CGN 2420
Iterative Solutions and Optimization Using Excel Solver

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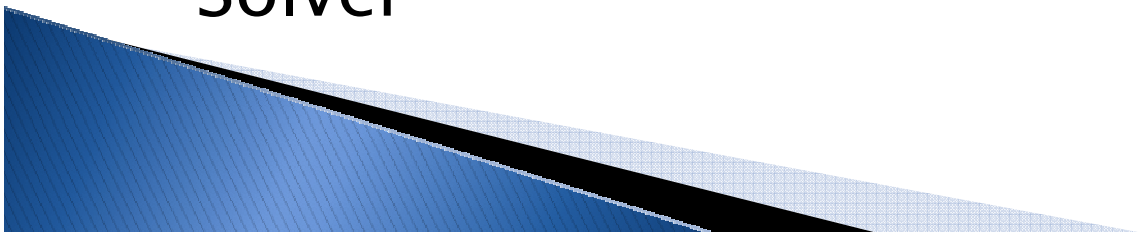
Objectives

- Find solutions, or “roots”, of equations using a graph.
- Find roots of equations using several iterative solution methods:
  - “Guess and check” iteration.
  - Direct substitution.
  - Excel’s Goal Seek, to solve for roots of equations.
  - Excel’s Solver, to solve for roots of equations.
- Solve optimization problems using Excel’s Solver



Introduction

Some equations are easy to rearrange to solve for a variable, as an example, solve for the volume (V) of an ideal gas:

$$PV = nRT \Rightarrow V = \frac{nRT}{P}$$

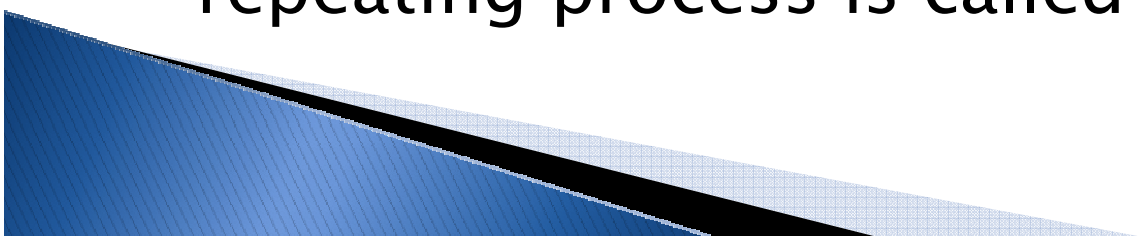
Try to solve for the porosity (ε) in the following Eq:

$$\frac{\Delta P}{L} = \frac{150\overline{V_0}\mu}{\Phi_s^2 D_p^2} \cdot \frac{(1-\varepsilon)^2}{\varepsilon^3} + \frac{1.75\rho\overline{V_0}^2}{\Phi_s D_p} \cdot \frac{1-\varepsilon}{\varepsilon^3}$$

Iterative techniques can be used to solve a variety of complex equations.

Iterative Solutions

- Nearly all iterative solution techniques require an initial guess to be provided by the user.
- Then the equation is solved using the guess value and a result is calculated.
- A test is performed to see if the solution is close enough to the correct answer.
- If it is not, a new guess value is used; the repeating process is called *iteration*.

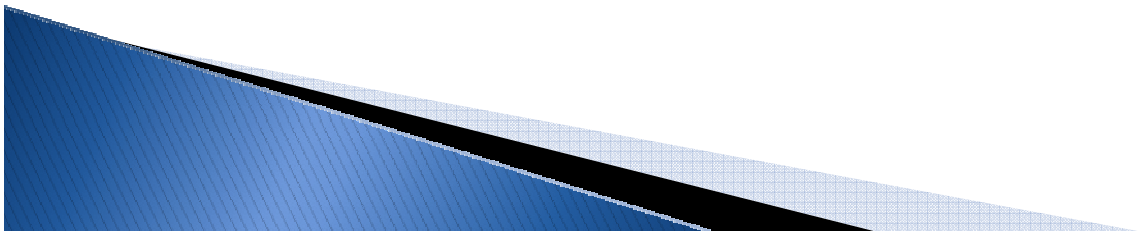


Standard Forms

- The equation to be solved should be written into a standard form. Consider the equation

$$x^3+12=17x$$

Form	Example	Convenient for..
(1) Set Equation equal to Zero	$x^3-17x+12=0$	•Plot Method •Excel's Solver
(2) Get an "x" by itself on the left side	$x=(x^3+12)/(17)$	•Direct-substitution Method •In cell Iteration



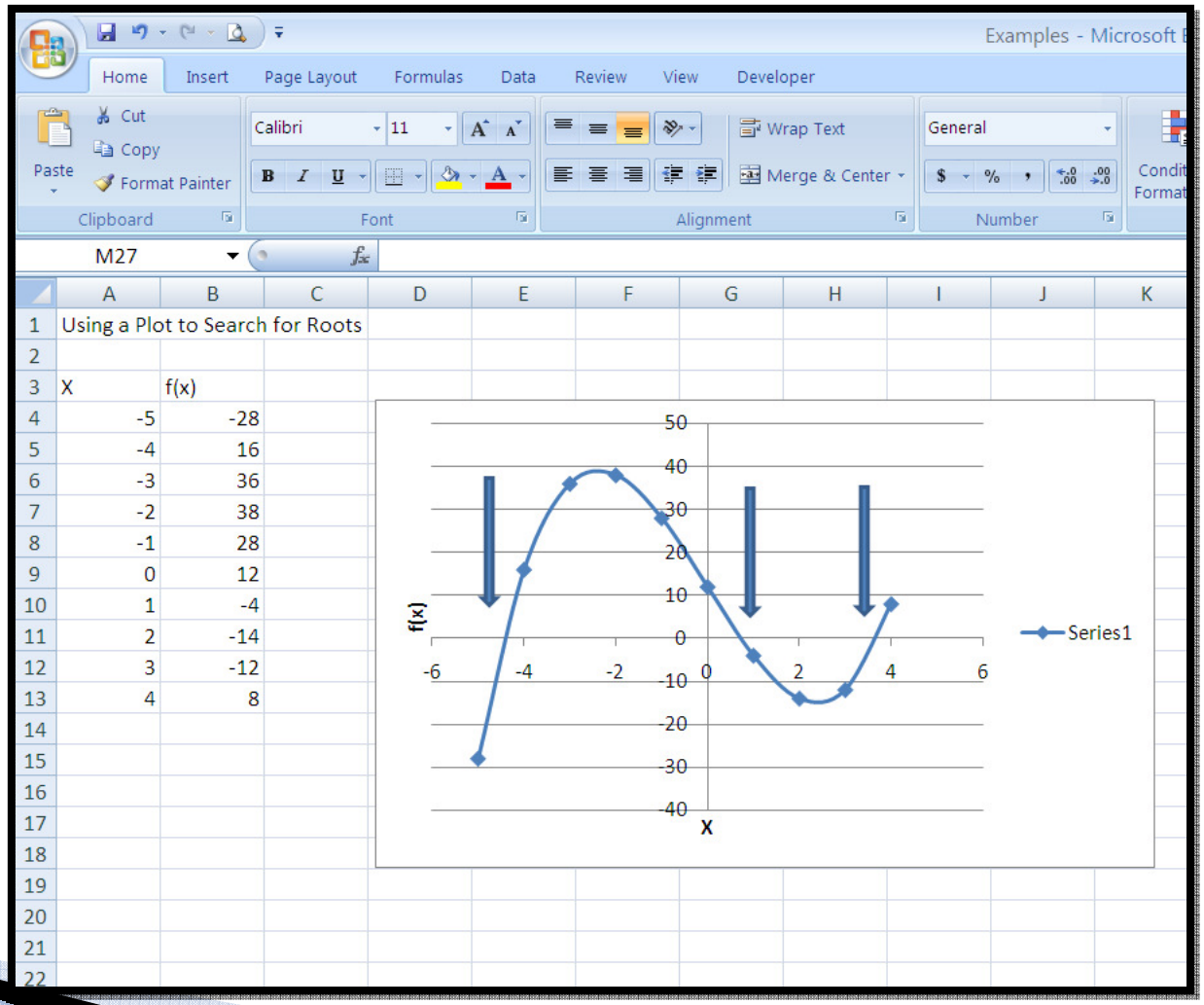
Using a Plot to Search for Roots

Procedure:

- Set equation equal to zero.
- To search for roots, we will try various values of x and solve for f(x) (when a change of sign is found then is known a root is in between).
- Graph f(x) vs. x.

