Chapter 1

Introduction

Examples

INVESTMENT BANKS	PORTFOLIO ANALYSIS SECURITIES PRICING, CASH FLOW MATCHING
TRANSPORTATION	VEHICLE ROUTING
MARKETING	DISTRIBUTION CHANNELS, PRODUCT/BUDGET PLAN, MERCHANDISING
TELE-COMM.	CALL ROUTING
MANUFACTURING	PRODUCTION PLANNING, PLANT LOCATION
SEMI-COND. MFG.	PICK & PLACE SEQUENCING

Course Objectives

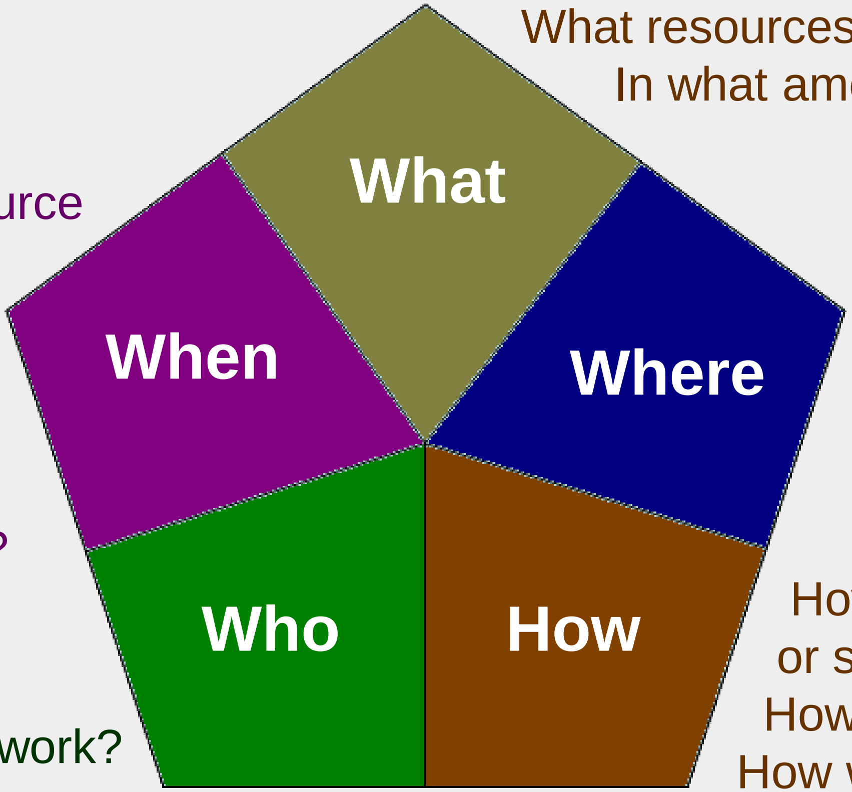
- Convert a business problem description into a rigorous structure: objective, decision variables, and constraints
- Understand the principles of optimization in the context of business decisions
- Determine optimal solutions, and interpret solutions including sensitivity analysis

Course Theme

- Model and analyze complex business/management problems
- The ‘Art’ of Modeling
  - Translate reality to model
  - Apply tools to analyze model (Gurobi)
  - Interpret the model and solution
- Become a model thinker!

Decision Making

Most operations decisions involve many alternatives that can have quite different impacts on costs or profits.



What resources are needed?
In what amounts?

When will each resource be needed?
When should the work be scheduled?
When should materials & other supplies be ordered?

Where will the work be done?

How will the product or service be designed?
How will the work be done?
How will the resources be allocated?

Who will do the work?

General Approach to Decision Making

- Modeling is a key tool used by all decision makers
  - ***Model*** - an abstraction of reality; a simplification of something.
  - Common features of models:
    - They are simplifications of real-life phenomena
    - They omit unimportant details of the real-life systems they mimic so that attention can be focused on the most important aspects of the real-life system

Understanding Models

- Keys to successfully using a model in decision making
  - What is its purpose?
  - How is it used to generate results?
  - How are the results interpreted and used?
  - What are the model’s assumptions and limitations?

Benefits of Models

- Models are generally easier to use and less expensive than dealing with the real system
- Require users to organize and sometimes quantify information
- Increase understanding of the problem
- Enable managers to analyze “What if?” questions
- Serve as a consistent tool for evaluation and provide a standardized format for analyzing a problem
- Enable users to bring the power of mathematics to bear on a problem.

Benefits of Modeling

- Economy - It is often less costly to analyze decision problems using models.
- Timeliness - Models often deliver needed information more quickly than their real-world counterparts.
- Feasibility - Models can be used to do things that would be impossible.
- Models give us insight & understanding that improves decision making.

Model Limitations

- Quantitative information may be emphasized at the expense of qualitative information
- Models may be incorrectly applied and the results misinterpreted
  - This is a real risk with the widespread availability of sophisticated, computerized models are placed in the hands of uninformed users.
- The use of models does not guarantee good decisions.

Example of a Mathematical Model

Profit = Revenue - Expenses

or

Profit = $\boldsymbol{f}$(Revenue, Expenses)

or

$Y = \boldsymbol{f}(X_1, X_2)$

A Generic Mathematical Model

$$Y = \boldsymbol{f}(X_1, X_2, \ldots, X_n)$$

Where:

Y = dependent variable

(***aka*** bottom-line performance measure)

X_i = independent variables (inputs having an impact on Y)

$\boldsymbol{f}(\cdot)$ = function defining the relationship between the X_i & Y

Categories of Mathematical Models

Model Category	Form of $f(\cdot)$	Independent Variables	OR/MS Techniques
Prescriptive	known, well-defined	known or under decision maker's control	LP, Networks, IP, CPM, EOQ, NLP, GP, MOLP
Predictive	unknown, ill-defined	known or under decision maker's control	Regression Analysis, Time Series Analysis, Discriminant Analysis
Descriptive	known, well-defined	unknown or uncertain	Simulation, PERT, Queueing, Inventory Models

Chapter 2

Linear Programming

Mathematical Programming (MP)

But there is no programming required ☹

- MP, a.k.a. ***optimization***, is an area in MS/BA that finds the optimal, or most efficient, way of using limited resources to achieve the objectives of an individual or a business.
- Some example applications of optimization
  - Determining Product Mix
  - Manufacturing
  - Routing and Logistics
  - Financial Planning

General Form of An Optimization Problem

- Every optimization problem involves the following:
  - ✓ ***decisions*** that must be made
  - ✓ ***objective(s) (or goal(s))***
  - ✓ a set of ***restrictions (or constraints)***

MAX (or MIN): $f_0(X_1, X_2, \ldots, X_n)$

Subject to: $f_1(X_1, X_2, \ldots, X_n) <= b_1$

$:$

$f_k(X_1, X_2, \ldots, X_n) >= b_k$

$:$

$f_m(X_1, X_2, \ldots, X_n) = b_m$

Note:

If <u>all</u> the functions in an optimization are *linear(ized)*, the problem is a ***Linear Programming* (LP)** problem

Linear Programming (LP) Problems

MAX (or MIN): $c_1X_1 + c_2X_2 + \ldots + c_nX_n$

Subject to: $a_{11}X_1 + a_{12}X_2 + \ldots + a_{1n}X_n <= b_1$

$$\vdots$$

$$a_{k1}X_1 + a_{k2}X_2 + \ldots + a_{kn}X_n >= b_k$$

$$\vdots$$

$$a_{m1}X_1 + a_{m2}X_2 + \ldots + a_{mn}X_n = b_m$$