EXCEL SOLVER IN OPTIMIZATION PROBLEMS

Solver Function

- **Optimization problems are real world problems we encounter in many areas such as *mathematics, engineering, science, business and economics*.**
- **In these problems, we find the optimal, or most efficient, way of using limited resources to achieve the objective of the situation.**

- **This may be maximizing the profit, minimizing the cost, minimizing the total distance travelled or minimizing the total time to complete a project.**
- **For the given problem, we formulate a mathematical description called a mathematical model to represent the situation. The model consists of following components:**

- ***Decision variables***: such as **X1, X2, X3,…..Xn**. These variables represent unknown quantities

- ***Objective function***: The objective of the problem is expressed as a mathematical expression in decision variables. The objective may be maximizing the profit, minimizing the cost, distance, time, etc.

- ***Constraints:*** The limitations or requirements of the problem are expressed as inequalities or equations in decision variables.

If the model consists of a linear objective function and linear constraints in decision variables, it is called a *linear programming model.*

A nonlinear programming model consists of a nonlinear objective function and nonlinear constraints.

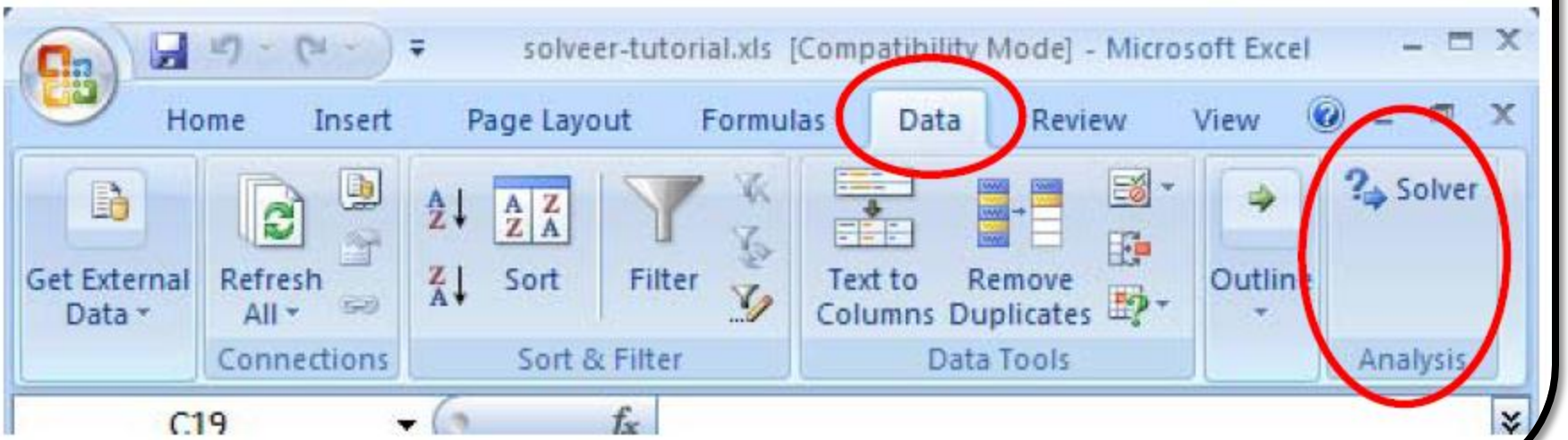
Linear programming: It is a technique used to solve models with linear objective function and linear constraints. The Simplex Algorithm developed by Dantzig (1963) is used to solve linear programming problems.

Installing the Excel Solver

Figure 1. Solver Button

To do exercises from this handout, you will need to use the "Solver" add-in for Microsoft Excel. When installed, it appears in the "Analysis" toolbar under the "Data" tab:

Figure 1. Solver Button



If the "Analysis" toolbar does not appear, or does not have the "Solver" button, the add-in must first be activated:

1. Click on the "Office" button in the top left corner:
2. Choose "Excel Options" (Figure 2)
3. Choose "Add-Ins" in the vertical menu on the left (Figure 3)
4. Pick "Excel Add-Ins" from the "Manage" box and click "Go…"(Figure 3)
5. Check "Solver Add-In" and press "OK" (Figure 4)
6. The Solver add-in should now appear in the Analysis toolbar (Figure 1)