Number of roots must be equal to degree of equation.

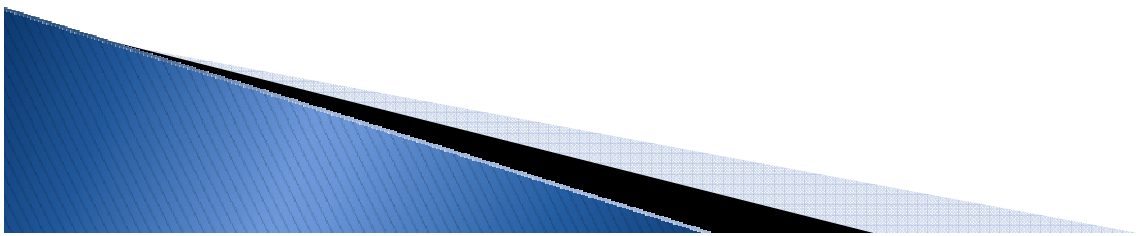
Using a Plot to Search for Roots (Cont.)



Guess and Check Iteration

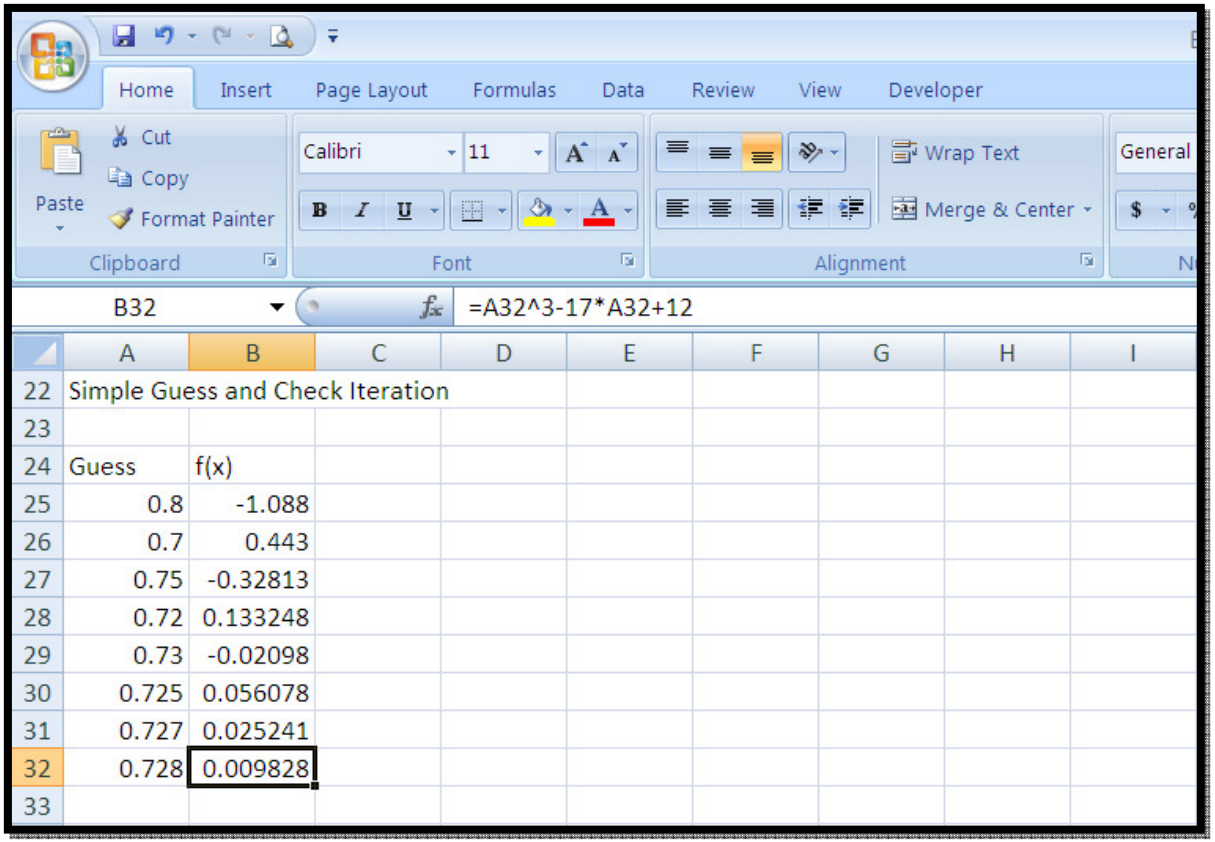
One of the easiest ways to find the root is simply to create a worksheet with a place to enter guess values (x) and a formula that evaluates f(x).

- F(x) can be inserted in form 1 or form 2.
- A tolerance value is used to judge whether the value is close enough to zero (form1) or to the guessed value (form 2).



Guess and Check Iteration (Cont.)

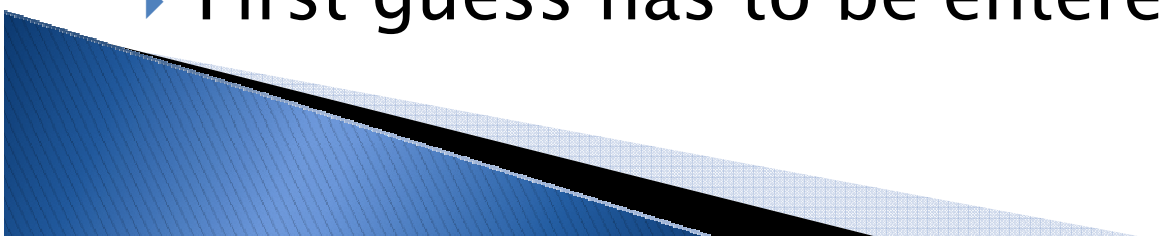
- Only one root can be found at a time.



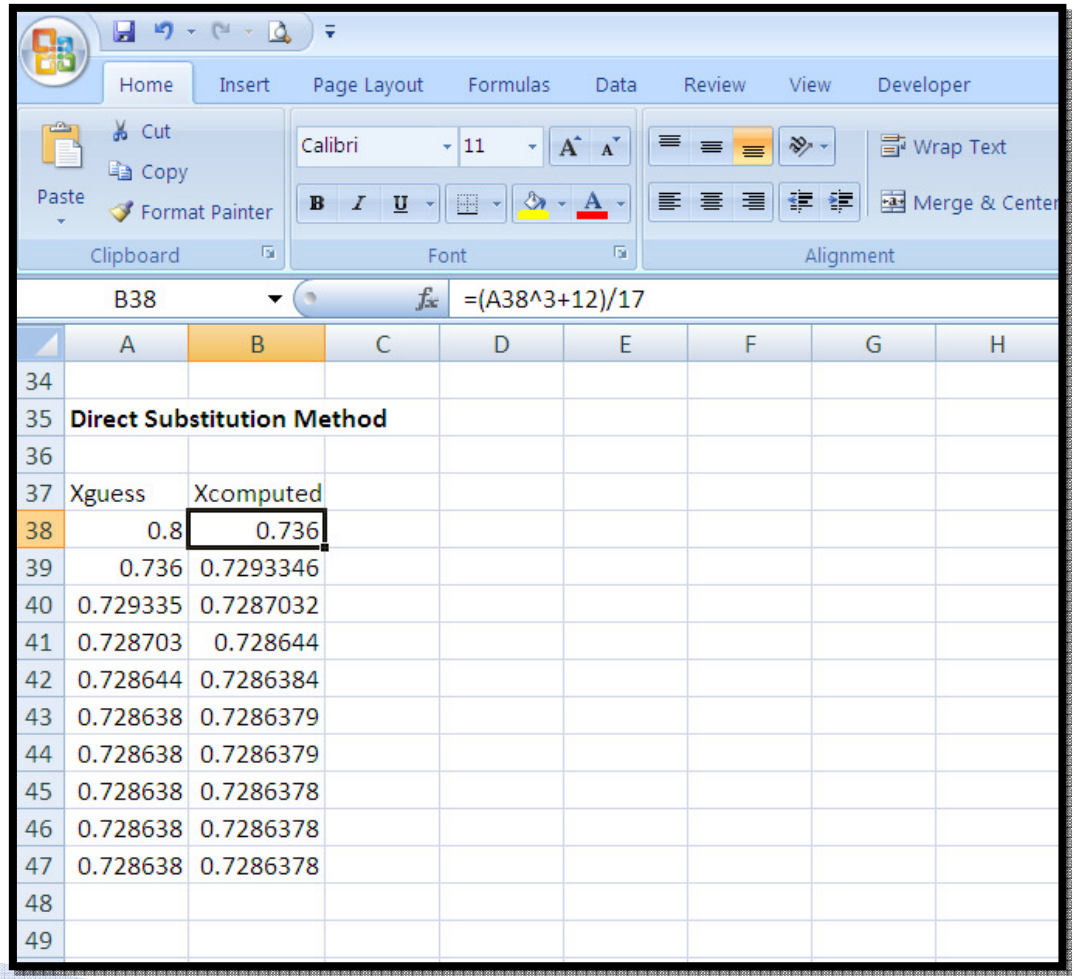
	A	B
22	Simple Guess and Check Iteration	
23		
24	Guess	f(x)
25	0.8	-1.088
26	0.7	0.443
27	0.75	-0.32813
28	0.72	0.133248
29	0.73	-0.02098
30	0.725	0.056078
31	0.727	0.025241
32	0.728	0.009828
33		

