

CHAPTER 1
INTRODUCTION TO MANAGEMENT SCIENCE MODELS

TRUE/FALSE QUESTIONS

1. Other than for the military, the application of management science is inappropriate for non-profit organizations.
(False, easy)
2. Management science replaces common sense with scientific analysis. (False, easy)
3. Constrained mathematical models contain **variable** constraints as well as **functional** constraints. (True, easy)
4. Heuristic solution procedures always yield an optimal solution if one exists. (False, medium)
5. Constrained mathematical models are sometimes used to find merely "good" or "better" solutions, not always "optimal" ones.
(True, medium)
6. In defining decision variables, it is important to specify the time frame involved as well as the units of measure. (True, easy)
7. In management science problems, **algorithms** are rarely used since they tend to be very complex and costly. (False, easy)
8. Both management and operating personnel should be involved throughout the management science process, even before the implementation phase. (True, medium)
9. The linear constraints in a management science model need not be in the same units of measure. (True, medium)
10. Frederick Taylor applied the scientific approach to improving operations in a production setting more than 100 years ago.
(True, easy)
11. Mathematical modeling is a process that translates observed or desired phenomena into mathematical expression. (True, easy)
12. Once a mathematical model is complete, you cannot change the problem definition. (False, easy)
13. The management science team should make certain that management is sure of its objective before developing and solving a model. (True, easy)
14. Computer programs exist for all standard management science solution procedures. (True, easy)
15. Sensitivity analysis means "what if". (True, easy)

MULTIPLE CHOICE QUESTIONS

1. Management science does not:
 - a. use the scientific approach
 - b. provide a tool to aid in executive decision making.
 - c. involve mathematical modeling
 - d. guarantee improvement

(d, easy)
2. The developer of the simplex method in linear programming is generally regarded to be:
 - a. Gene Woolsey.
 - b. N. Karmarkar.
 - c. A. A. Markov.
 - d. George Dantzig

(d, medium)
3. If "necessity is the mother of invention," management science's mother was probably:
 - a. World War II.
 - b. the electronic computer.
 - c. the Great Depression
 - d. linear programming

(a, medium)
4. Constrained mathematical models do not contain:
 - a. functional constraints.
 - b. non-negativity requirements.
 - c. management preferences.
 - d. boundary restrictions.

(c, easy)
5. Constrained mathematical models may be characterized as:
 - a. optimization vs. prediction.
 - b. linear vs. quadratic.
 - c. probabilistic vs. stochastic.
 - d. heuristic vs. deterministic.

(a, medium)

6. Profit maximization will yield the same result as cost minimization when:

- a. costs and revenues are both variable.
- b. costs are constant.
- c. per unit profits are constant.
- d. revenues are constant.

(d, easy)

7. In management science problems, algorithms are:

- a. very complex, thus rarely used.
- b. used in optimization but not in heuristics.
- c. employed in heuristics as well as optimization.
- d. substitutes for computer-based solution techniques.

(c, difficult)

8. **Variable** constraints may **not** include:

- a. non-negativity constraints.
- b. boundary (upper or lower) constraints.
- c. integer constraints.
- d. resource constraints.

(d, easy)

9. A "model shell" contains:

- a. actual data.
- b. generic symbols.
- c. both actual data and generic symbols.
- d. neither actual data nor generic symbols.

(b, medium)

10. Decision variable definition need not include:

- a. specific units of measure.
- b. the time frame involved.
- c. variable names.
- d. integer requirements, if any.

(d, medium)

11. In a business organization, the "80/20" rule relates to:

- a. work accomplished vs. people who perform it.
- b. the average input/output ratio of production processes.
- c. the value of a "good" problem solution vs. its cost.
- d. "key" products vs. product line "fillers."

(c, difficult)

12. At what state in the management science process should the operating personnel, who are responsible for solution implementation, **first** be consulted?

- a. Problem definition.
- b. Mathematical modeling.
- c. Solution of the model.
- d. Communication/marketing of results.

(a, easy)

13. The worst mistake a management science analyst can make in addressing the organization's problem is probably:

- a. giving the wrong answer to the right question.
- b. giving the right answer to the wrong question.
- c. including extraneous data in the model.
- d. failing to anticipate "what if" questions.

(b, medium)

14. Management science applications do not include:

- a. simulation.
- b. queuing.
- c. decision analysis.
- d. internet programming.

(d, easy)

15. Constraints in the mathematical model do not include:

- a. amount of resources (decision variables) required.
- b. relational operators.
- c. availability of resources.
- d. shadow prices.

