Chapter 1
Introduction

- Management Science
- Problem Solving and Decision Making
- Quantitative Analysis
- Models of Cost, Revenue, and Profit
- *The Management Scientist*

Background Needed in This Course

- Mathematical prerequisite: algebra
- Some introductory knowledge of probability and statistics
- Key to success in the course:
  - Smooth translation between business language (common sense) and mathematical language.
  - Readings before each class
  - Practices and exercises beyond homeworks + cases

Management Science

- Management science is a quantitative approach to decision making based on the scientific method of problem solving.
- A synonymous term is operations research or decision science.
- It had its early roots in World War II and is flourishing in business and industry with the aid of computers in general and the microcomputer in particular.
- Some of the primary applications areas of management science are forecasting, production scheduling, inventory control, capital budgeting, advertising, marketing research, and transportation.

Problem Solving and Decision Making

- 7 Steps of Problem Solving

  (First 5 steps are the process of decision making)
  - Identify and define the problem.
  - Determine the set of alternative solutions.
  - Determine the criteria for evaluating the alternatives.
  - Evaluate the alternatives.
  - Choose an alternative.

  - Implement the chosen alternative.
  - Evaluate the results.

Quantitative Analysis and Decision Making

- Potential Reasons for a Quantitative Analysis Approach to Decision Making
  - The problem is complex.
  - The problem is very important.
  - The problem is new.
  - The problem is repetitive.

Quantitative Analysis

- Quantitative Analysis Process
  - Model Development
  - Data Preparation
  - Model Solution
  - Report Generation

Model Development

- Models are representations of real objects or situations.
- Three forms of models are iconic, analog, and mathematical.
  - Iconic models are physical replicas (scalar representations) of real objects.
  - Analog models are physical in form, but do not physically resemble the object being modeled.
  - Mathematical models represent real world problems through a system of mathematical formulas and expressions based on key assumptions, estimates, or statistical analyses.

Mathematical Models

- Cost/benefit considerations must be made in selecting an appropriate mathematical model.
- Frequently a less complicated (and perhaps less precise) model is more appropriate than a more complex and accurate one due to cost and ease of solution considerations.
- The **purpose**, or **value**, of any **model** is that it enables us to make inferences about the real situation by studying and analyzing the model.
  - more efficient; less time required.
  - less expensive.

Mathematical Models

- Mathematical models relate decision variables (or controllable inputs) with fixed or variable parameters (or uncontrollable inputs).
- Frequently mathematical models seek to maximize or minimize some objective function subject to constraints.
- If any of the uncontrollable inputs is subject to variation the model is said to be stochastic; otherwise the model is said to be deterministic.
- Generally, stochastic models are more difficult to analyze.
- The values of the decision variables that provide the mathematically-best output are referred to as the optimal solution for the model.

Example: Iron Works, Inc.

Iron Works, Inc. (IWI) manufactures two products made from steel and just received this month's allocation of b pounds of steel. It takes a_1 pounds of steel to make a unit of product 1 and it takes a_2 pounds of steel to make a unit of product 2.

Let x_1 and x_2 denote this month's production level of product 1 and product 2, respectively. Denote by p_1 and p_2 the unit profits for products 1 and 2, respectively.

The manufacturer has a contract calling for at least m units of product 1 this month. The firm's facilities are such that at most u units of product 2 may be produced monthly.

Example: Iron Works, Inc.

- Mathematical Model
  - The total monthly profit =

(profit per unit of product 1)
x (monthly production of product 1)
+ (profit per unit of product 2)
x (monthly production of product 2)
= $p_1x_1 + p_2x_2$

We want to maximize total monthly profit:

Max $p_1x_1 + p_2x_2$

Example: Iron Works, Inc.

- Mathematical Model (continued)
  - The total amount of steel used during monthly production =

(steel required per unit of product 1)
x (monthly production of product 1)
+ (steel required per unit of product 2)
x (monthly production of product 2)
= $a_1x_1 + a_2x_2$

This quantity must be less than or equal to the allocated b pounds of steel:

$a_1x_1 + a_2x_2 \leq b$

Example: Iron Works, Inc.