Direct Substitution Technique

- This method uses the previous computed value as the next guess value.
- The equation is entered using standard form 2.
- Simple method but some roots cannot be found using it.
- First guess has to be entered by hand.



Direct Substitution Technique (Cont.)



	A	B	C	D	E	F	G	H
34								
35	**Direct Substitution Method**							
36								
37	Xguess	Xcomputed						
38	0.8	0.736						
39	0.736	0.7293346						
40	0.729335	0.7287032						
41	0.728703	0.728644						
42	0.728644	0.7286384						
43	0.728638	0.7286379						
44	0.728638	0.7286379						
45	0.728638	0.7286378						
46	0.728638	0.7286378						
47	0.728638	0.7286378						
48								
49								

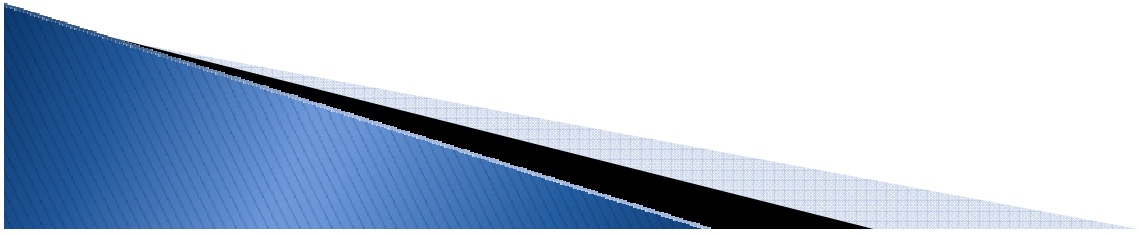
Using Goal Seek in Excel

This feature allows you to solve problems backwards: to find the input values needed to generate the answers you want.

Procedure:

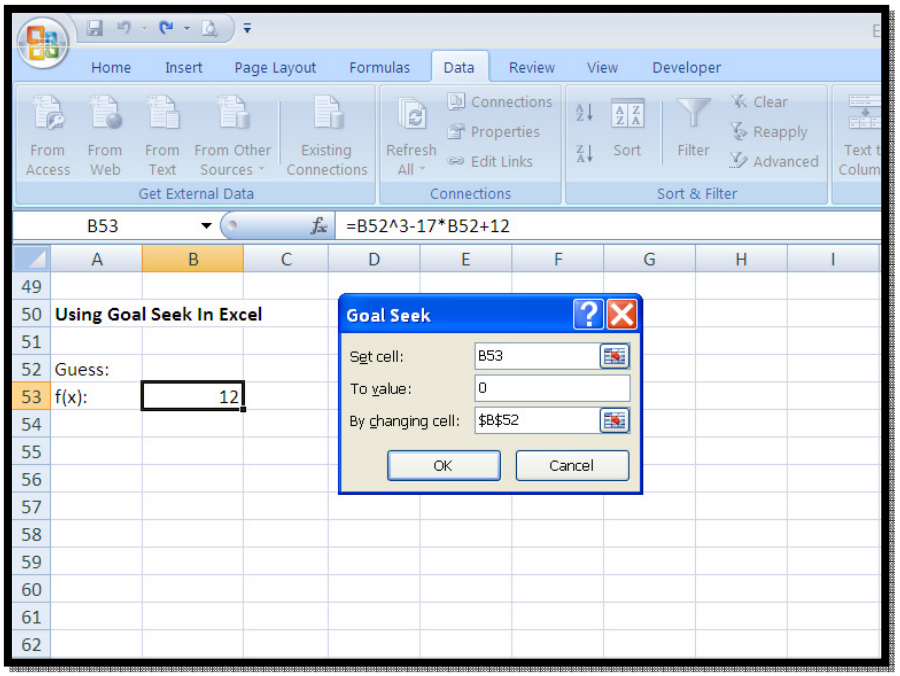
- Express equation using form 1
- Set a cell to hold the guess value
- Set a cell containing the formula (form 1)
- Open the Goal Seek dialog, use ribbon options:

  Data/Data Tools/What-if Analysis/Goal Seek

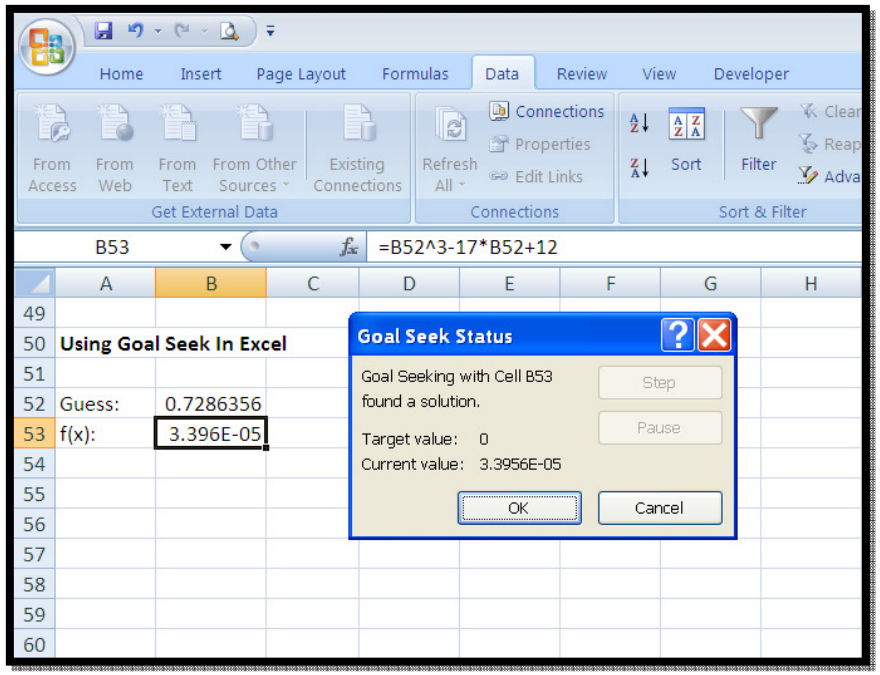


Using Goal Seek in Excel (Cont.)

- Set cell that contains the formula (B53) to zero.
- The cell that will be changed is the one set for the guess value.
- Click OK.