(d, easy)

16. Which name is most commonly associated with Game Theory?

- a. Andrey A. Markov
- b. E. K. Erlang
- c. Jon von Neuman
- d. N. Karmarkar

(c, easy)

17. Which step is not part of the mathematical modeling process?

- a. Problem definition.
- b. Data gathering.
- c. Constructing a model shell.
- d. Quantifying the objective and constraints.

(a, easy)

18. Which executive reaction to your management science solution would suggest the model is invalid?
- a. "We never tried this before."
 - b. "This doesn't make sense to me."
 - c. "We may not have as much money for this as we thought."
 - d. "We're profitable and have always done things our way."

(b, medium)

19. Which Excel function finds the value X such that 55% of the probability lies below X from a normal distribution with mean $\mu = 20$ and standard deviation $\sigma = 3$?

- a. `NORMDIST(.55,20,3,TRUE)`
- b. `NORMSDIST(.55,20,3)`
- c. `NORMINV(.55,20,3)`
- d. `NORMSINV(.55,20,3)`

(c, easy)

20. Which Excel data analysis tool returns the p-value for the F-test?
- a. Descriptive Statistics.
 - b. Regression.
 - c. Exponential Smoothing.
 - d. ANOVA.

(b, medium)

SHORT ANSWER QUESTIONS

1. Erlang's pioneering work in queuing theory emerged shortly after the start of the twentieth century. The next truly significant work in the field (by Little, et al) came roughly fifty years later. Why the long delay?

(Beyond the theoretical, the applications of queuing theory and analysis needed, in a very real sense, to wait for the development of the computational power of electronic computers.) (easy)

2. How should a management science analyst proceed when it is obvious that the "front line" people and their immediate management do not agree as to the definition of the problem to be addressed?

(Proceed with diplomacy! The "front line" people may be least willing to admit that a problem exists since it may be perceived to reflect negatively on their current performance. Yet they will be the ones most directly responsible for the implementation of the management science study's recommendations. Interview each group separately, then jointly, seeking consensus. If serious conflicts cannot be resolved, call in a third party: the next level of management, the management science analyst's supervisor, or perhaps a neutral but knowledgeable outsider.) (medium)

3. What is the purpose of model shells in the management science process?

(Model shells define the model before actual data are gathered. Building a model shell guides the decision maker as to what kind of data to seek and the relative accuracy required of the data. Once the appropriate data has been determined, actual numbers replace the parametric unknowns in the model and the model is solved.) (medium)

4. "Let X = the number of 750 ml bottles of Federini Chablis to be produced and shipped next calendar month." Critically evaluate this as the definition of a decision variable in a management science problem.

(Excellent. The definition specifically identifies the units of measure, the product, and the time frame involved. "Produced and shipped" also implies a neutral position regarding changes in the level of finished goods inventory.) (easy)

5. Why should the management science analyst anticipate resistance from operating personnel responsible for implementation of the study's results, most especially when the study's recommendations are substantially different from current practices? What should be done to eliminate or reduce such resistance?

(When the study's recommendations differ significantly from the current practices, the perceived implication is likely to be a critical rebuke of current personnel because what they are doing is "so far off the mark." This may result in a range of dysfunctional behavior, from subtle resistance to outright sabotage. It will be even worse if the operating personnel do not understand the methods of the management science study. The actions to eliminate or reduce

such resistance must be preventive and pre-emptive: enlist, encourage, and sustain the understanding and active participation of the operating personnel from the very outset of the study and throughout.) (medium)

6. Globe Spanners, a local travel agency, is facing a financial "crunch." In September, 1997, most airlines reduced the commissions they pay travel agencies to book airline tickets from ten percent to eight percent. Having initially capped commissions at \$25 for a one way ticket and \$50 for a round trip in February of 1995, the combination of both changes had reduced Globe Spanners' compensation to less than six percent, below their operating costs for booking air travel. Is this a problem amenable to management science analysis?

(Probably not. The appropriate disciplines in this case would likely be financial analysis, to find ways to reduce costs, and managerial economics, to determine what types and levels of service fees might be instituted with minimal travel client loss.) (easy)

7. What is the difference between "deterministic" and "stochastic"?

("Deterministic" means "known with certainty." "Stochastic" means "based on a probability distribution.") (easy)

8. What are three time and cost considerations for data gathering?

(Collecting, organizing and sorting relevant data.
Generating a solution approach.
Using the model.) (medium)

9. Name one thing you should do if the results of your model validation are unacceptable to management.

(Check assumptions.
Check data.
Modify approximations.
Add constraints.
Develop an entirely new model.) (medium)

10. What does a dollar sign ("\$\$") in an Excel address signify?

(An absolute rather than a relative address.) (easy)

FORMULATION/SOLUTION/ANALYSIS QUESTIONS

1. Dr. Zuck wants to study the effectiveness of a particular type of back brace on patients suffering from scoliosis (curvature of the spine). He wants to locate and test the largest possible number of patients. He has obtained a grant for one million dollars and estimates the cost of locating and recruiting a patient to be \$5,000. Half of the patients drop out of the study. There are two types of patients. Type A must constitute at least 50% of the study.

Create a mathematical model shell (objective function and constraints).

$$\begin{array}{ll} (\text{MAX} & X_1 + X_2 \\ & (X_1 = \text{the number of type A patients} \\ & \quad X_2 = \text{the number of type B patients}) \\ \text{ST} & 10X_1 + 10X_2 \leq 1000 \text{ (dollars expressed in thousands)} \\ & X_1 - X_2 \geq 0 \text{ (Type A must be at least half the study)} \\ & X_1, X_2 \geq 0 \text{ (non-negativity constraint)} \\ & \text{(medium)} \end{array}$$

2. The Deepsea Sponge Company wishes to maximize profit. Real sponges cost C_1 dollars and sell for P_1 . Synthetic sponges cost C_2 and sell for P_2 . Deepsea wants at least $M\%$ of their sales to be real sponges. Create a mathematical model shell (objective function and constraints).

$$\begin{array}{ll} (\text{MAX} & (P_1 - C_1)X_1 + (P_2 - C_2)X_2 \\ \text{ST} & X_1 + X_2 - X_3 = 0 \\ & X_1 - MX_3 \geq 0 \\ & X_1, X_2, X_3 \geq 0 \text{ (difficult)} \end{array}$$

3. Harold Shein, the accordion teacher, charges \$A per hour lesson for a novice and \$B (greater than \$A) for an advanced student. P percent of novice students become advanced, and R percent of advanced students cease taking lessons. Shein has H hours available each week and prefers that at least half his students are advanced. Create a mathematical model shell (objective function and constraints) of his business.

$$\begin{array}{ll} (\text{MAX} & AX_1 + BX_2 \\ \text{ST} & -X_1 + X_2 \geq 0 \\ & X_1 + X_2 \leq H \\ & X_1, X_2 \geq 0 \\ & X_1, X_2 \text{ integers} \\ & \text{(R and P are not relevant)} \text{ (difficult)} \end{array}$$

4. The Dennis Advertising Company wants you to model their business. Create a model shell for the following. For each client, Dennis estimates per person costs for each type of media:

D	Direct Mail
P	Newspaper Ad
M	Movies
T	Television
R	Radio

S Roadsigns

With a budget of Z dollars, Dennis wants to reach the largest population. Dennis is required to spend at least \$A on radio ads, \$B on television, and \$C on other media.

$$\begin{array}{llllllll}
 (\text{MAX} & X_D & + & X_P & + & X_M & + & X_T & + & X_R & + & X_S \\
 \text{ST} & DX_D & + & PX_P & + & MX_M & + & TX_T & + & RX_R & + & SX_S & \leq & Z \\
 & & & & & & & & & X_R & & & \geq & A \\
 & & & & & & & & & X_T & & & \geq & B \\
 & X_D & + & X_P & + & X_M & & & & & + & X_S & \geq & C \\
 & X_D, & X_P, & X_M, & X_T, & X_R, & X_S \geq 0) & (\text{medium})
 \end{array}$$

5. Boragon Middle School wishes to minimize the cost of audio-visual equipment. The school has R classrooms, each of which must have at least one piece of AV equipment. The school as a whole must have at least one TV/VCR combination, one computer projector, one laptop, and one overhead slide projector. Create a model shell.

$$\begin{array}{llllll}
 (\text{MIN} & VX_1 & + & DX_2 & + & CX_3 & + & PX_4 \\
 \text{ST} & X_1 & + & X_2 & + & X_3 & + & X_4 & \geq & R \\
 & X_1 & & & & & & & \geq & 1 \\
 & & & X_2 & & & & & \geq & 1 \\
 & & & & & X_3 & & & \geq & 1 \\
 & & & & & & & X_4 & \geq & 1 \\
 & X_1, & X_2, & X_3, & X_4 & \text{ integers) } & (\text{medium})
 \end{array}$$

16.