

## MODELING WITH EXCEL, AND MORE

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All problems in this workshop are taken from *FINITE MATHEMATICS for Business, Economics, Life Sciences, and Social Sciences*, Tenth Edition, by Raymond A. Barnett, Michael R. Ziegler, and Karl E. Byleen, Prentice Hall, 2005. In this session, we will look at

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### Find Minimum Average Cost

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Financial analysts in a company that manufactures audio CD players arrived at the following daily cost equation for manufacturing  $x$  CD players per day:

$$C(x) = x^2 + 2x + 2000$$

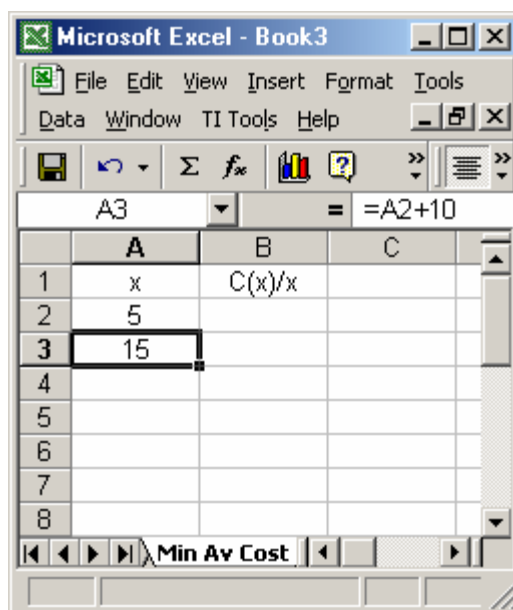
The average cost per unit at a production level of  $x$  players per day is  $\overline{C(x)} = \frac{C(x)}{x}$

- (A) Find the rational function  $\overline{C}$ .
- (B) Use EXCEL to graph  $\overline{C}$  for  $5 \leq x \leq 150$ .
- (C) For what daily production level (to the nearest integer) is the average cost per unit at a minimum, and what is the minimum average cost per player (to the nearest cent)?

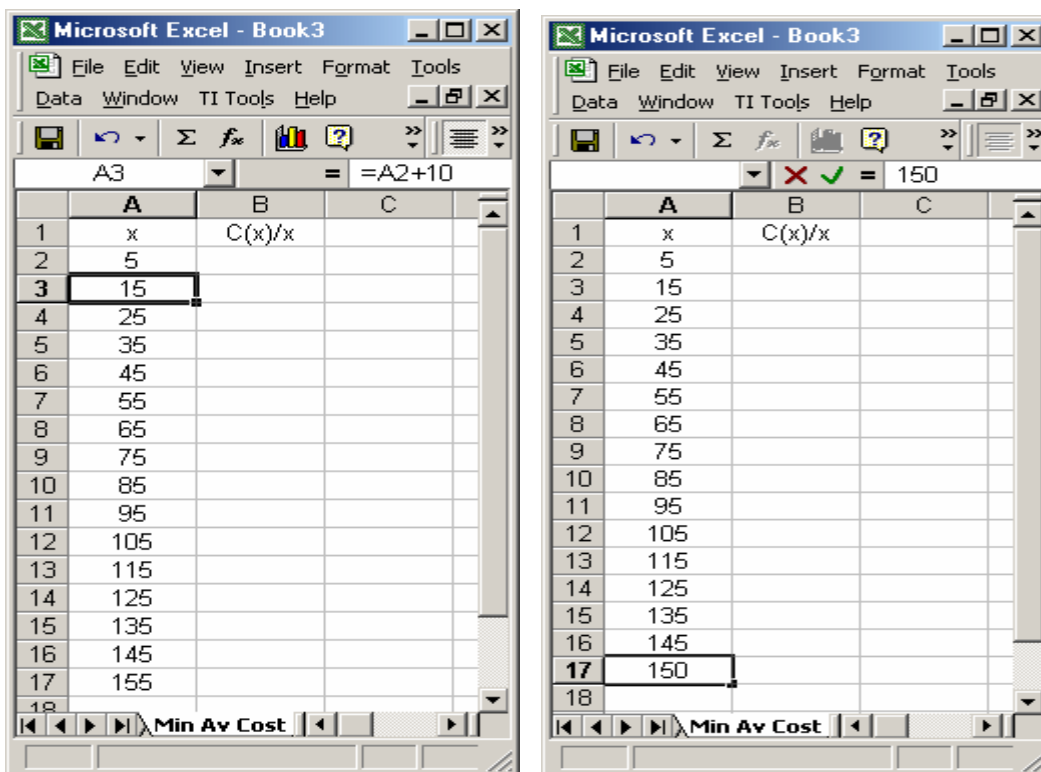
[Hint: Refer to the graph in part (B) and evaluate  $\overline{C(x)} = \frac{C(x)}{x}$  at appropriate integer values until a minimum value is found. (Problem # 60 p. 93 parts A, B, and C)

Create a Data Set to Graph the Function  $\overline{C(x)} = \frac{x^2 + 2x + 2000}{x}$

- Open a new worksheet in EXCEL.
- Label two columns as  $x$  and  $C(x)/x$ , using cells A1 and B1.
- Let's format columns A and B so that the values in the cells are centered. To do this, go to the column A title, hold the left mouse button down and scroll thru column B. This highlights all of columns A and B.
- On the toolbar, select Center. Now all entries will be centered in the column.
- To create the data set quickly, choose a regular increase in the value of  $x$ . We'll use 10.
- In cell A2 enter the first value, 5.
- In cell A3 type the formula  $=A2+10$ . To do this by referencing the A2cell, type the = sign in A3, then left click on the A2 cell. Finally type +10. This is a relative reference, so subsequent values of  $x$  change according to this formula. Note that the formula used appears in the formula bar on the last line of the toolbar.
- Press ENTER.