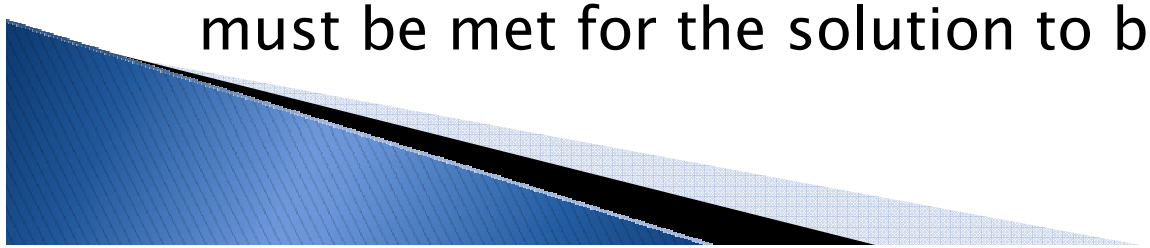
Using Goal Seek in Excel (Cont.)



- Clicking OK causes Excel to change the cell values until a solution is met.
- Goal Seek leaves the root in the guess cell.
- In other to find the other roots, the initial guess must be changed.

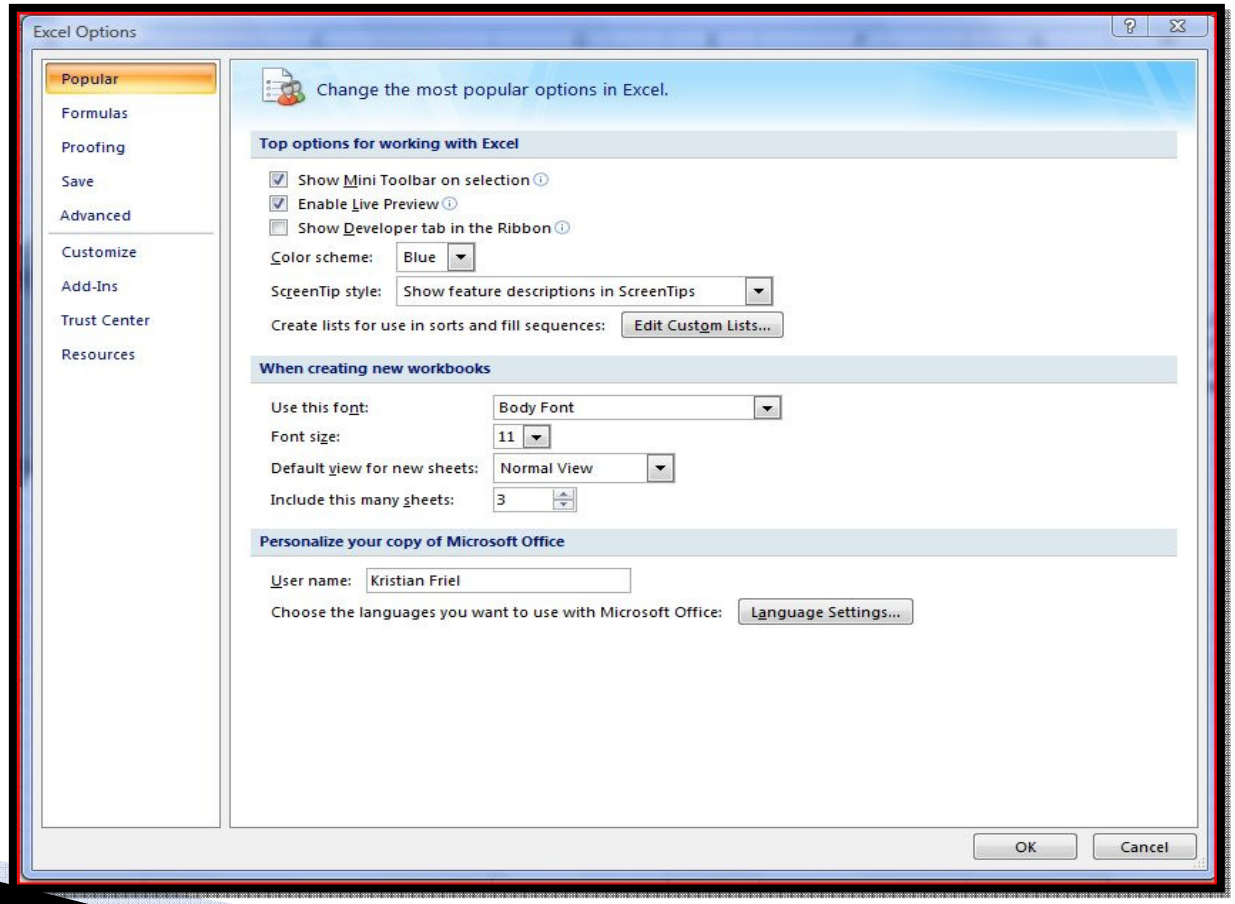
Introduction to Excel's Solver

- The **Goal Seek** command is handy for problems that involve an exact target value that depends on a single unknown value.
- For problems that are more complex, you should use the Solver add-in.
- The Solver can handle problems that involve many variable cells and can help you find combinations of variables that maximize or minimize a target cell.
- It also specifies one or more constraints conditions that must be met for the solution to be valid.



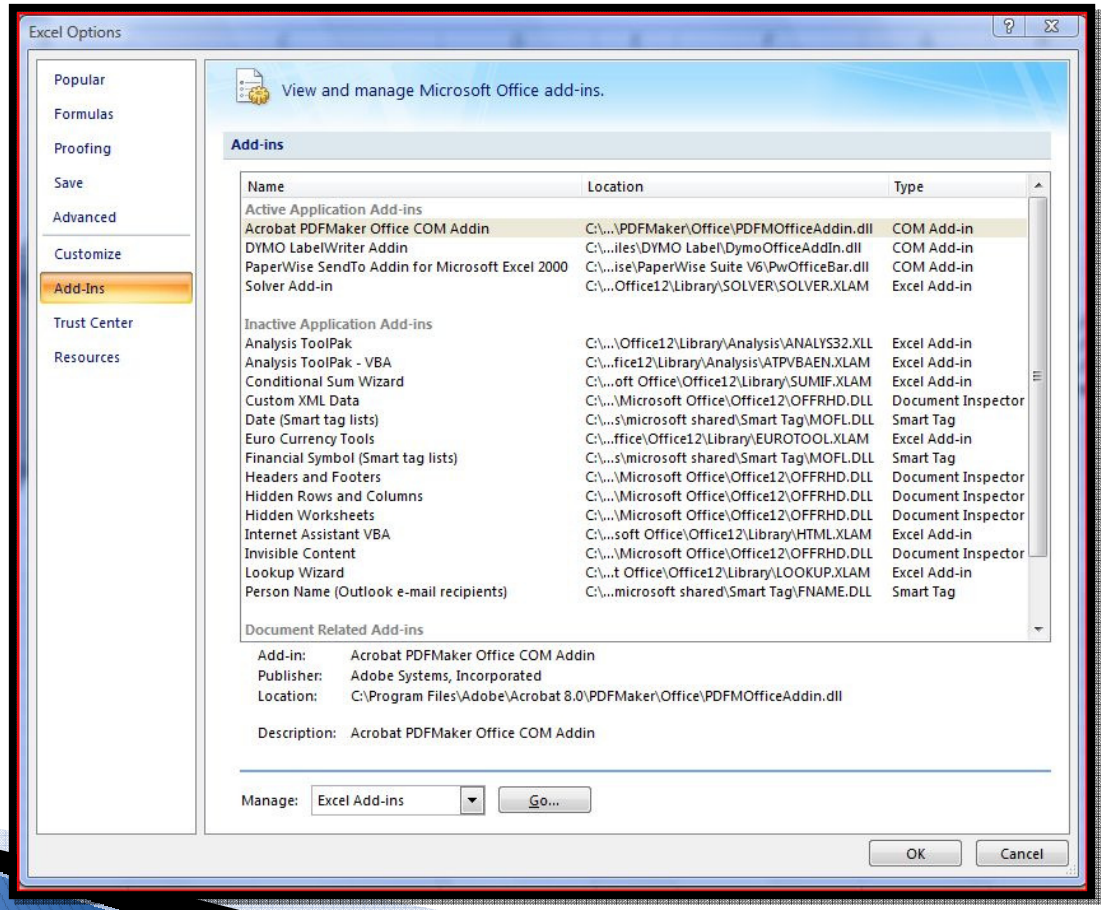
Activating Solver

To use solver in Office 2007, Click the **Office** button, then click the **Excel Options** button at the bottom – You'll see a screen like this:



