**MS Excel**

**Topics - Solver, Linear Programming Problems.**

**Linear Programming Problems**

One of the tools offered by MS Excel is solver which helps in solving linear programming problems i.e. solving the constrained optimization problems.

A typical constrained optimization problem involves an objective function which is available in the form of a linear combination of involved variables. The goal of the problem is to find those values of the involved variables at which the objective function either takes its optimum value (maximum or minimum) subject to a list of constraints. A linear programming problem can be written as follows:

Optimize  
\[ Z = c_1x_1 + c_2x_2 + \ldots + c_nx_n \]

Subject to the constraints:
\[ a_{11}x_1 + a_{12}x_2 + \ldots + a_{1n}x_n \leq \text{or} = \text{or} \geq b_1 \]
\[ a_{21}x_1 + a_{22}x_2 + \ldots + a_{2n}x_n \leq \text{or} = \text{or} \geq b_2 \]
\[ \vdots \]
\[ a_{m1}x_1 + a_{m2}x_2 + \ldots + a_{mn}x_n \leq \text{or} = \text{or} \geq b_m \]
\[ x_1, x_2, \ldots, x_n \geq 0 \]

In manually, the solution of linear programming is obtained by using graphical method or simplex method. The method may result into successful discovery of values of variables that satisfy the given LPP problem if the solution is feasible. Otherwise the method results into cases where either no solution exists, or more than one solutions exist or the solutions are degenerative. Simplex is a lengthy process. However, the solver tool can quickly solve an LPP problem.

**Solving LPP using Excel**

One should follow the following steps to solve an LPP.

- Step 1: Enable Solver if not already enabled.
- Step 2: Identify the cells that represent the input variables.
- Step 3: Enter the formula of the objective function in some cell
- Step 4: Enter the LHS and RHS for each of the constraints
- Step 5: Start Solver
- Step 6: Select the goal of the objective function to maximize, minimize or take the function’s value to some fixed value
- Step 7: Provide the address of the input cells
- Step 8: Add each constraint one by one by specifying the cell references for the LHS part, RHS part and the type of constraint.
- Step 9: Select the solving method as Simplex LP solution is to be found using Simplex method.
- Otherwise a user can also select the method of GRG engine which computes a nonlinear local optimal solution for non-convex problems.
- Step 10: Select Solve

If the solver finds a solution, it puts the computed values for the input variables in the cells designated for them and shows a screen that tells that it has found a solution. It can further asks if user also want to generate additional reports for Answer, Sensitivity and Limits.

**Understanding additional reports**

If solver is able to find an optimum solution of an LPP, it can provide three reports namely answer, sensitivity and limit reports. However if solver does not find a solution, it provides a feasibility report indicating the constraints that make the solution infeasible. And if there is no converging solution for an LPP, solver only informs that solution is non convergent, but it does not give any report in that case.
**Answer Report**

Answer Report provides the result of the solver. The report also the optimum value achieved by the objective function and the values of the variables at which the optimum value of the objective function is achieved. However, these values are also available in the corresponding cells on the excel sheet. It also suggests if any constraint has been exhausted completely or not. If not it shows that the constraint is not binding and shows the value of slack variable.

<table>
<thead>
<tr>
<th>Objective Cell (Max)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cell</strong></td>
</tr>
<tr>
<td>$S1S7$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variable Cells</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cell</strong></td>
</tr>
<tr>
<td>$S1D3$</td>
</tr>
<tr>
<td>$S1G3$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Constraints</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cell</strong></td>
</tr>
<tr>
<td>$S1S11$</td>
</tr>
<tr>
<td>$S1S12$</td>
</tr>
<tr>
<td>$S1S13$</td>
</tr>
<tr>
<td>$S1S14$</td>
</tr>
</tbody>
</table>

**Sensitivity Report**

The sensitivity report suggest as to how much change in the variables or constraint limits can be made so that the input variables required to achieve the objective function still remains same.

**Limits Report**

The report shows the value of objective function at the lower and upper limits of the input variables.
Feasibility Report (In fact infeasibility report)
This report is generated when the solver is not able to find a solution. The report mentions the constraints which make the problem infeasible.

Graphically representing the feasible region of an LPP
A user can graphically represent the feasible region of an LPP by plotting each equation on a scatter plot. Use the following procedure for this purpose:

Step 1: Convert each equation into an equality relationship
Step 2: Find the coordinates on the line when x is zero and when y is zero.
Step 3: Prepare x-axis point for the scatter graph
Step 4: Plot each line as a separate series
Step 5: Identify the area represented by each line by using the inequality
Step 6: Insert an scribbled area for the common feasible region.