be withdrawn upon retirement and length of payouts will be required to compare both systems.

**Methodologies**:

1. Modeling with Decision Theory

Decision Theory can be used to determine the investment profile for a 401K account. The optimization criterion of interest would be Maximin Criterion for a modest return and lowest risk in a retirement account. However, the alternative criterion Expected Value, Coefficient of optimism, and Minimax regret will also be considered.

1. Optimization of Discrete Models with the Simplex method

The investment mix for a 401K account can be an optimization problem. Most optimization problems can be solved through the Simplex method. We will use Simplex method to determine the best mix of security types in 401K for accounts.

**Results To Be Obtained**:

The best investment mix for a 401K will be determined through the use of both modeling methods. The results of these two models will be compared against the sole use of the Social Security program. This will provide several options for towards saving for retirement. The model with the best results will be selected to maximize a person's savings over their career towards retirement.