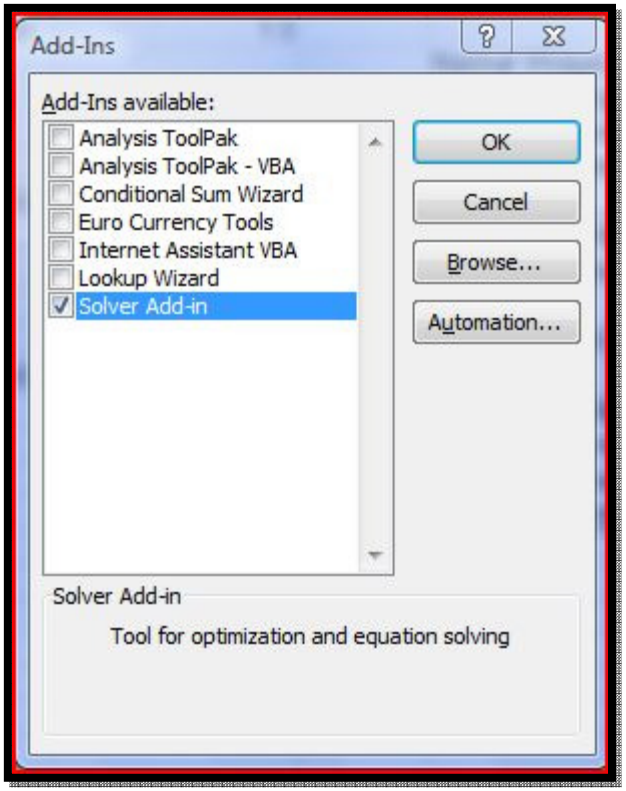
Activating Solver (Cont.)

- Click **Add-Ins**, In the Manage box, choose **Excel Add-ins**, select **Solver Add-in**, Click **Go…**



Activating Solver (Cont.)

- Check the **Solver Add-in** box, and click **OK**.

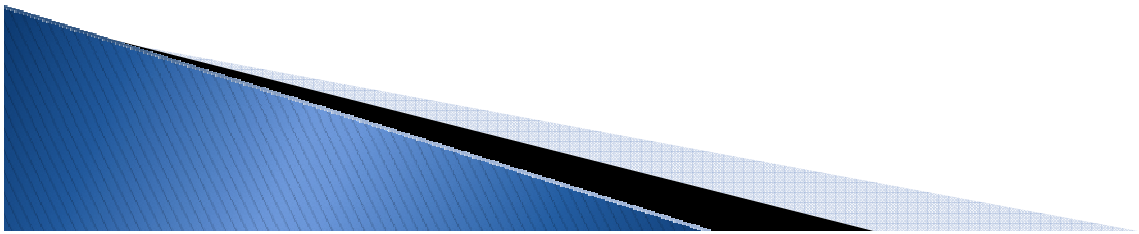


Solver Components

- Solver has three core components:

  ✓Target cell (objective function).
  ✓Changing cell (design variables).
  ✓Constraints.

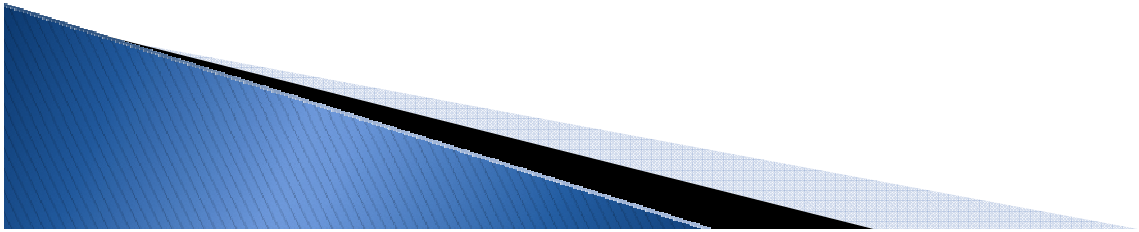
  The target cell represents the objective or goal that we want to achieve.



Solver Components (Cont.)

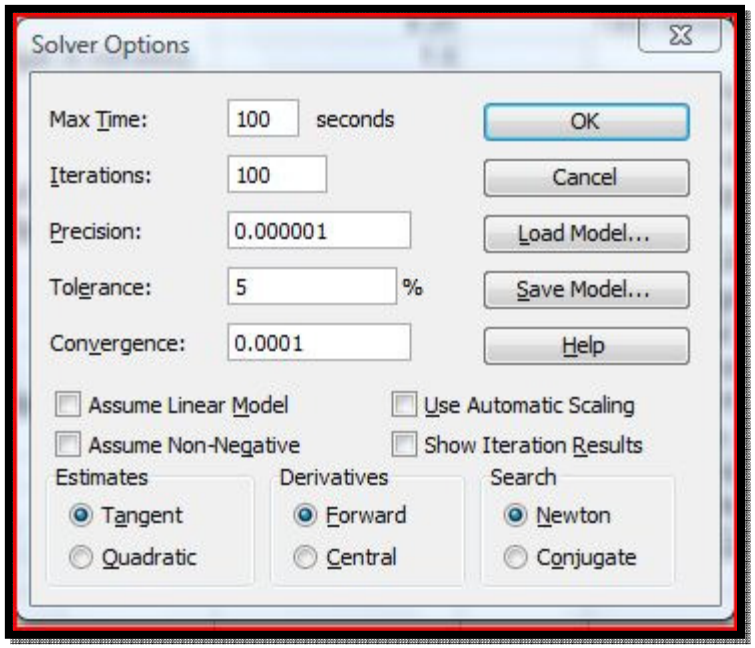
- The changing cell represent the range of variables from which the solver selects the specific number(s) that satisfies the optimization.

- The constraints are restrictions that we impose when constructing the function to be solved.



What options can we choose?

- Solver has several options you can play with to optimize your results:



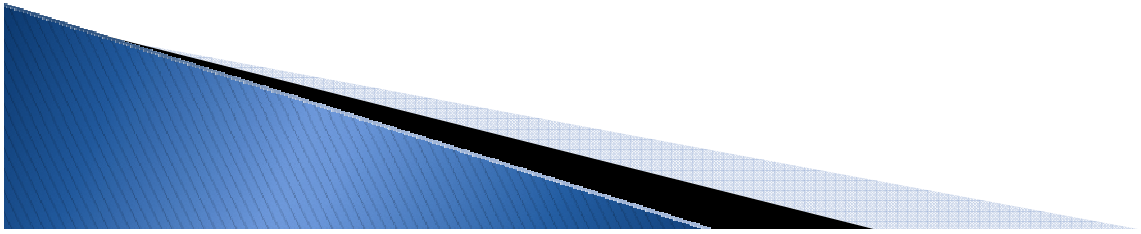
Finding Roots With Solver

- Solver requires that the equation be written in a variation of standard form 1.

Procedure:

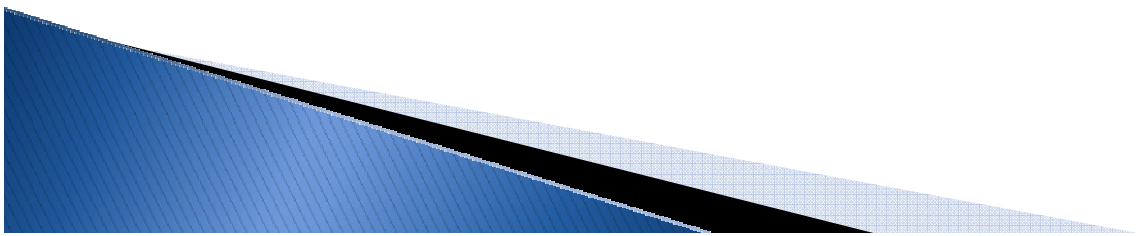
- Express equation using form 1.
- Set a cell to hold the guess value.
- Set a cell containing the formula (form 1).
- Start the Solver using menu options:

  Data/Analysis/[Solver]
- The solver parameter dialog will be displayed.

