Management science process: **observation** (identify problems) - **problem definition** - **model construction** (develop function: DV, objective, constraints) - solution - **implementation** (use of model

Decision variables: mathematical symbols representing levels of activity of a firm

Object function: a linear mathematical relationship describing an objective, the function is maximized or minimized

Constrains: requirements/restrictions

Parameters: numerical coefficients and constants used in objective function and constraints

A **feasible solution** does not violate any constraints while **infeasible solution** violates at least one of the constraints

Slack variable / Surplus variable:

- is added to a <= / >= constraint to convert it to an equation (=).
- Represents unused / excess resource
- No contribution to objective function value.

Special types of problems: multiple optimal solutions, infeasible solutions, unbounded solutions.

Characteristics of linear programming:

- Decision variable: A decision amongst alternative courses of action
- Objective function: expresses a goal that the decision maker wants to achieve
- Constrains: limits the extent of achievement of the objective
- Objective and constraints must be definable by linear mathematical function.

Properties of linear programming model:

- Proportionality: the slope of objective function and constraint equations is constant
- Additivity: terms in objective function and constraints must be additive
- Divisibility: decision variables can take on any fractional value and are therefore continuous.
- Certainty: value of all parameters are assumed to be known with certainty.

LP model in Slover:

- Target cell: the cell representing the objective function
- Changing cell: cells representing decision variables
- Constraint cell: cells representing the LHS formulas on the constraints

Goals for spreadsheet design:

- Communication: the primary business purpose is communicating information to managers.
- Reliability: the output generated should be correct and consistent.
- Auditability: a manager should be able to retrace the steps followed to generate the different outputs of the model.
- Modifiability: should be easy to change or enhance in order to meet dynamic user requirements.

Sensitivity report:

- **Allowable increase / decrease:** the coefficients of the original objective function can be increased / decreased by _____ without changing the optimal solution.
    - allowable increase / decrease = 0
        - For **objective function:** Alternative optimal solution exists
        - For **constraints:** LP problem degenerate
            - Cannot detect alternate optimal solutions
            - Reduced cost may not be unique; the coefficients in objective must change by at least as much as reduced costs before the optimal solution changes.
            - Allowable increase/decrease still hold for objective
            - Shadow price may not be unique.
- **Reduced cost:** = unit profit - unit cost
    - Interpretation: the objective coefficients (unit profits) can be increased or decreased by ____ before the optimal solution changes.
- **Shadow price:** the objective values will increase / decrease by shadow price for every unit change of RHS value.
    - Shadow price is **only valid** within the corresponding range of allowable increase / decrease
    - Shadow price for nonbinding constraints are 0.
    - Changing a RHS value for a binding constraint will change the feasible

region and the optimal solution.

  - **calculate profit:** a marginal profit of \$320 and requires: 1 pump(shadow price = \$200), 8 labor (sp = \$16.67), 13 tubing (sp=\$0). Would it be profitable to produce any? Ans: 320-200*1-16.67*8-0*13 = -13.33 = No!
  - Calculate max. resource required so that still profitable: unit profit - cost of resources >= 0

Simultaneous changes in coefficients in objective function & constraints:

- all changes within the range of allowable increase/decrease (all **reduced cost** $\neq$ **0**): Solution remains optimal
- **100% rule:** if at least change is outside the range of allowable (variable has reduced cost = 0): $\sum \frac{changes}{allowable\ increase\ /\ decrease}$
  - If sum <=1 (100%), solution remains optimal; if sum >1, solution might be optimal but not guaranteed.

Bound: optimal solution to an LP relaxation of an integer LP problem gives us a bound on the optimal objective value (for max / min, the optimal relaxed objective value is an upper / lower bound on the optimal integer value)

Branch-and-Bound can solve any ILP, it requires the solution of a series of LP problems termed "candidate problems"

- Stopping rules: stop once an integer solution is found that is within some % of the global optimal solution

Transportation model:

- Has constraints for supply at each source and demand at each destination
- All constraints are qualities where supply equals demand
- Constraints contain inequalities where supply does not equal demand.

Transshipment model (for minimum cost)

- Total supply > total demand: inflow-outflow>=supply / demand (in each node)
- Total supply < total demand: inflow-outflow<=supply/demand
- Total supply = total demand: inflow-outflow=supply/demand

Assignment model:

- Supply at each source and demand at each destination is 1 unit.

- Supply = demand in a balanced model
- Supple $\neq$ demand in an unbalanced model

The shortest path problem

- One supply node with a supply of -1
- One demand node with a demand of +1
- All other nodes have supply/demand of 0