- Mathematical Model (continued)
  - The monthly production level of product 1 must be greater than or equal to m:

    $$x_1 \geq m$$

  - The monthly production level of product 2 must be less than or equal to u:

    $$x_2 \leq u$$

  - However, the production level for product 2 cannot be negative:

    $$x_2 \geq 0$$

Example: Iron Works, Inc.

- Mathematical Model Summary

$$\begin{array}{lrcl} \text{Max} & p_1x_1 + p_2x_2 & & \\ \text{s.t.} & a_1x_1 + a_2x_2 & \leq & b \\ & x_1 \qquad\quad & \geq & m \\ & x_2 & \leq & u \\ & x_2 & \geq & 0 \end{array}$$

Example: Iron Works, Inc.

- Question:

  Suppose b = 2000, a_1 = 2, a_2 = 3, m = 60, u = 720, p_1 = 100, p_2 = 200. Rewrite the model with these specific values for the uncontrollable inputs.
- Answer:

  Substituting, the model is:

$$\begin{array}{lrcl} \text{Max} & 100x_1 + 200x_2 & & \\ \text{s.t.} & 2x_1 + \quad 3x_2 & \leq & 2000 \\ & x_1 \qquad\qquad & \geq & 60 \\ & x_2 & \leq & 720 \\ & x_2 & \geq & 0 \end{array}$$

Example: Iron Works, Inc.

- Question:

  The optimal solution to the current model is x_1 = 60 and x_2 = 626 2/3 [after using the Management Scientist]. If the product were engines, explain why this is not a true optimal solution for the "real-life" problem.
- Answer:

  One cannot produce and sell 2/3 of an engine. Thus the problem is further restricted by the fact that both x_1 and x_2 must be integers. They could remain fractions if it is assumed these fractions are work in progress to be completed the next month.

The Management Scientist

- Major Elements
  - Top Level Menu
  - Problem Selection Menu
  - Data Input
  - Problem Disposition Menu
  - Solution and Output Information
  - Data Editing
  - Saving, Retrieving, and/or Deleting Problems

The Management Scientist

- Top Level Menu

THE MANAGEMENT SCIENTIST
Top Level Menu

1 Linear Programming	7 PERT/CPM
2 Transportation	8 Inventory Models
3 Assignment	9 Waiting Lines
4 Integer Linear Programming	10 Decision Analysis
5 Shortest Route	11 Forecasting
6 Minimal Spanning Tree	12 Markov Processes

13 EXIT PROGRAM

The Management Scientist

- Problem Selection Menu

PROBLEM SELECTION MENU
Choices
1 Create a New Problem
2 Retrieve a Previously Saved Problem
3 Continue with the Current Problem
4 Delete a Previously Saved Problem
5 Return to the Top Level Menu

The Management Scientist

- Problem Disposition Menu

PROBLEM DISPOSITION MENU
Choices
1 Solve the Problem
2 Save the Problem
3 Display/Edit the Problem
4 Return to the Problem Selection Menu

Breakeven Analysis

Fixed costs (c_f) - costs that remain constant regardless of number of units produced

Variable cost (c_v) - unit cost of product

Total variable cost ($v\ c_v$) - function of volume (v) and variable per-unit cost

Total cost (TC) - total fixed cost plus total variable cost

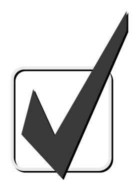
Profit(Z) - difference between total revenue vp (p=price) and total cost:

$Z = v\ p - c_f - v\ c_v$

The ***break-even point*** is that volume at which total revenue equals total cost and profit is zero:

$$V = c_f/(p-c_v)$$

The End of Chapter 1



Self Quiz

- Algebra Basics: Solve for x_1 and x_2 in the following equations

  $4x_1 - x_2 = 12$

  $x_1 + x_2 = 4$

- Statistics Basics: Suppose z is a standard normal variable (with mean 0 and standard deviation of 1).
  - What is the probability that z is less than z_0=1?
  - What is the probability that z is greater than z_0=1?

Self Quiz

The price of a particular stock listed in NYSE is fluctuating up and down from one transaction to the next according to the following probability distribution.

Price Change	Probability
-3/8	.08
-1/4	.04
-1/8	.16
0	.40
+1/8	.20
+1/4	.06
+3/8	.04
+1/2	.02
TOTAL	1.00

Q: What is the cumulative probability that the price change is less than and equal to +1/4?

Q: What is the expected amount of price change (per transaction)?