Figure 2. MS Office Menu

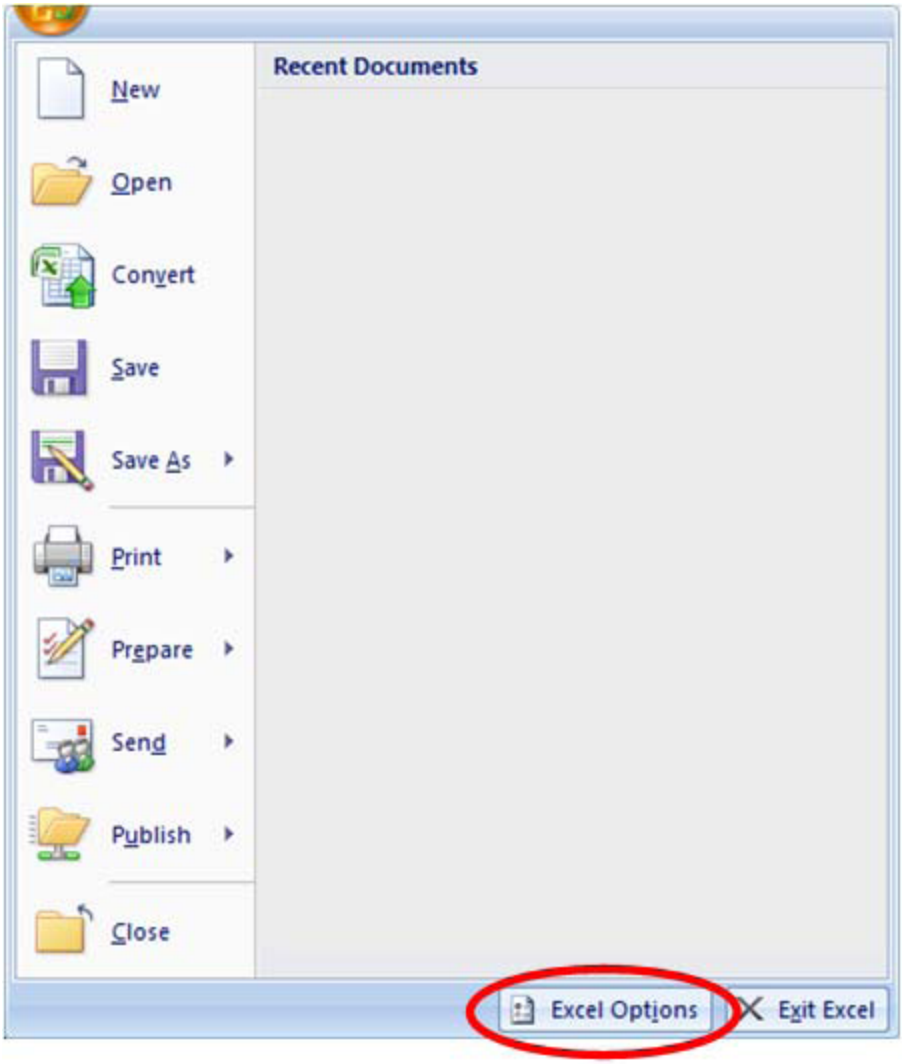


Figure 3. Excel Options Menu

