

## Lesson 1. Introduction

### What is operations research?

- “The most influential academic discipline field you’ve never heard of” [Boston Globe, 2004]
- **Operations Research (OR)** is the discipline of applying advanced mathematical methods to help make better decisions
- “The Science of Better” [INFORMS slogan]
- “A liberal education in a technological world” [Thomas Magnanti, former Dean of Engineering at MIT]
- Numerous applications, e.g.
  - logistics
  - manufacturing
  - workforce scheduling
  - finance
  - marketing

### OR and the military

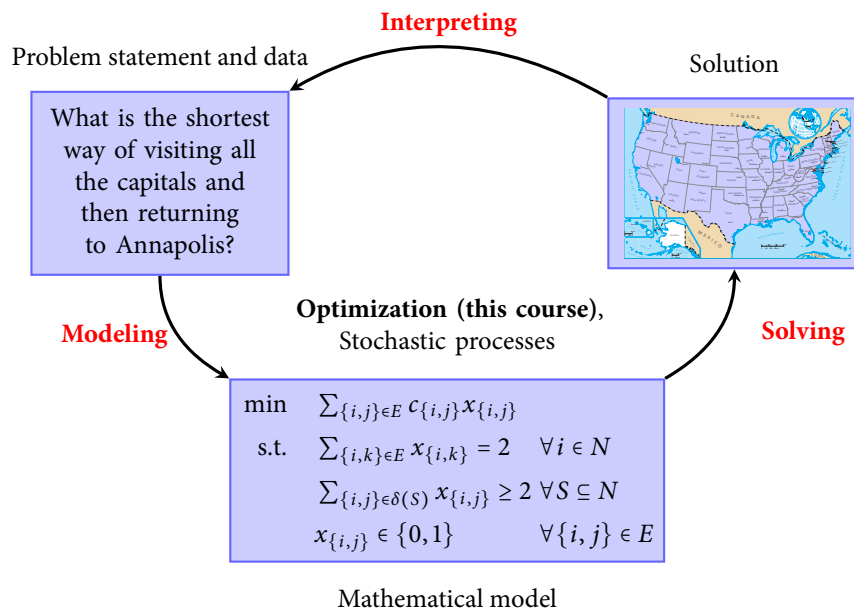
- The military uses OR to improve decision making in a variety of ways, e.g.
  - force composition
  - weapon selection
  - search and detection
  - flight operations scheduling
  - training and personnel assignment
- Assessment Division (OPNAV N81) at the Pentagon
- The Naval Postgraduate School has one of the oldest and highest ranking OR departments in the US
- *Naval Research Logistics* is a prominent academic journal featuring research in OR

### The traveling salesperson problem

- A salesperson located in Annapolis wants to visit clients in each of the 48 state capitals of the continental US and Washington DC
- What is shortest way of visiting all the capitals and then returning to Annapolis?
- Entire books have been written on the TSP

- 1962: contest by Proctor and Gamble - best TSP tour through 33 US cities
- 1998: The Florida Sun-Sentinel's Science page ponders Santa Claus's traveling problem
- One of the most popular problems in operations research
- Numerous applications in expected and unexpected places
  - Circuit board manufacturing
  - Genome sequencing
- Your turn! Try to find the shortest way of visiting all the capitals and then returning to Annapolis
- What about 13,509 cities in the US?
- Sophisticated mathematical techniques are our best bet

### The OR approach



### Goals for this course

- Modeling
  - Recognize opportunities for mathematical optimization
  - Formulate optimization models – **linear programs** – that capture the essence of the problem
  - Illustrate applications of real-world problems
- Solving
  - **Algorithms** to solve these mathematical models
- Detailed topic list and schedule is on the syllabus

### Optimization is everywhere

- “Minimize” time it takes to get from class to class
- “Maximize” the company’s profits
- (Moneyball) “Best” lineup for the Oakland A’s
- We are always trying to make **decisions** in a way that meets some **objective** subject to some **constraints**
- Some success stories of optimization helping solve complex real-world decision-making problems ...

### Package delivery

- UPS has an air network consisting of 7 hubs, nearly 100 additional airports in the US, 160 aircraft of nine different types
- Decision:
- Objective:
- Constraints:
- UPS credits optimization-based planning tools with identifying operational changes that have saved over \$87 million to date, reduced planning times, peak and non-peak costs, fleet requirements

### Sports scheduling

- ACC Basketball earns over \$30 million in revenue annually, almost all from TV and radio
- TV networks need a steady stream of “high quality” games, NCAA rules, school preferences and traditions
- Decision:
- Objective:

- Constraints:

- Optimization approaches yields reasonable schedules very quickly

### **Radiation therapy**

- High doses of radiation can kill cancer cells and/or prevent them from growing and dividing
- Can also kill healthy cells!
- Radiation can be delivered at different angles and intensities

- Decision:

- Objective:

- Constraints:

- Many successes reported using different types of optimization models

### **Next time...**

- Introduction to optimization models
- Homework posted on course website
  - Read the course policy statement
  - Watch out for an e-mail from POET and make sure you can log in  
<http://www.hivelab.org/POET>
  - Bring your laptop to class