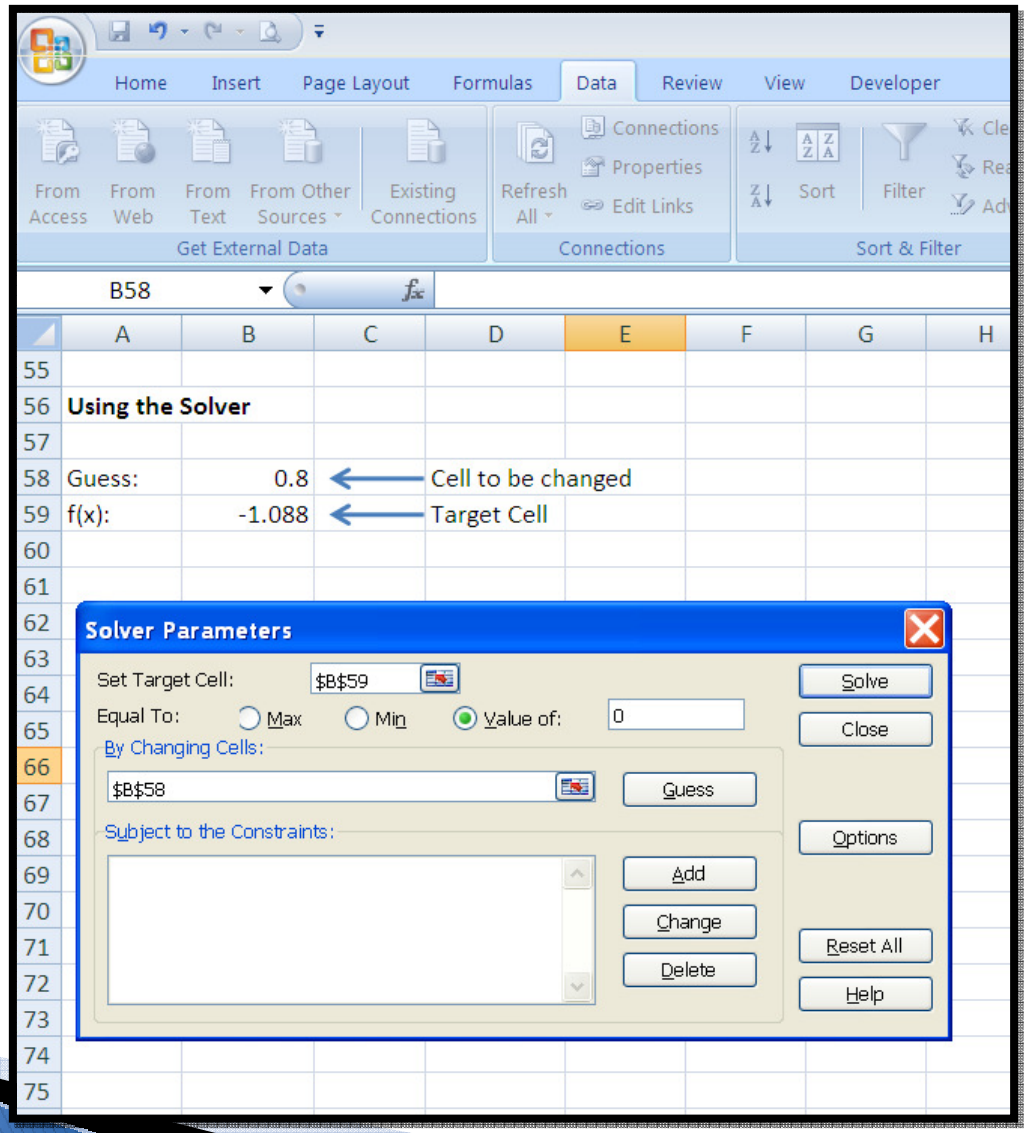


Finding Roots with Solver (Cont.)

- The target cell is the cell containing the formula.
- Set target cell equal to Zero. By doing this Excel will continue guessing until the formula is equal to zero.
- Set the value of the field “By Changing Cell” equal to the cell that holds the guess value.

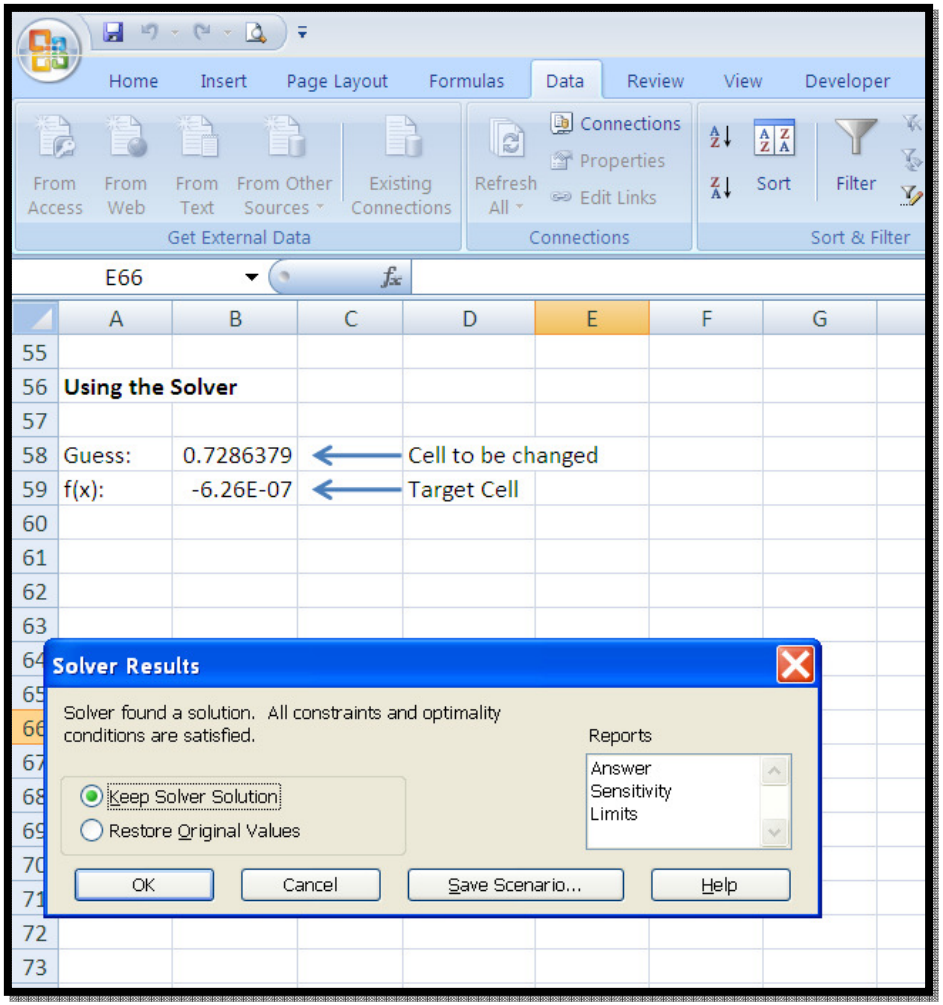


Finding Roots with Solver (Cont.)



Finding Roots with Solver (Cont.)

- Once the required information has been set, click on the solve button to iterate for a solution.
- Here the Solver Results Dialog indicates that a solution was found.
- To search for other roots, set a new guess value and run the Solver again.

