

## Glickman Electronics Example

The Glickman Electronics Company in Washington, DC, produces two products: (1) the Glickman x-pod, a portable music player, and (2) the Glickman BlueBerry, an internet-connected color telephone. The production process for each product is similar in that both require a certain number of hours of electronic work and a certain number of labor-hours in the assembly department. Each x-pod takes 4 hours of electronic work and 2 hours in the assembly shop. Each BlueBerry requires 3 hours in electronics and 1 hour in assembly. During the current production period, 240 hours of electronic time are available, and 100 hours of assembly department time are available. Each x-pod sold yields a profit of \$7; each BlueBerry produced may be sold for a \$5 profit.

Glickman's problem is to determine the best possible combination of x-pod and BlueBerrys to manufacture to reach the maximum profit.

## Solution:

- a. Formulate the problem as a linear programming model (that is, define the variables, and write down the objective function and all constraints mathematically).

We begin by summarizing the information needed to formulate and solve this problem. Further, let's introduce some simple notation for use in the objective function and constraints.

### Decision Variables

$X_1$  = number of x-pods to be produced  
 $X_2$  = number of BlueBerry to be produced

### Objective Function and constraints

$$\text{Max } (\$7X_1 + \$5X_2)$$

Subject to:

$$\begin{aligned} 4X_1 + 3X_2 &\leq 240 \\ 2X_1 + 1X_2 &\leq 100 \\ X_1, X_2 &\geq 0 \end{aligned}$$

The objective function created this way represents the overall profit from the operation. Since each x-pod yields a profit of \$7,  $X_1$  of them yield  $7X_1$  dollars. Similarly, each BlueBerry yields a profit of \$5, which means  $X_2$  BlueBerrys yield  $5X_2$  dollars. The overall profit will therefore be  $= \$7X_1 + \$5X_2$ , which is the objective function we are trying to maximize.

As for the constraints, one general relationship is that the amount of a resource used is to be less than or equal to the amount of resource available. Both these constraints represent production capacity restrictions and, of course, affect the total profit.

*First constraint:*

Electronic time used is  $\leq$  Electronic time available.

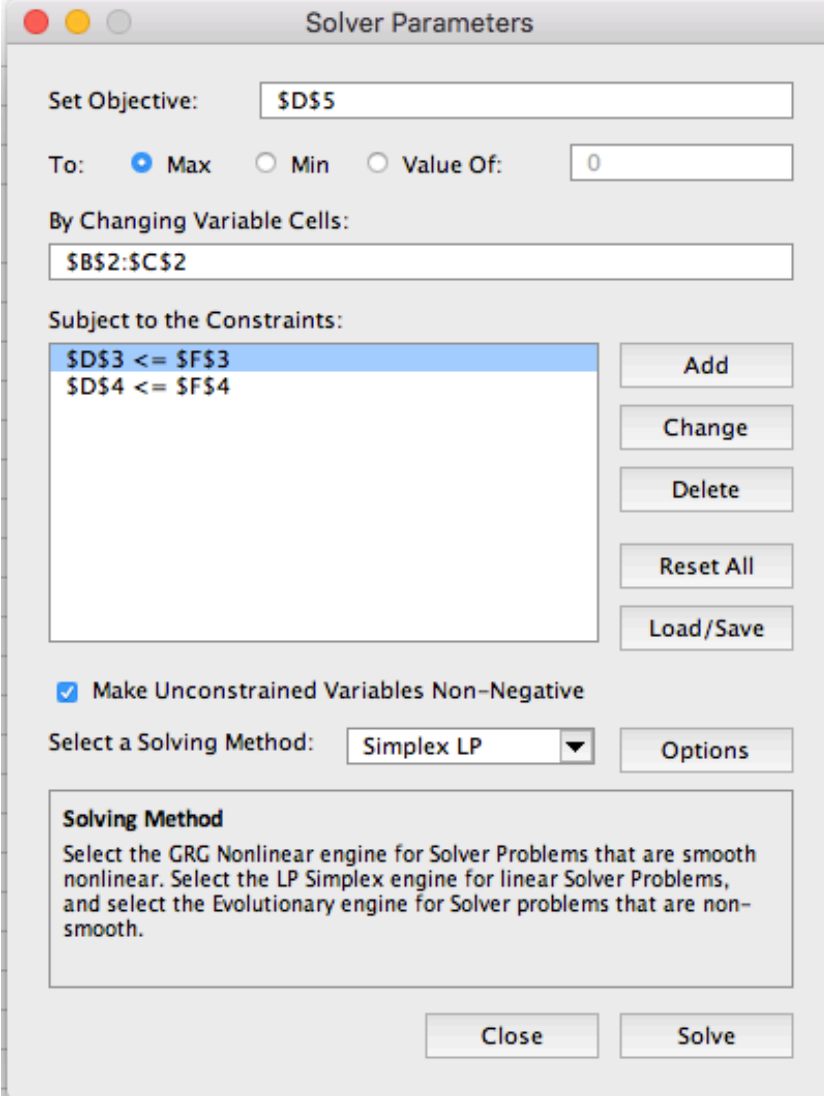
*Second constraint:*

Assembly time used is  $\leq$  Assembly time available.

For example, Glickman Electronics cannot produce 70 x-pods during the production period because if  $X_1 = 70$ , both constraints will be violated. It also cannot make  $X_1 = 50$  x-pods and  $X_x = 10$  BlueBerrys.

What is more, since the decision variables represent units of production, we should add a non-negativity constraint for each variable.

- b. Create a spreadsheet model for this problem and solve with Excel Solver.



The image shows the 'Solver Parameters' dialog box in Microsoft Excel. The 'Set Objective' field is set to '\$D\$5'. The 'To' section has three radio buttons: 'Max' (selected), 'Min', and 'Value Of:'. The 'By Changing Variable Cells' field is set to '\$B\$2:\$C\$2'. The 'Subject to the Constraints' list contains two constraints: '\$D\$3 <= \$F\$3' and '\$D\$4 <= \$F\$4'. To the right of this list are buttons for 'Add', 'Change', 'Delete', 'Reset All', and 'Load/Save'. Below the constraints list is a checked checkbox labeled 'Make Unconstrained Variables Non-Negative'. The 'Select a Solving Method' dropdown is set to 'Simplex LP', with an 'Options' button to its right. A 'Solving Method' text box provides instructions: 'Select the GRG Nonlinear engine for Solver Problems that are smooth nonlinear. Select the LP Simplex engine for linear Solver Problems, and select the Evolutionary engine for Solver problems that are non-smooth.' At the bottom are 'Close' and 'Solve' buttons.

**Solver Parameters**

Set Objective:

To: ☒ Max ☐ Min ☐ Value Of:

By Changing Variable Cells:

Subject to the Constraints:

\$D\$3 <= \$F\$3	Add Change Delete Reset All Load/Save
\$D\$4 <= \$F\$4	

☒ Make Unconstrained Variables Non-Negative

Select a Solving Method:  Options

**Solving Method**  
Select the GRG Nonlinear engine for Solver Problems that are smooth nonlinear. Select the LP Simplex engine for linear Solver Problems, and select the Evolutionary engine for Solver problems that are non-smooth.

Close Solve

Figure 1 - Solver parameters

	A	B	C	D	E	F
1		X-PODS (X <sub>1</sub> )	BLUEBERRYS (X <sub>2</sub> )	240 <= 240 100 <= 100		
2	Production	30	40			
3	Electronic Constraint	4	3			
4	Assembly Constraint	2	1			
5	Objective Function (Maximization)	7	5	410		

	A	B	C	D	E	F
1		<b>X-PODS (X<sub>1</sub>)</b>	<b>BLUEBERRYS (X<sub>2</sub>)</b>			
2	<b>Production</b>	30	40			
3	<b>Electronic Constraint</b>	4	3			
4	<b>Assembly Constraint</b>	2	1			
5	<b>Objective Function (Maximization)</b>	7	5			
				=SUMPRODUCT(B2:C2,B3:C3)	<=	240
				=SUMPRODUCT(B2:C2,B4:C4)	<=	100
				=SUMPRODUCT(B2:C2,B5:C5)		

c. What is the optimal solution? What is the optimal value?

The Optimal Solution:

$$X_1 = 30$$

$$X_2 = 40$$

The optimal value:

Maximum profit = \$410