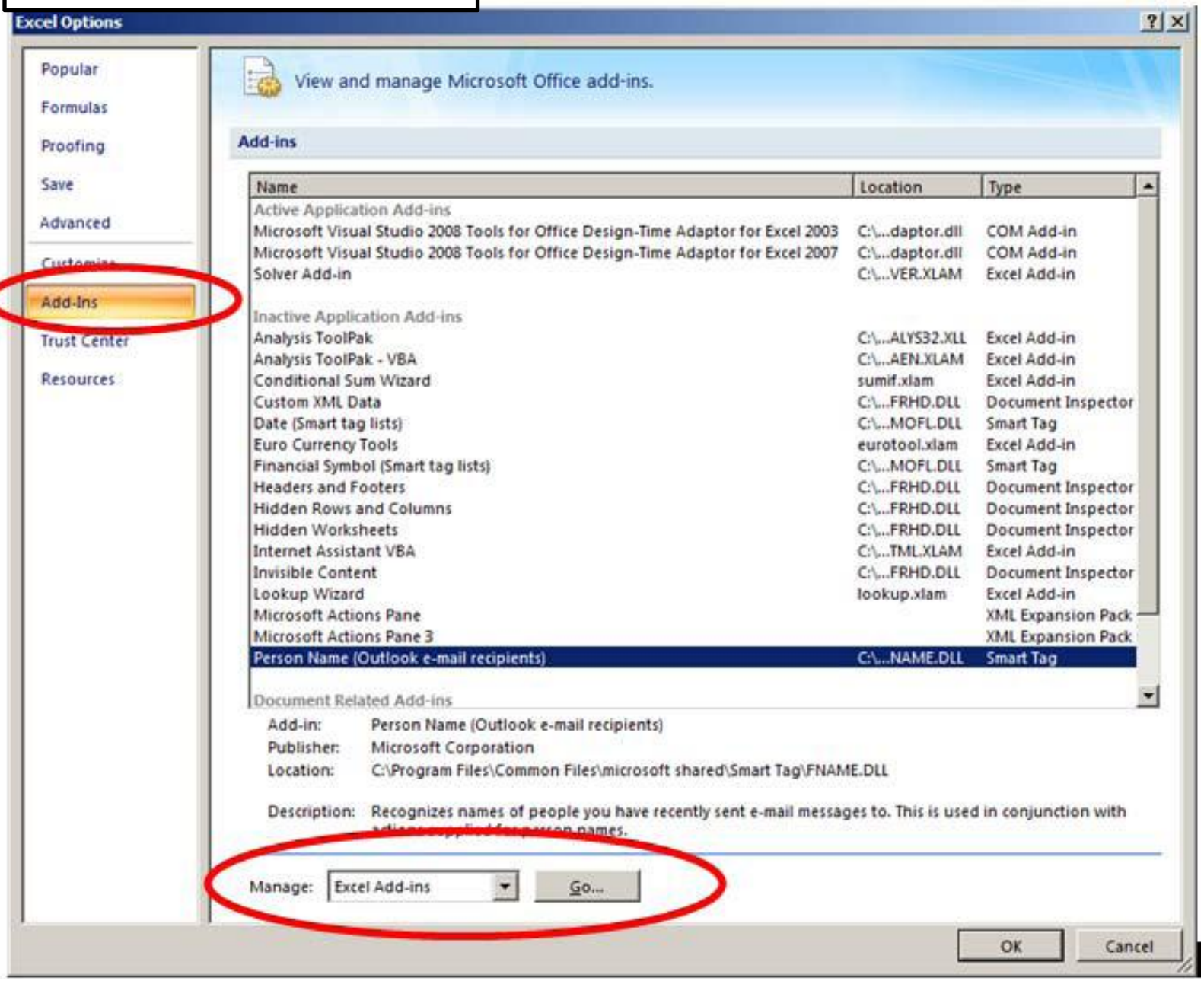
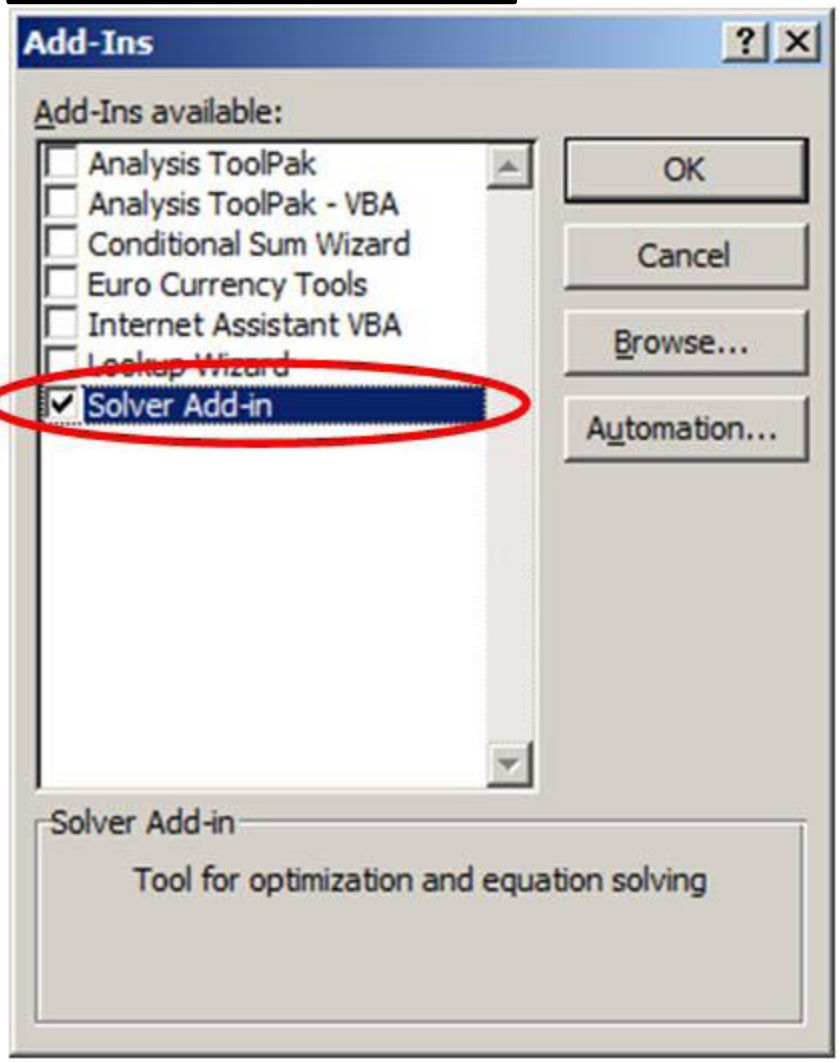


Figure 4. Add-Ins Menu



Example : Use excel solver to solve the following equations

$$Minimize \quad 0.6X_1 + 0.5X_2$$

Constraints

$$20X_1 + 50X_2 \geq 100$$
$$25X_1 + 25X_2 \geq 100$$
$$50X_1 + 10X_2 \geq 100$$

Initial condition

$$X_1, X_2 \geq 0$$

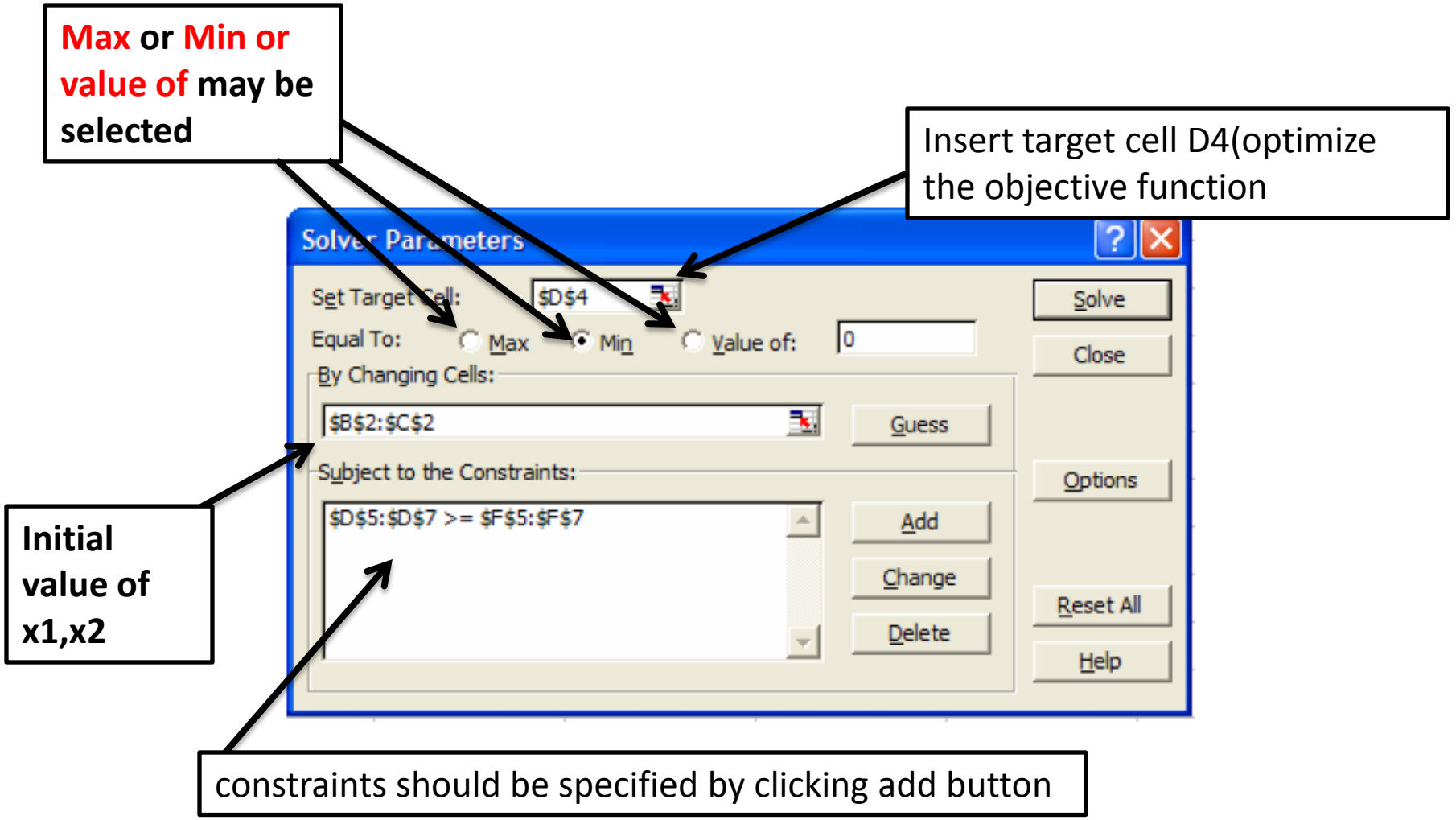
	A	B	C	D	E	F
1		X1	X2			
2	Decision Var.	0	0			
3				Total		
4	Objective	0.6	0.5	0		
5	Const. 1	20	50	0	>=	100
6	Const. 2	25	25	0	>=	100
7	Const. 3	50	10	0	>=	100

Initial guess

=SUMPRODUCT($B$2:$C$2,B4:C4)

Coefficients of objective and constraints

Select solver from ribbon and this window will appear:



The ***Set Target Cell*** **box should contain the cell location of the objective function for the problem under consideration**

If **Value is selected, the Solver will attempt to find a value of the Target Cell equal to whatever value is placed in the box just to the right of this selection.**

The ***By Changing Cells*** **box should contain the location of the decision variables for the problem.**

Finally, the constraints must be specified in the *Subject to the Constraints* box by clicking on Add.

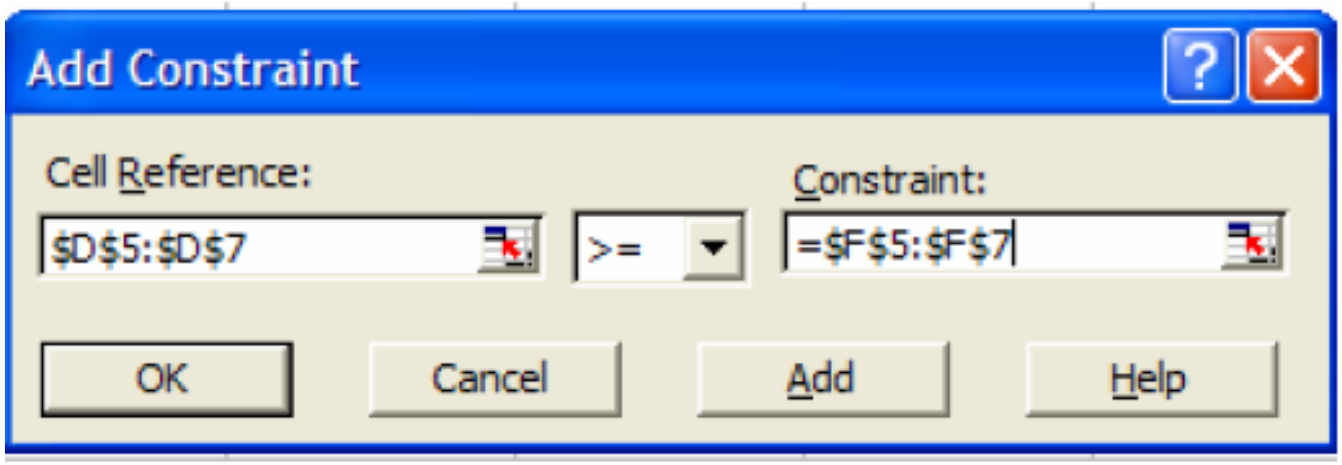
Change **allows you to modify a constraint already entered and Delete allows you to delete a previously entered constraint.**