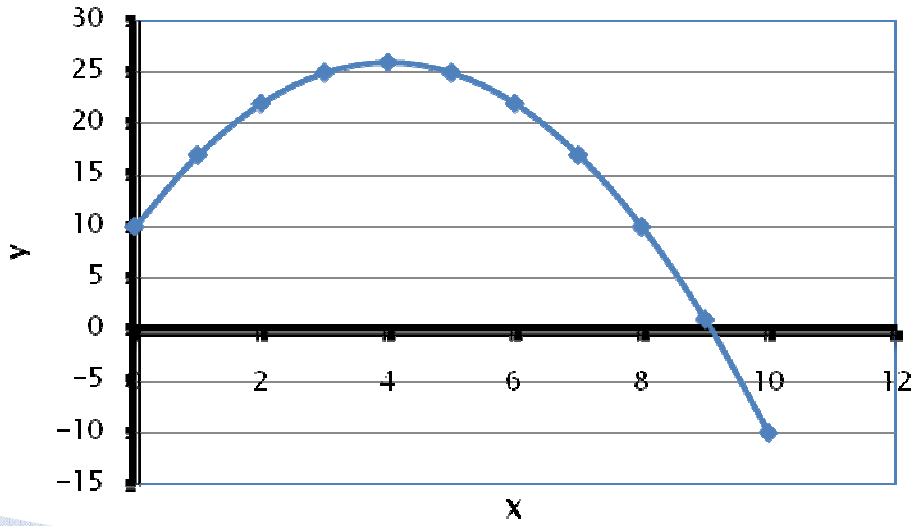


Optimization Using Solver (Cont.)

- The Solver can also be used for optimization problems. As a simple example, consider:

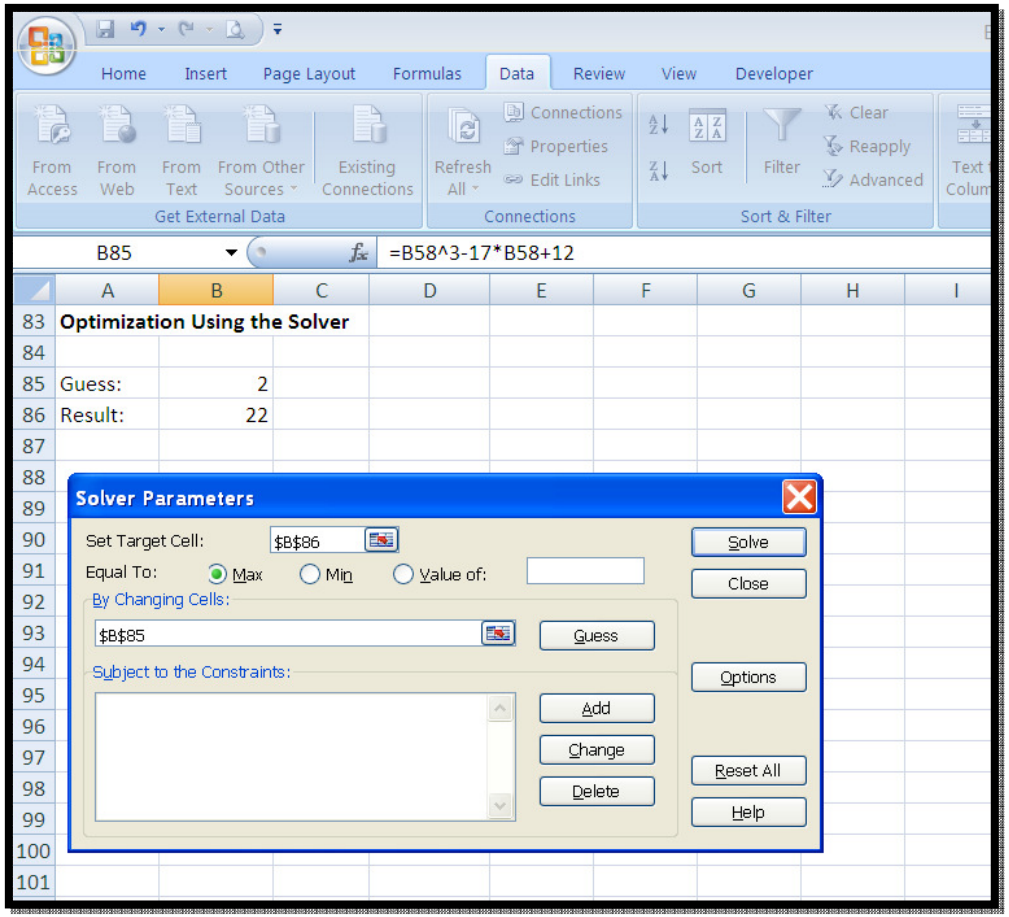
$$y = 10 + 8x - x^2$$

This equation has a maximum value of 26 at x=4



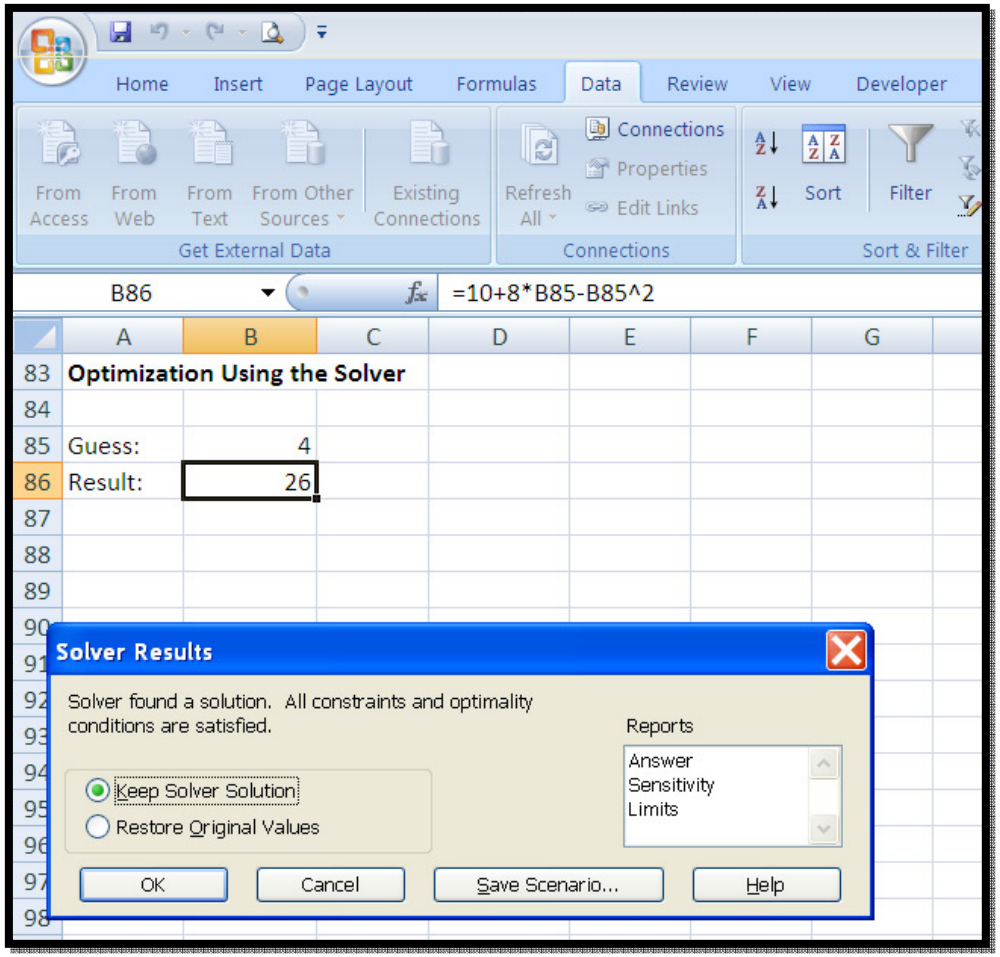
Optimization Using Solver (Cont.)

- Set the target cell as the cell containing the formula.
- Set the target cell equal to “Max”.
- Set changing cell as the cell that holds the guess value.
- Click solve.



Optimization Using Solver (Cont.)

- Here the Solver Results Dialog indicates that a solution was found.

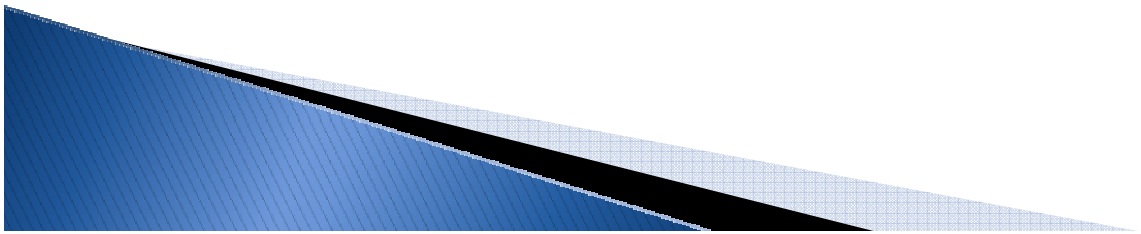


Optimization Using Solver (Cont.)

