Rules for model building (from Revelle et. al)

1. Keep things as <u>simple</u> as possible, at least in the beginning. Describe the system in the most straight forward way possible.

   Example: <u>Water distribution systems</u> are commonly represented as a collection of junctions and links, which represent the pipe junctions and pipelines. Junctions merely serve as places where several pipes (& their flows) come together, and pipes (links) are represented by only their length, internal diameter, and resistance to flow.

   There is a lot of detail about the characteristics of the network which are ignored (type of junction, pipe material, location relative to structures & highways, etc.)

   Physicists are sometimes faulted for extreme simplification, as in "consider a rectangular cow..." This might be extreme, or not, depending on whether you were interested in the cows milk production, or how many cows could be fit into a transport vehicle. Sometimes it is useful for Civil / Env. Engineers to think like a physicist!

2. Use good <u>notational</u> style. E.g. let x_j denote the unknown level of the jth decision to be made. Determining/defining all these decisions is a crucial step in model building. Using good, consistent, notation helps keep things straight.

3. List all <u>constraints</u> and <u>objective functions.</u>

Normal to be some ambiguity between Objs. & Constraints

- Constraint – must achieve (e.g. stress < max. allowable stress)
- Objective – desired outcome (measure) (e.g. cost, water quality params.)

4. Try to form models where all objectives & constraints are additive & proportional in terms of the decision variables (x_j). <u>Linear.</u>

FORM OF A LINEAR PROGRAM (a linear programming model)

The classical "<u>activity analysis</u>" problem.

Define by index j the jth activity.

Each unit of activity results in a constant amount of <u>profit</u>.

Each unit of activity requires ("uses up") a constant amount of one or more <u>resources</u>.

Each resource is available in <u>limited quantities</u>. (else what would happen?)

Define:

j, n = index & number of activities or decisions.

i, m = index & number of resources.

x_j = extent of activity j

c_j = cost, profit, or payoff (depending on problem context) for each unit of activity j which is undertaken.

a_{ij} = Coefficient (parameter) of activity j in constraint i. This represents how much of resource i is used for each unit of activity j that is undertaken.

b_i = The amount of each resource i that is available.

We can now write down a <u>Linear Programming model</u> for the general activity analysis problem.

Objective $\longrightarrow$ Maximize $Z = c_1 x_1 + c_2 x_2 + \cdots + c_n x_n$

Subject to:

Constraints $\longrightarrow$ $a_{i1} x_1 + a_{i2} x_2 + \cdots + a_{in} x_n \leq b_i$

$i = 1, 2, \ldots, m$

Non-negativity requirement $\longrightarrow$ $x_1 \geq 0, \; x_2 \geq 0, \ldots, \; x_n \geq 0$

Note each equation is <u>proportional to</u> and <u>additive in</u> the decision variables x_j. Each is <u>linear</u> in x_j. Fortunately, many important problems can be expressed in this way.

In general, can have Minimization, & either $\leq, \geq, =$ constraints.

Example: Furniture factory.

Specializes in dormitory furniture. Manufactures only student desks, chairs, dressers, & lounge tables.

Uses maple & pine for various parts, which are available in limited amounts each month.

The following Table summarizes costs, revenues, utilization factors, and resource availabilities for the factory.

Item	Desks (1)	Desk Chairs (2)	Dressers (3)	Tables (4)	Available Amt. (board-ft)	Cost ($/board-ft)
Pine	7	1.5	10	4	4000	2.00
Maple	15	4	22	10	2000	4.00
Revenue	$150	$ 100	$250	$ 170	—	—

FORMULATE model in class.