Chapter 1

Exercise Solutions

1-1. **(a)** The only unsettled quantity is decision variable s. **(b)** Given quantities or parameters are d, p and b. **(c)** Minimize the maximum error, i.e. objective min $(d/s)^2$ **(d)** We must have an integer number of sensors and not exceed the available budget, i.e. constraints $ps \leq b$, s nonnegative and integer.

1-2. **(a)** Feasible because $3.5(4) \leq 14$, and optimal because any larger s would not be feasible. **(b)** Infeasible and thus not optimal because $3.5(6) \not\leq 14$. **(c)** Feasible because $3.5(2) \leq 14$, but not optimal because feasible solution $s = 4$ yields a better objective value.

1-3. **(a)** The only quantities to be determined are x_1 and x_2, the numbers of lots on the 2 lines. **(b)** Given quantities or parameters are t_1, t_2, c_1, c_2, b and T. **(c)** Minimize total production cost or objective min $c_1x_1+c_2x_2$. **(d)** $t_1x_1+t_2x_2 \leq T$ (at most T hours of production), $x_1 + x_2 = b$ (produce b lots), $x_1, x_2 \geq 0$ and integer (numbers nonnegative integers).

1-4. **(a)** Infeasible and thus not optimal because $10(0) + 20(3) \not\leq 40$. **(b)** Feasible because $10(2) + 20(1) \leq 40$ and $2 + 1 = 3$. Also optimal because no more or less expensive x_2 can be used if $b = 3$ lots are to run. **(c)** Feasible because $10(3) + 20(0) \leq 40$ and $3 + 0 = 3$, but not optimal because $x_1 = 2$, $x_2 = 1$ yields a lower cost.

1-5. **(a)** Exact numerical optimization because it is the maximum feasible choice for the given set of parameter values. **(b)** Descriptive modeling because we have merely evaluated the consequences of a given choice of decision variables and parameters. **(c)** Closed-form optimization because an optimal solution is specified for each choice of decision variables. **(d)** Heuristic optimization because a good feasible solution is identified for the given choice of parameter values, but a non-usual layout might yield superior results.

1-6. **(a)** Provides optimum for all choices of input parameters, not just one. **(b)** Provides a provably best solution, not just a good feasible one. **(c)** Systematically searches for a good feasible solution, rather than just evaluating the consequences of one.

1-7. Higher tractability usually means loss of validity, so results from the model might not be useful in the application.

1-8. **(a)** (3 for the first) $\cdot$ (3 for the second) $\cdot \ldots \cdot$ (3 for the nth) $= 3^n$ combinations. **(b)** One run per second is 3,600 per hour, 86,400 per day, 31,536,000 per year. The $3^{10} = 59,049$ requires $59,049/3,600 = 16.4$ hours; $3^{15} = 14,348,907$ requires 166.1 days; $3^{20} \approx 3.49 \times 10^9$ requires 110.6 years; and $3^{30} \approx 2.06 \times 10^{14}$ requires 6.5 million years. **(c)** Practical computation would be limited to a few days which could accommodate no more than $10 - 11$ decision variables.

1-9. **(a)** Random variable because short term rainfall is unpredictable. **(b)** Deterministic quantity because annual rainfall averages are fairly stable. **(c)** Deterministic quantity because history can be known with certainty. **(d)** Random variable because future stock market behavior is highly uncertain. **(e)** Deterministic quantity because the seating capacity is fairly fixed. **(f)** Random variable because night to night arrivals are usually variable. **(g)** Random variable because breakdowns make the effective production rate uncertain. **(h)** Deterministic quantity because a reliable robot has a predictable rate of production. **(i)** Deterministic quantity because short term demand for such an expensive product would be fairly well known for the next few days. **(j)** Random variable because long term demand for a product is usually uncertain.