Reset All **clears the current problem and resets all parameters to their default values.**

Options **invokes the Solver options dialog box (to be discussed later).**

The ***Guess*** **selection is not particularly useful for our purposes and will not be discussed here.**

When the ***Add*** **button is clicked, the Add Constraint dialog box appears:**



Clicking on the **Cell Reference Box allows you to specify a cell location (usually a cell with a formula).**

The constraint type may be set by selecting the down arrow (<=, >=, =, int, where int refers to integer, or bin, where bin refers to binary).

The **Constraint box may contain a formula of cells, a simple cell reference, or a numerical value.**

The **Add button adds the currently specified constraint to the existing model and returns to the Add Constraint dialog box**

The **OK button adds the current constraint to the model and returns you to the Solver Dialog box.**

Note: ***Solver does not assume nonnegative of the decision variables. The options dialog box discussed below allows you to specify that the variables must be nonnegative.***

Max Time allows you to set the number of seconds before Solver will stop. Iterations, similar to Max Time,

Precision is the degree of accuracy of the solver algorithm

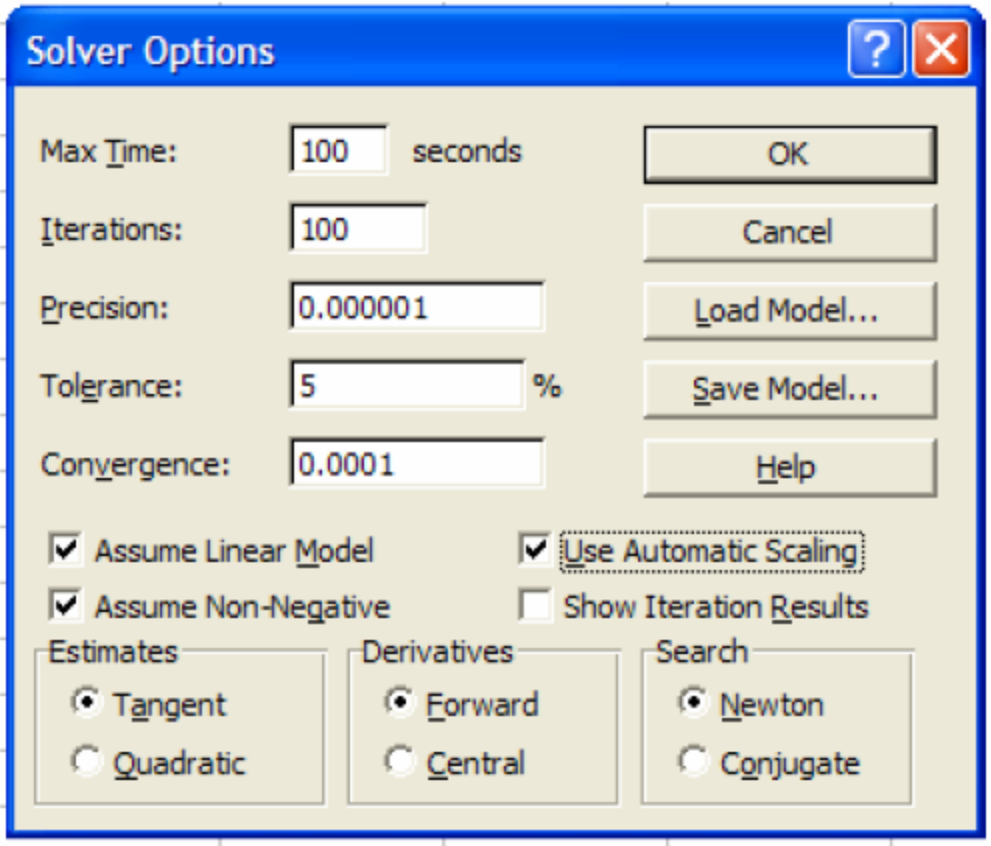
If you seek the optimal solution, Tolerance **must be set to zero**

If run time becomes too long, you may wish to set this to a higher value (if you are willing to accept a solution within this percent of optimality).

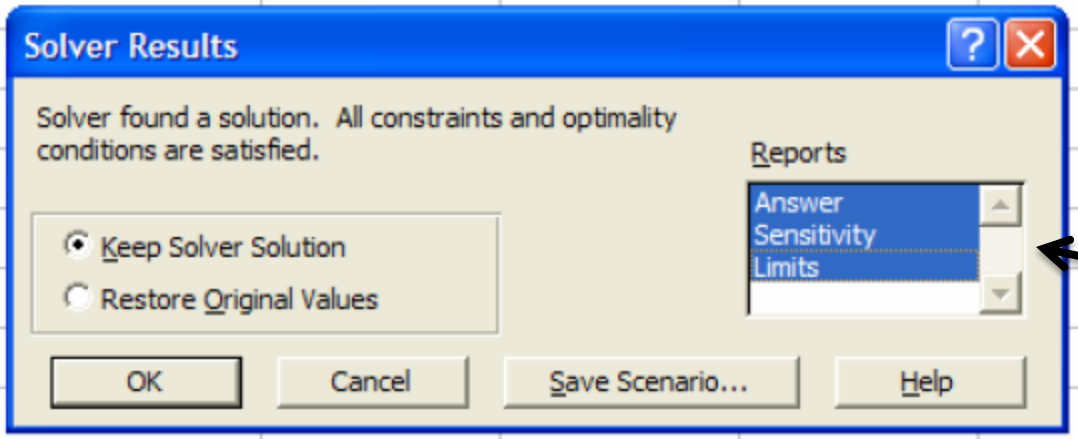
If your model is a linear program or a linear integer program, you should check Assume Linear Model.

Assume Non-Negative should be checked if you want all of your changing cell values to be ≥0.

Click OK



	A	B	C	D	E	F
1		X1	X2			
2	Decision Var.	1.5	2.5			
3				Total		
4	Objective	0.6	0.5	2.15		
5	Const. 1	20	50	155	>=	100
6	Const. 2	25	25	100	>=	100
7	Const. 3	50	10	100	>=	100
8						
9						
10						
11						
12						
13						
14						
15						



Select the reports & click OK

You can see the report in the next worksheet

Microsoft Excel 10.0 Answer Report
Worksheet: [Book2]Sheet1
Report Created: 2/28/2003 9:21:11 PM

Target Cell (Min)

Cell	Name	Original Value	Final Value
$D$4	Objective Total	0	2.15

Adjustable Cells

Cell	Name	Original Value	Final Value
$B$2	Decision Var. X1	0	1.5
$C$2	Decision Var. X2	0	2.5

Constraints

Cell	Name	Cell Value	Formula	Status	Slack
$D$5	Const. 1 Total	155	$D$5>=$F$5	Not Binding	55
$D$6	Const. 2 Total	100	$D$6>=$F$6	Binding	0
$D$7	Const. 3 Total	100	$D$7>=$F$7	Binding	0

Microsoft Excel 10.0 Sensitivity Report
Worksheet: [Book2]Sheet1
Report Created: 2/28/2003 9:21:12 PM

Adjustable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
$B$2	Decision Var. X1	1.5	0	0.6	1.9	0.1
$C$2	Decision Var. X2	2.5	0	0.5	0.1	0.38

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
$D$5	Const. 1 Total	155	0	100	55	1E+30
$D$6	Const. 2 Total	100	0.019	100	150	23.91304348
$D$7	Const. 3 Total	100	0.0025	100	73.33333333	60

There are three categories of information needed for solving an optimization problem in Excel: an *Objective Function*, *Decision Variables, and Constraints*.

Example:

A shipping company has the capacity to move 100 tons of cargo per day by air. The company charges $250/ton for air freight. Besides the weight constraint, the company can only move 50,000 ft^3 of cargo per day because of limited volume of aircraft storage compartments. The following amounts of cargo are available for shipping each day:

Cargo	Weight (tons)	Volume (ft^3/ton)
1	30	550
2	40	800
3	50	400

Maximize the profit for the shipping company.

- Set up this problem:

Objective Function: Profit = 250*(Cargo1 + Cargo2+ Cargo3) (*$/week*)
Decision Variables:

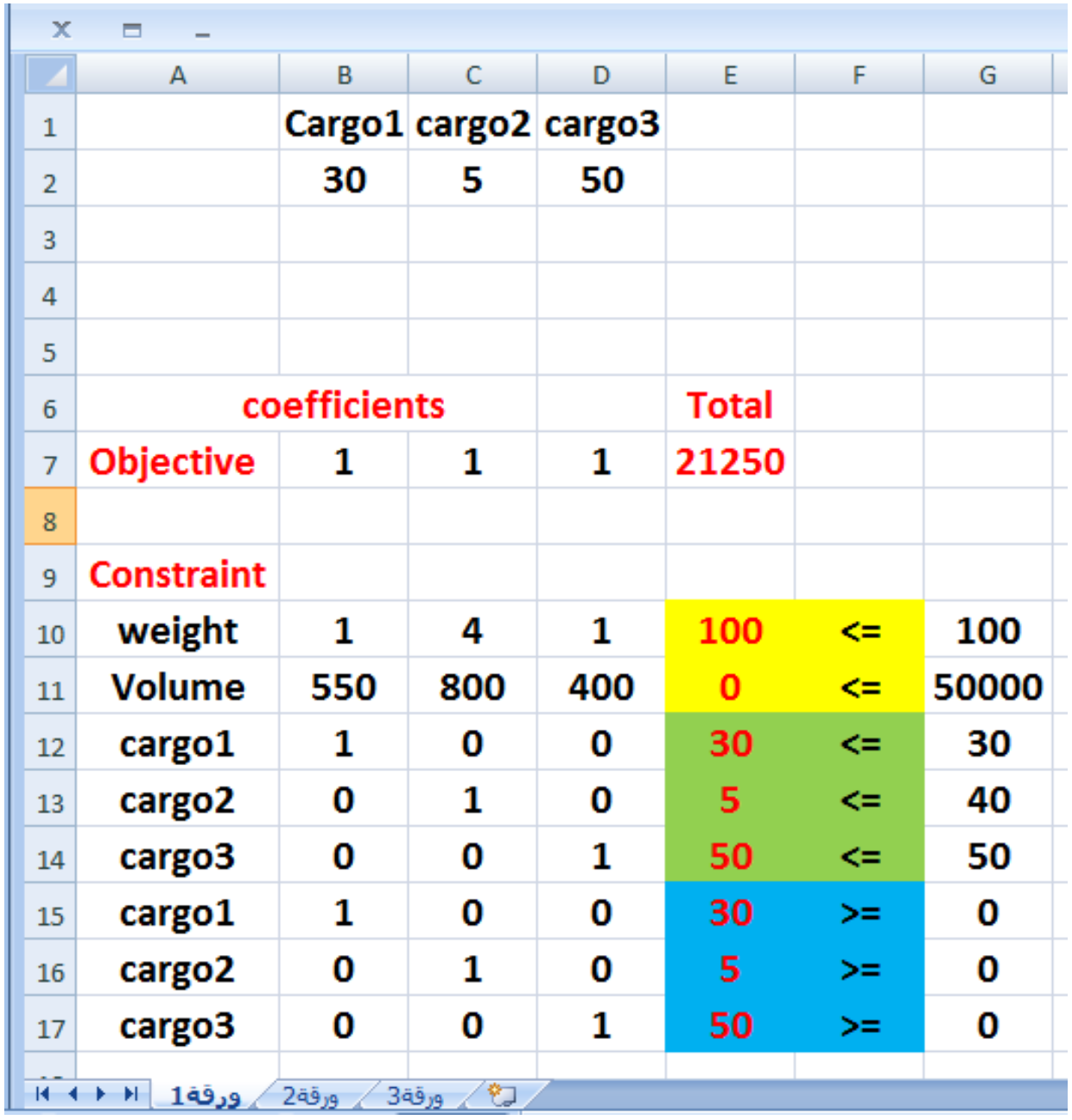
Cargo 1 (*weight in tons*)
Cargo 2
Cargo 3

Constraints:

Weight: Cargo1 + Cargo2 + Cargo3 ≤ 100
Volume: 550*Cargo1 + 800*Cargo2 +400*Cargo3 ≤ 50000
Amount 1: Cargo1 ≤ 30
Amount 2: Cargo2 ≤ 40
Amount 3: Cargo3 ≤ 50

***Do not forget to include the trivial constraints!**

Trivial 1: Cargo1 ≥ 0
Trivial 2: Cargo2 ≥ 0
Trivial 3: Cargo3 ≥ 0



	A	B	C	D	E	F	G
1		Cargo1	cargo2	cargo3			
2		30	5	50			
3							
4							
5							
6	coefficients				Total		
7	Objective	1	1	1	21250		
8							
9	Constraint						
10	weight	1	4	1	100	<=	100
11	Volume	550	800	400	0	<=	50000
12	cargo1	1	0	0	30	<=	30
13	cargo2	0	1	0	5	<=	40
14	cargo3	0	0	1	50	<=	50
15	cargo1	1	0	0	30	>=	0
16	cargo2	0	1	0	5	>=	0
17	cargo3	0	0	1	50	>=	0

ورقة1 ورقة2 ورقة3

	A	B	C	D	E	F	G
1		Cargo1	cargo2	cargo3			
2		30	5	50			
3							
4							
5							
6		coefficients			Total		
7	Objective	1	1	1	21250		
8							
9	Constraint						
10	weight	1	4	1	100	<=	100
11	Volume	550	800	400	0	<=	50000
12	cargo1	1	0	0	30	<=	30
13	cargo2	0	1	0	5	<=	40
14	cargo3	0	0	1	50	<=	50
15	cargo1	1	0	0	30	>=	0
16	cargo2	0	1	0	5	>=	0
17	cargo3	0	0	1	50	>=	0

A shipping c
per day by a
Besides the
ft3 of cargo

Solver Parameters

Set Target Cell: $E$7

Equal To: Max Min Value of: 0

By Changing Cells:

$B$2:$D$2

Subject to the Constraints:

$E$10:$E$11 <= $G$10:$G$11
$E$12:$E$14 <= $G$12:$G$14
$E$15:$E$17 >= $G$15:$G$17

Solve
Close
Guess
Options
Add
Change
Delete
Reset All
Help

ورقة1 ورقة2 ورقة3

The Problem

A knapsack is being loaded for a camping trip. This knapsack has a maximum weight-carrying limit and a maximum load size limit. The camper can choose from 4 different food items to put into the knapsack. The selected items must maximize the overall number calories and provide at least a minimum number of grams of protein while not exceeding the maximum load size and weight-carry capacity of the knapsack.

The knapsack's load cannot exceed a weight of 10 kilograms or a volume of 0.125 m^3. The load of food items must contain at least 200 grams of protein.

The load may contain any number of each of the 4 following food items:

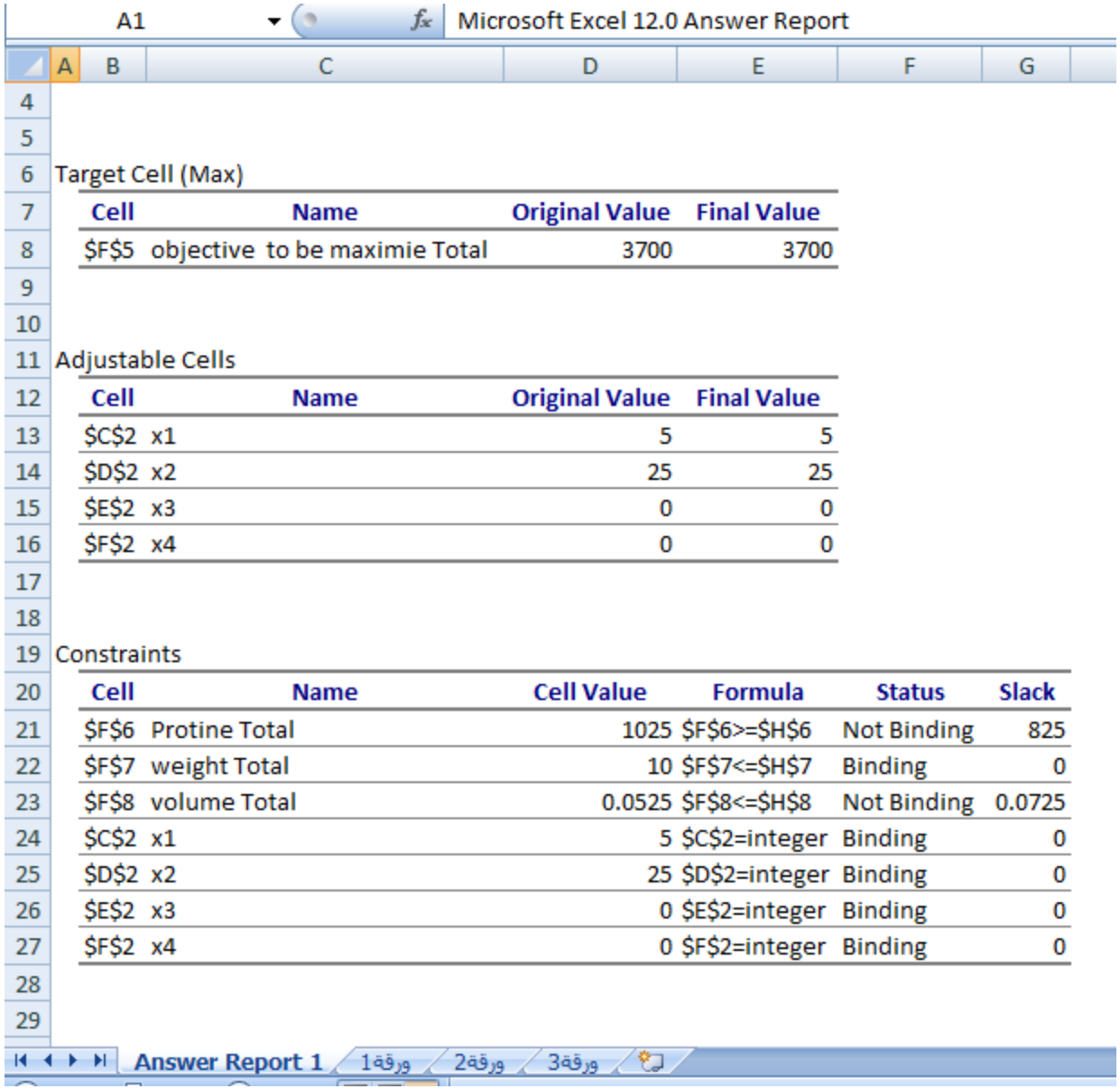
- Candy Bar
- Sandwich
- Can of Juice
- Apple

Specific information about each food items are as follows:

Object	Calories Per Object	Protein (grams) Per Object	Weight (kg) Per Object	Volume (m^3) Per Object
Candy Bar	90	5	0.25	0.0005
Sandwich	130	40	0.35	0.002
Juice Can	100	15	0.35	0.00075
Apple	40	3	0.3	0.0009

L10

	A	B	C	D	E	F	G	H	I
1			x1	x2	x3	x4			
2			5	25	0	0			
3									
4		Coefficients				Total			
5	objective to be maximie	90	130	100	40	3700			units
6	Protine	5	40	15	3	1025	>=	200	g
7	weight	0.25	0.35	0.35	0.3	10	<=	10	kg
8	volume	5E-04	0.002	8E-04	9E-04	0.0525	<=	0.125	m3
9									
10									
11									
12									
13									
14									



Target Cell (Max)

Cell	Name	Original Value	Final Value
$F$5	objective to be maximie Total	3700	3700

Adjustable Cells

Cell	Name	Original Value	Final Value
$C$2	x1	5	5
$D$2	x2	25	25
$E$2	x3	0	0
$F$2	x4	0	0

Constraints

Cell	Name	Cell Value	Formula	Status	Slack
$F$6	Protine Total	1025	$F$6>=$H$6	Not Binding	825
$F$7	weight Total	10	$F$7<=$H$7	Binding	0
$F$8	volume Total	0.0525	$F$8<=$H$8	Not Binding	0.0725
$C$2	x1	5	$C$2=integer	Binding	0
$D$2	x2	25	$D$2=integer	Binding	0
$E$2	x3	0	$E$2=integer	Binding	0
$F$2	x4	0	$F$2=integer	Binding	0