Adding Constrains:

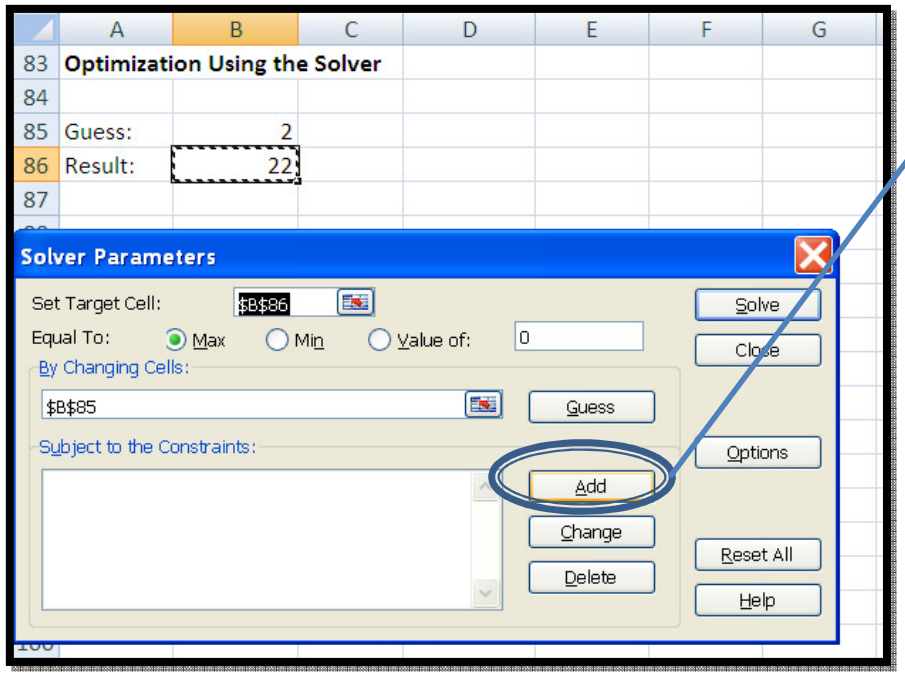
- If you want to find the maximum value of y for $x \leq 3$, a constrain must be added.

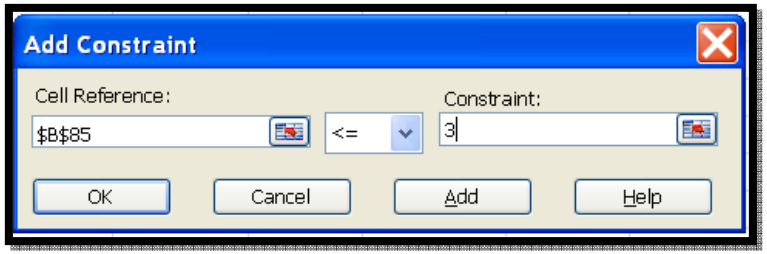
- To include a constrain:
  - Click the Add Button at the right of the constrains box.
  - Add constrain.

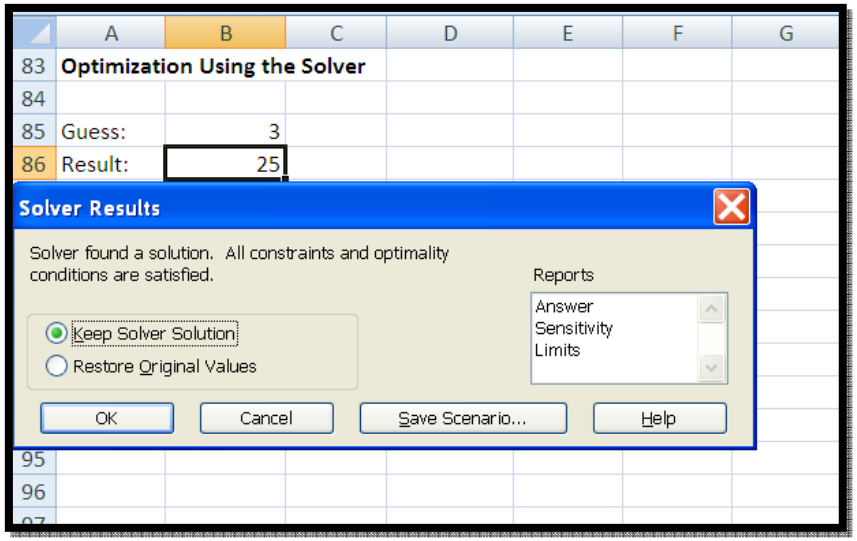


Optimization Using Solver (Cont.)

Adding Constrains:





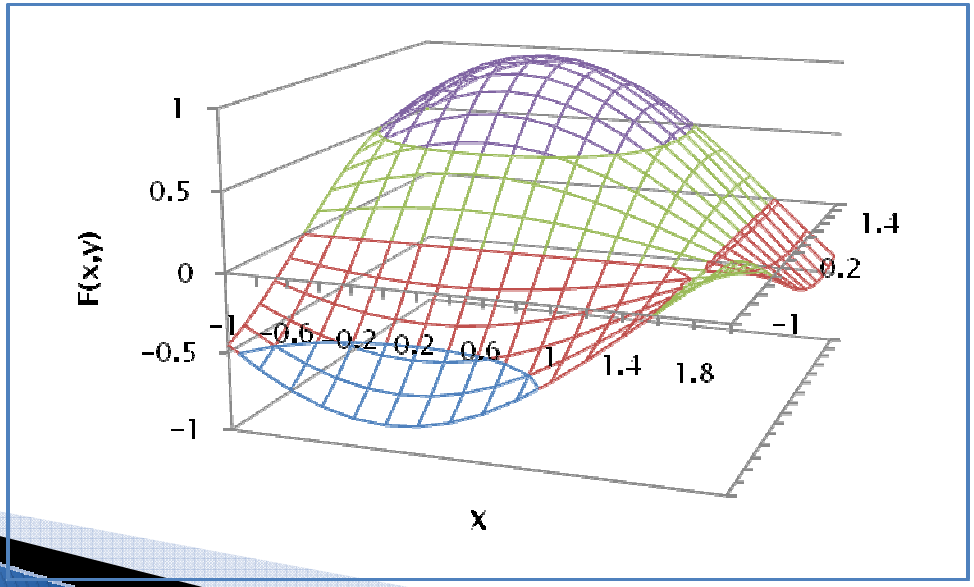


Optimization Using Solver (Cont.)

Solving for Multiple Values:

The function: $f(x, y) = \sin(x).\cos(y)$

Has a maximum at x=1.5708 and y=0 in the region (–1≤x ≤2, –1 ≤y ≤2).

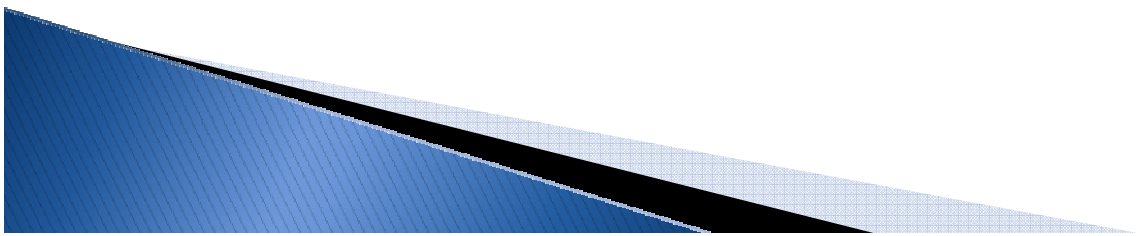


Optimization Using Solver (Cont.)

Solving for Multiple Values:

- The solver will change multiple cells to try to find the requested result.

- Procedure:
  - Enter guesses for x and y, and the equation to be solved.
  - Enter constrains.
  - Click Solve.



Optimization Using Solver (Cont.)

Solving for Multiple Values: