

## IEOR Lecture #1 Notes – Brookey Villanueva

IEOR = Industrial Engineering (tools to improve performance in *industries* like food, travel, finance, etc.) + Operations Research (optimization in mathematical/statistical modeling)

### Timeline of IEO

- (1890) Frederick Taylor- father of IEO; scientific management
  - began in steel industry, measured/found variances in worker productivity
  - productivity was flat; workers just acted busy
  - found that most productive worker had productivity “tricks” (shovel size)
  - all his findings were based on the *quantification* of productivity
- (1940) Linear Programming- George Dantzig
  - linear (linear functions) , programming (simplex-algorithm)
  - basically, we can solve any linear program with a computer after simple modifications
  - allows programs with 1000s of variables to be solved quickly
- (1950) -Non-Linear Programming- relax the linearity, higher order functions
  - Integer Programming- solutions deal with integers instead of real values
  - Dynamic Programming- sequence of steps, optimize how that sequence should be performed
- (1960/70) Developments in database theory
- (Most Recently) –ways to speed up optimization techniques
  - extensions of machinery
  - deep learning

### Terminology

Operational Research (Britain)

Management Science/ Decision Science (Management Science is the ‘MS’ in ORMS)

### Math Models

- Relate decision variables (controllable inputs) with fixed constants (parameters)
- Maximize or minimize some objective function (ex: min. cost, max. profit)
- Stochastic (variabilities, more complex than det.), deterministic (no probability)
- Optimal Solution- specific choice of decision variables that is optimal

Project Schedule= 1) Suggest assumptions, 2) Make model deterministic, 3) Relax linearity by changing assumptions, 4) Look at decision variables and determine order of project, 5) Solve! ☺

### Application Areas

- Supply Chain Management: buildings construction
- Pricing & Revenue Management: set a price/factor in buyer’s flexibility, financial engineering, room for experimentation

- Logistics/ Site Location: routing Uber, where to put new store (factor in location of resources and buyers)
- Timing: very seasonal (movies; traffic on Saturday vs. Monday)
- Forecasting: predicting, look at past/current changes
- Auctions: market strategies, set up incentives to save energy/water
- Risk Analysis: set limits of risk/how much risk a company will take on

What do some specific IEOR depts do?

Disney:

- work on waiting lines (queuing), developed FastPass
- location of characters, merchandise/food stands

UPS/Amazon: dealing with deliveries, forecasting what's going to be bought

Kiva Systems: storing of items all over factory to make packaging faster

Finance Industry: picking the right stocks to maximize profit, minimize risk

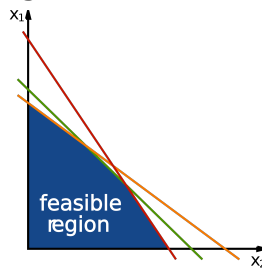
Outsourcing: working with different companies creates an IEOR problem;  
OR + information tech = outsourcing success!

Managers: if they know weaknesses of their companies, OR can help  
improve/fill the gaps in their business

Essentially, Operations Research is about finding quantitative methods to solve complex problems.

Example Problems in IEOR

- Linear Programming
  - Solutions for a linear program MUST lie on boundary of the feasible region



- Statistical Learning
  - ex: automatically tagging pictures as dog/cat
  - solution: find the line that differentiates betw. dogs/cats
- Graphs & Networks
  - if everyone takes shortest path (intuitive), networks overload
  - basically, a multi-commodity flow problem; minimize the maximum load
- Markov Chains
  - Memoriless property—queuing theory tactable
- Graphs and Markov Chains (website example; how to rank websites)
  - find probability distributions that people will end up on the page
  - search engine optimization- link websites to other links