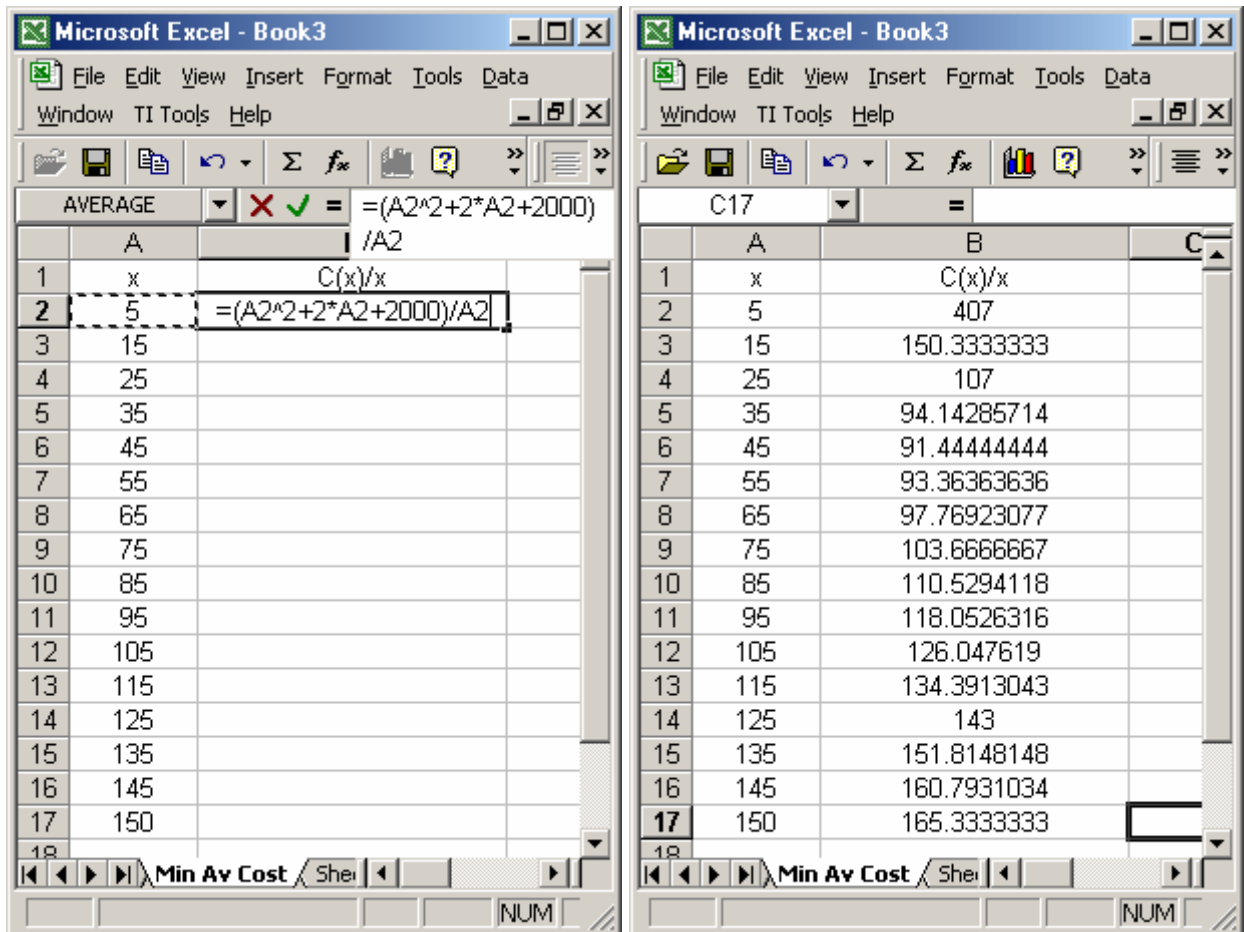


- Click back in cell A3. Now use the lower right handle of the A3 cell to drag the formula through cell A17 where  $x = 155$  to cover the domain of the function. Note that the value in A17 is 155, which is outside the domain of the function.
- Click on A17, and change the value to 150 to include the given endpoint of the domain interval  $5 \leq x \leq 150$ .



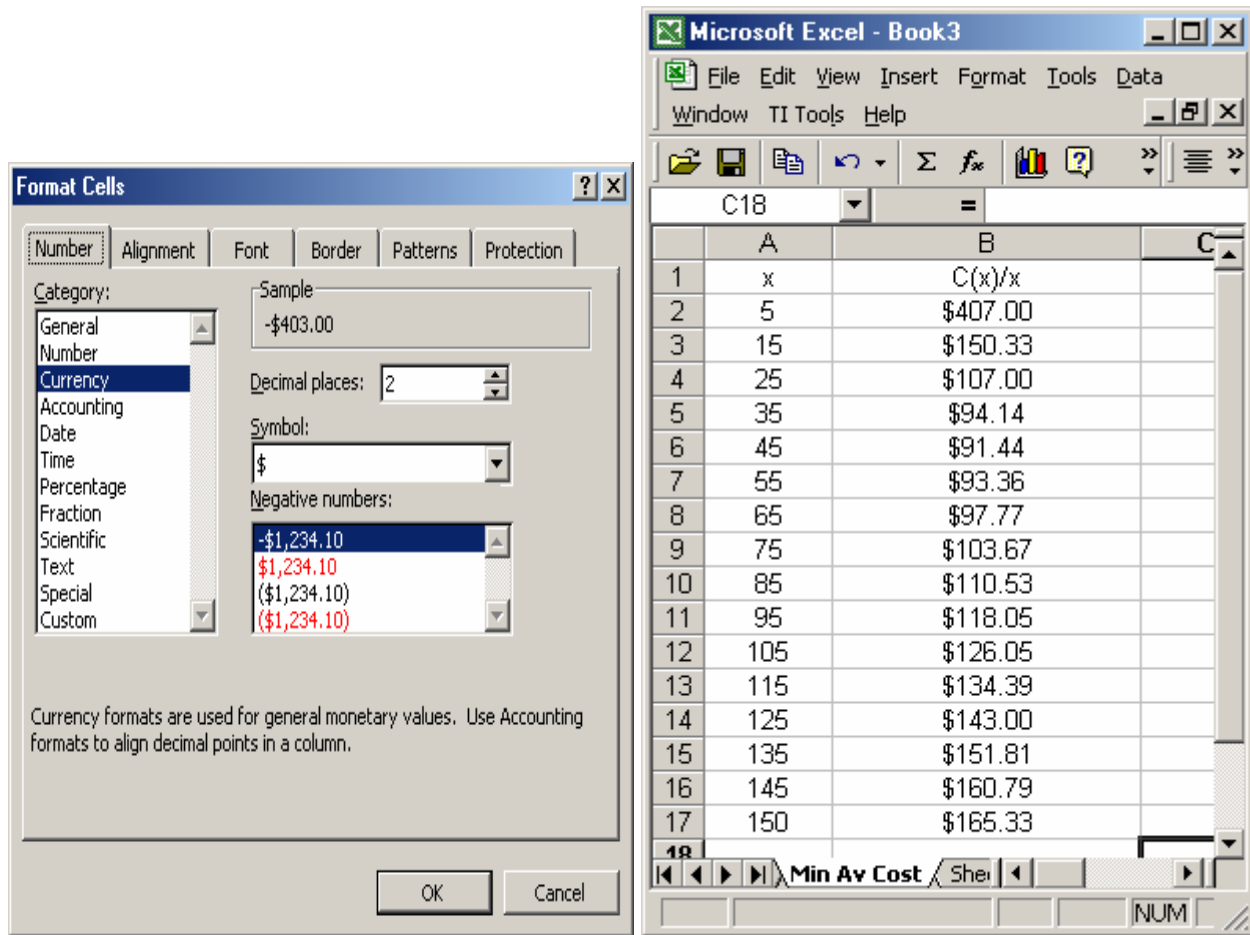
Enter the formula  $\overline{C(x)} = \frac{x^2 + 2x + 2000}{x}$

- Before you enter the formula into cell B2, widen the column. To do this, place the cursor on the far right edge of the name of the column. Hold the left mouse button down and drag it to the right about 2 inches so that the entire formula is shown in cell B2.
- Enter the right side of the formula for  $C(x)/x$  in cell B2. Click in cell B2. Enter  $=(A2^2+2*A2+2000)/A2$ . Again, reference cell A2 by clicking in it. Note that the formula must begin with the equal sign. Exponents are entered with the caret ^ key. Multiplication must always use the asterisk \*. EXCEL does not understand implied multiplication such as  $2x$  or  $2(x)$ .
- Press ENTER. You will see the value 407 in cell B2. You are now in cell B3.
- Click back in cell B2. Note that the formula is shown in the formula bar on the toolbar.
- Grab the right handle in cell B2 and drag the formula through cell B17. Note that when you are in a cell such as B17, the formula is shown in the toolbar with the correct references for the variable.



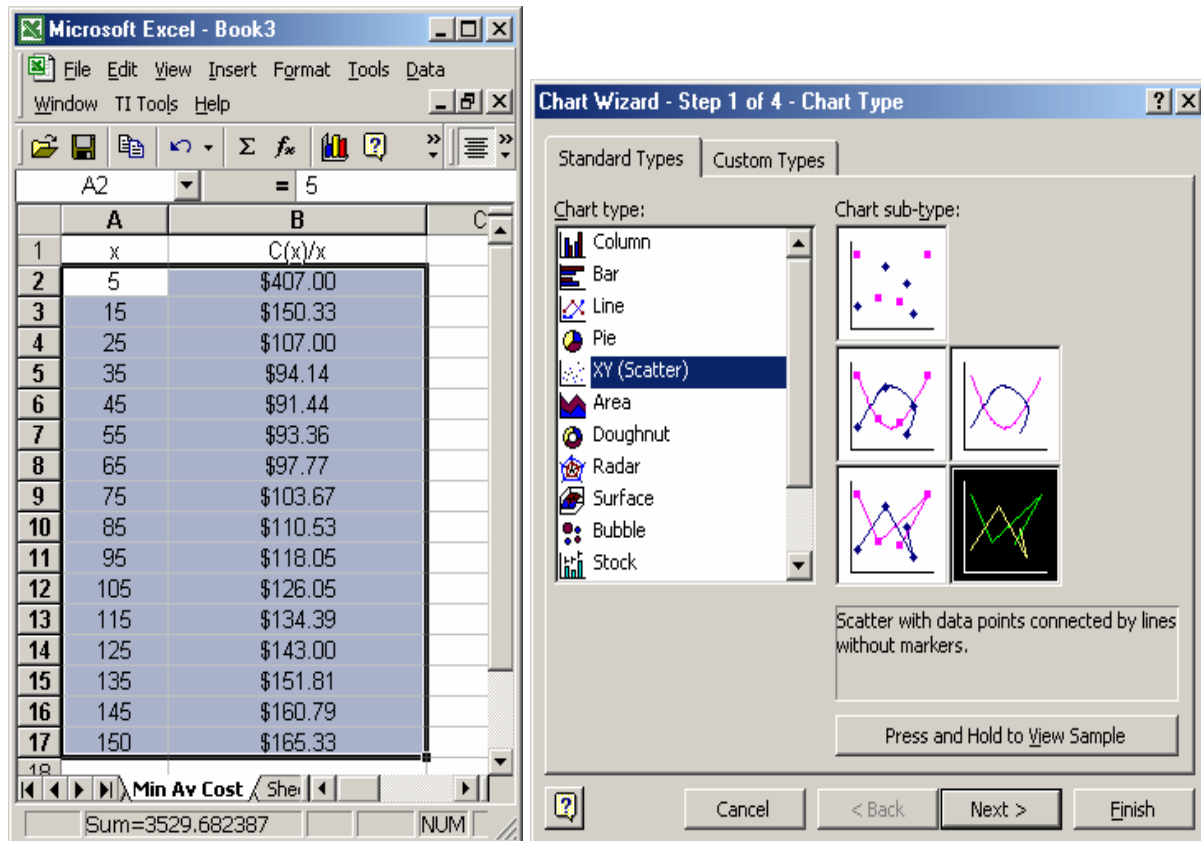
**Format the results of  $C(x)/x$  to show only 2 decimal places**

- First highlight the values that you wish to format. Let's format cells B2 thru B17. To highlight these cells, click in cell B2, hold the left mouse button down, and drag thru B17. The highlighted values will be shown in blue.
- Go to Format on the toolbar, click on Format, and click on Cells to select Format Cells.
- In the Category box on the left you may select Number or Currency. Let's select Currency for column B.
- Click OK.
- The values are now shown as currency to two decimal places.



Create a Scatter plot to Graph the Equation  $\overline{C(x)} = \frac{x^2 + 2x + 2000}{x}$

- To graph the function, first select the data set. To do this, left click on cell A2 and hold the left mouse button down until you highlight the entire table that contains the data.
- Select **Chart Wizard** on the menu bar. The chart wizard looks like a bar graph and is colored.
- Select XY Scatter.
- Select Scatter data points connected by lines without markers. This is the last selection of scatter plot in the bottom right corner. You could also use Scatter data points connected by smoothed lines without markers.



	A	B
1	x	C(x)/x
2	5	\$407.00
3	15	\$150.33
4	25	\$107.00
5	35	\$94.14
6	45	\$91.44
7	55	\$93.36
8	65	\$97.77
9	75	\$103.67
10	85	\$110.53
11	95	\$118.05
12	105	\$126.05
13	115	\$134.39
14	125	\$143.00
15	135	\$151.81
16	145	\$160.79
17	150	\$165.33

- Click on **NEXT**.
- Data range should be the range of cells you highlighted.
- Check to see that Series in Columns is selected. This means that your data is entered in columns rather than rows.

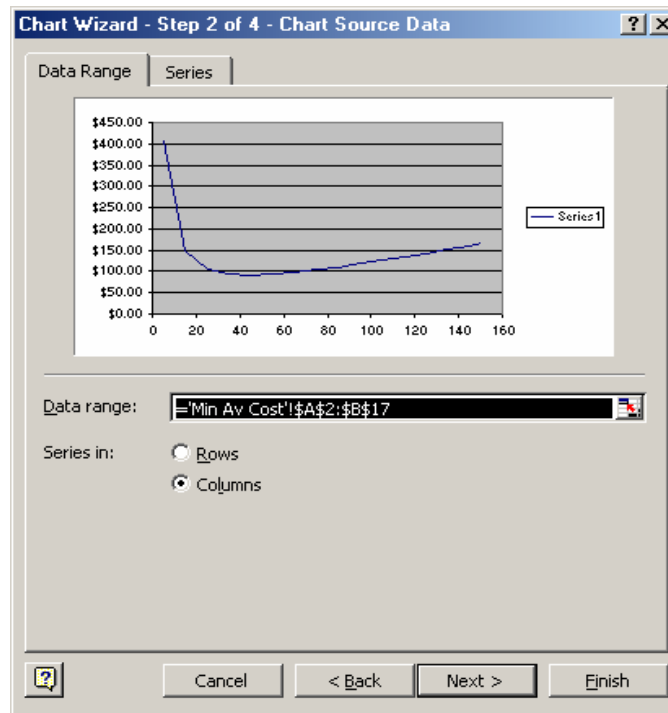
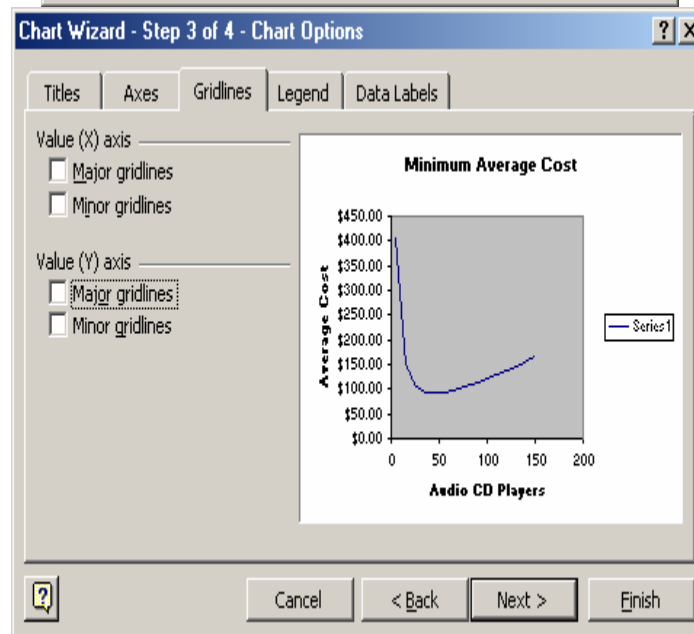
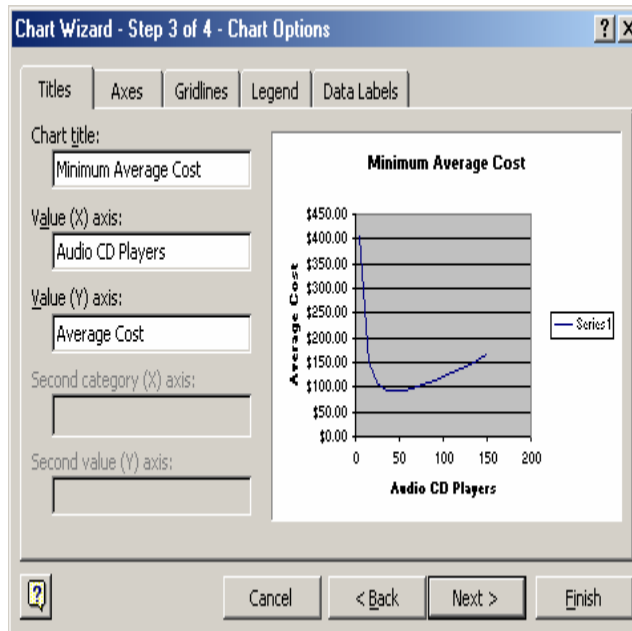


Chart Wizard - Step 2 of 4 - Chart Source Data

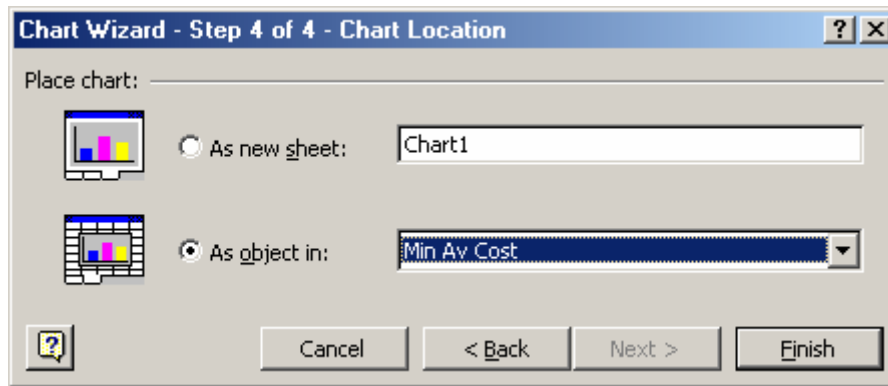
Data Range:

Series in:  Rows  Columns

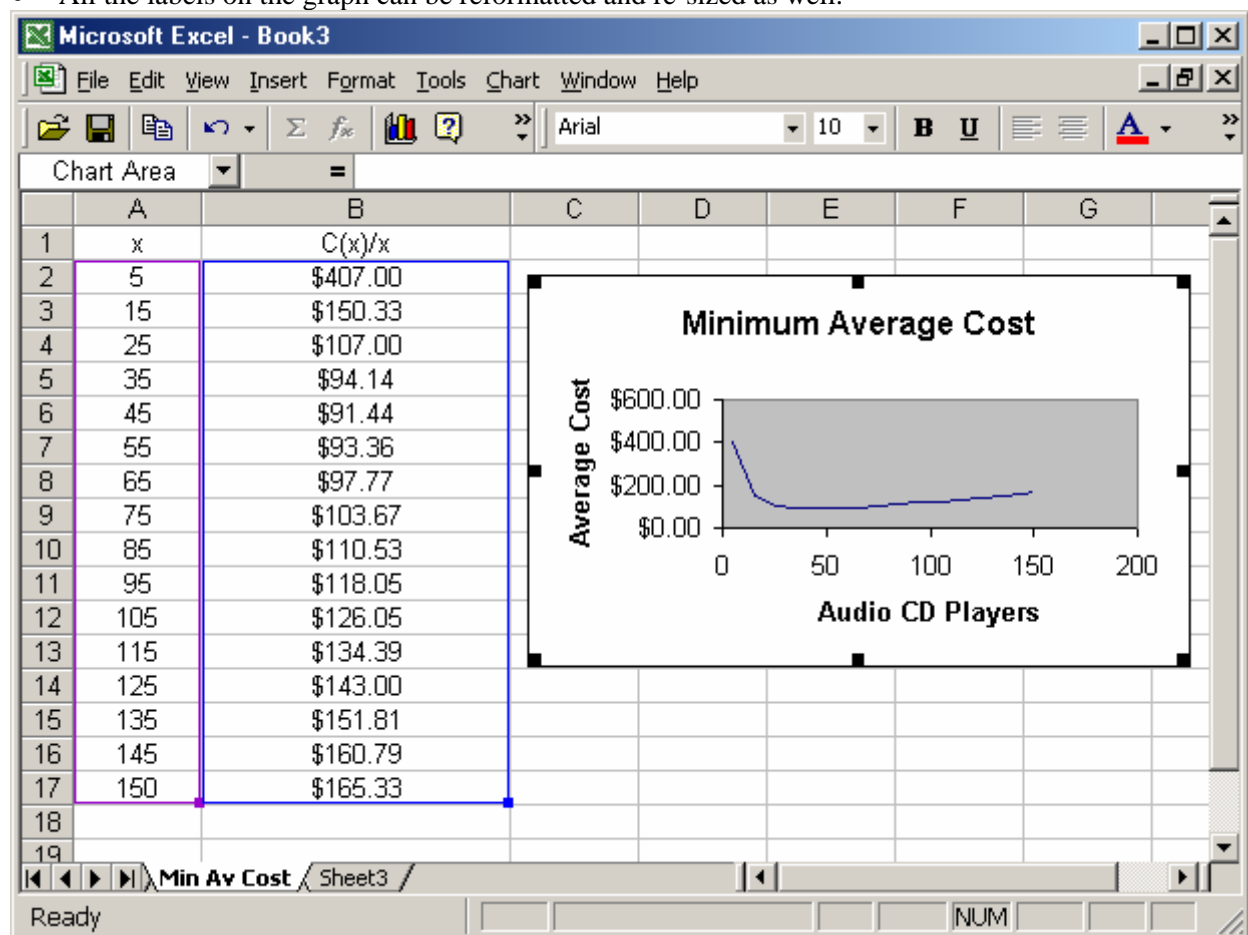
- Click on **NEXT**.
- Click on the **Titles** tab and fill in the titles for the chart and the x and y axes.
- In Chart Title field type **Minimum Average Cost**.  
 In Value (X) axis field type **Audio CD Players**.  
 in Value (Y) axis field type **Average Cost**.
- Click on the **Gridlines** tab and *uncheck* the **major gridlines** box.



- Click on **Legends** tab and *uncheck* the **Show Legend** box.
- Click on **NEXT**.
- Select **As object** in.
- Click on **FINISH**.

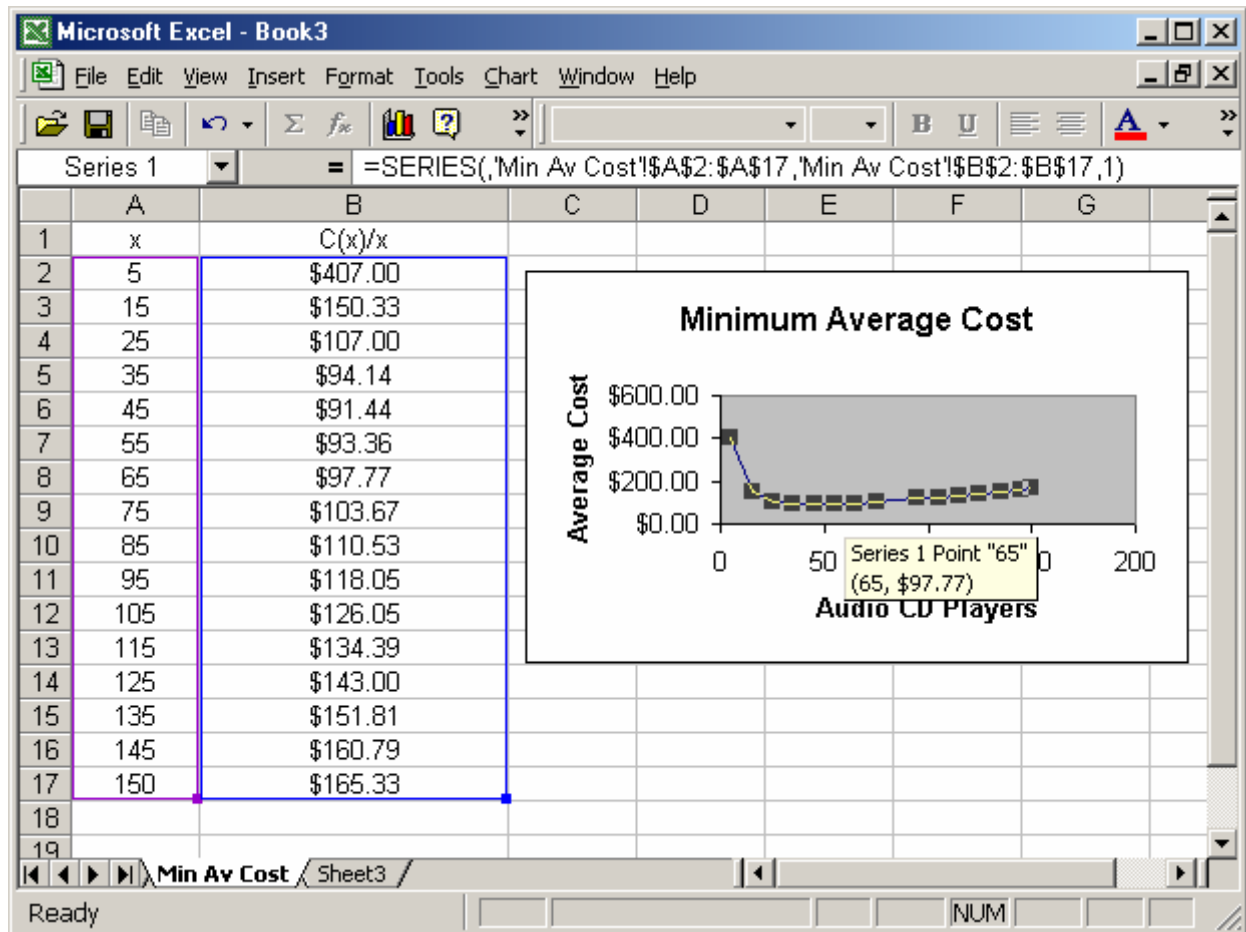


- The scatter plot will appear in EXCEL.
- You may right click on the chart to format the chart at any time.
- You may click on the graph and move it wherever you want on the screen.
- You can also change the dimensions of the box and the plot itself by clicking on it and using the eight tabs to re-size it.
- All the labels on the graph can be reformatted and re-sized as well.

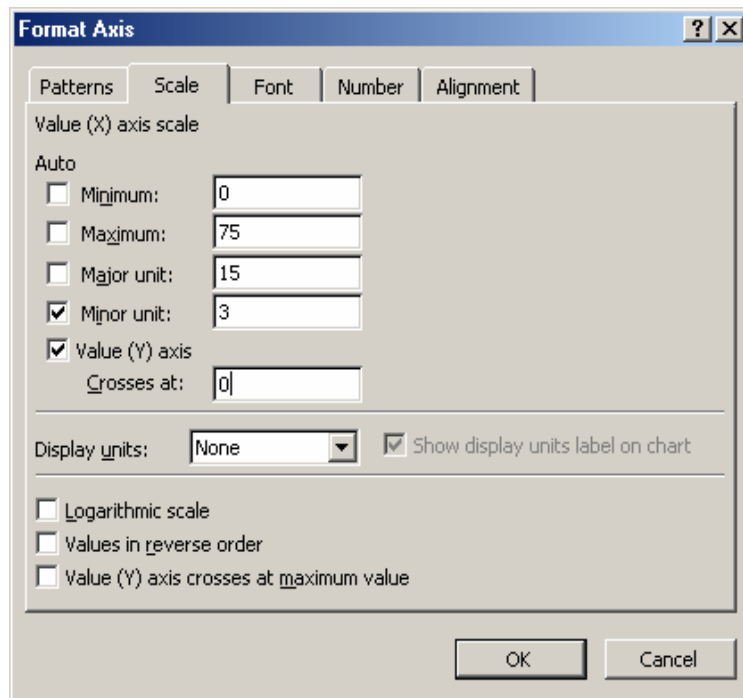


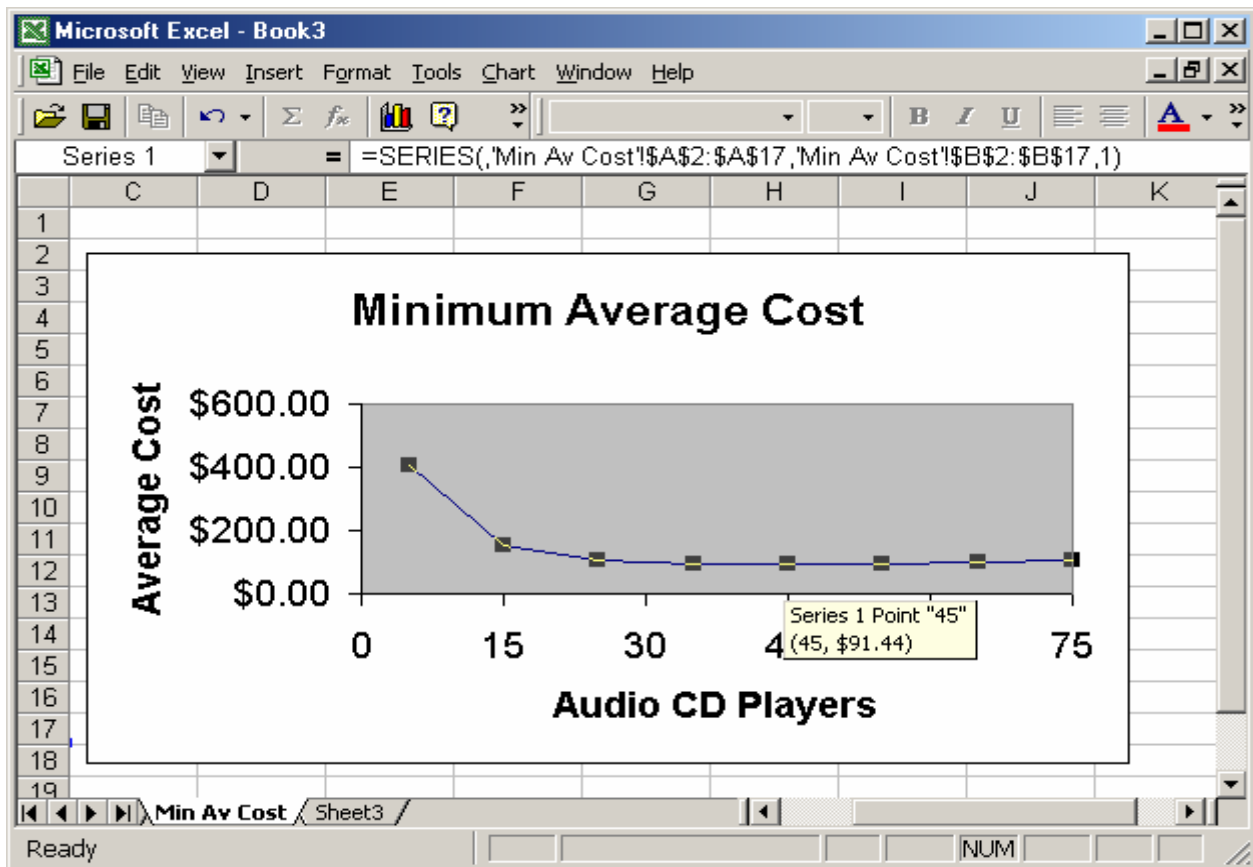
### Find the minimum of the function

- Click anywhere on the graph itself to see the data points.
- Move the cursor near any of the points to see its coordinates.



- From the data column, we can see that the minimum is somewhere between 35 and 55.
- The location of the minimum is not obvious from the graph as it is currently formatted.
- Let's re-format the x-axis values to  $x_{\min} = 0$ ,  $x_{\max} = 75$ ,  $xscl = 15$ .
- To do this, right click anywhere on the x-axis. Select **Format Axis**.
- Choose the **Scale** tab. The following box comes up. Make the changes as shown.
- Click OK. Repeat for the y-axis.
- To examine the graph in more detail, click on the curve to show the data points.
- Hold the cursor over a point until you see the y-value of the point.
- Note that the minimum occurs at the point (45, \$91.44).





## GOAL SEEK

GOAL SEEK, which is found in Tools, can be used to

- Find a value in an equation for a specific situation such as compound interest
- Find an intersection point of two functions by finding where the difference of the functions is 0.
- Find equilibrium price.
- Find the break-even point

### Use GOAL SEEK and Compound Interest to find number of periods

Use the compound interest formula and Goal Seek to find the number of periods it takes \$10,000 to grow to \$12,000 at 9% compounded monthly. (EXAMPLE 4 p. 145)

COMPOUND INTEREST  $A = P \cdot (1 + i)^n$ , where  $i = \frac{r}{m}$  and

$A$  = amount or future value at the end of  $n$  periods

$P$  = principal or present value

$r$  = annual rate of interest

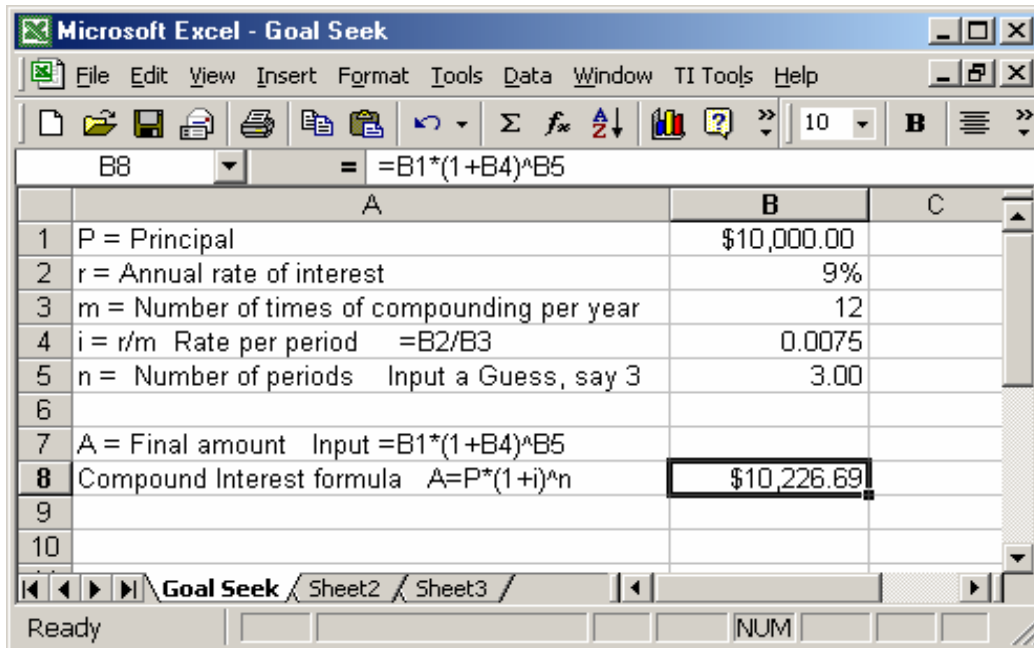
$m$  = number of compounding periods per year

$i = \frac{r}{m}$  rate per compounding period

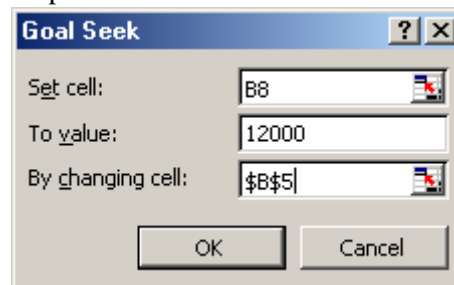
$n$  = number of periods

- Move to another sheet. To do this, click on Sheet 2.

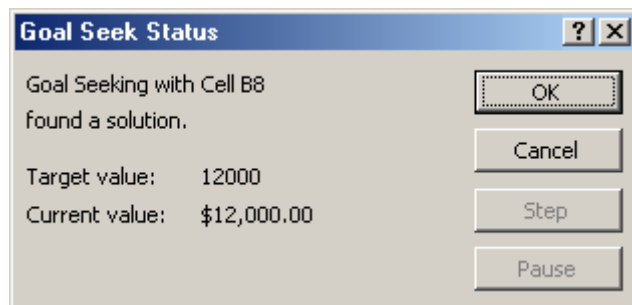
- You can name the sheet by double clicking on the tab and typing the name you want for the sheet.
- Enter the values as shown in B1 thru B5. Enter the Compound Interest formula found in A7 into cell B8.



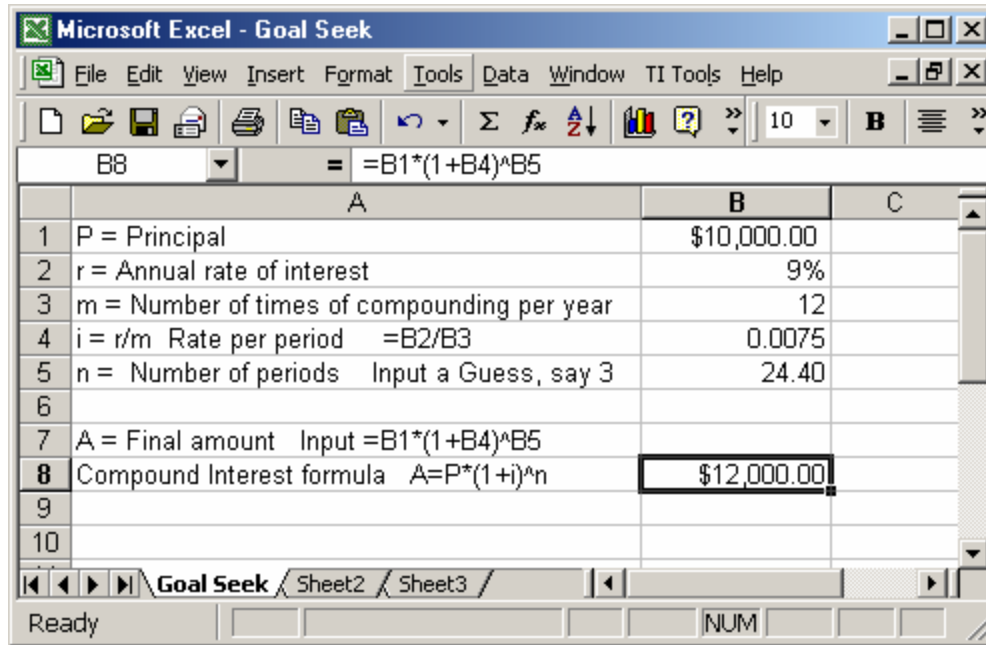
- Format cell B8 as currency, and cell B5 as number with 2 decimal places.
- Place the cursor back into B8, the cell that contains the Compound Interest formula.
- Go to **Tools** on the toolbar.
- Select **Goal Seek**. A dialog box appears.
- Fill in the dialog box as follows:
- **Set cell: B8** Note that you can just click in cell B8 if the cursor is not already at B8.
- **To value: 12000**
- **By changing cell: \$B\$5** Note that you can just click in cell B5 to put it here.



- Click **OK**.
- Another dialog box appears that tells you a solution has been found.
- Click **OK**.
- Cell B5 was changed to the value 24.40 and cell B8 contains \$12,000.



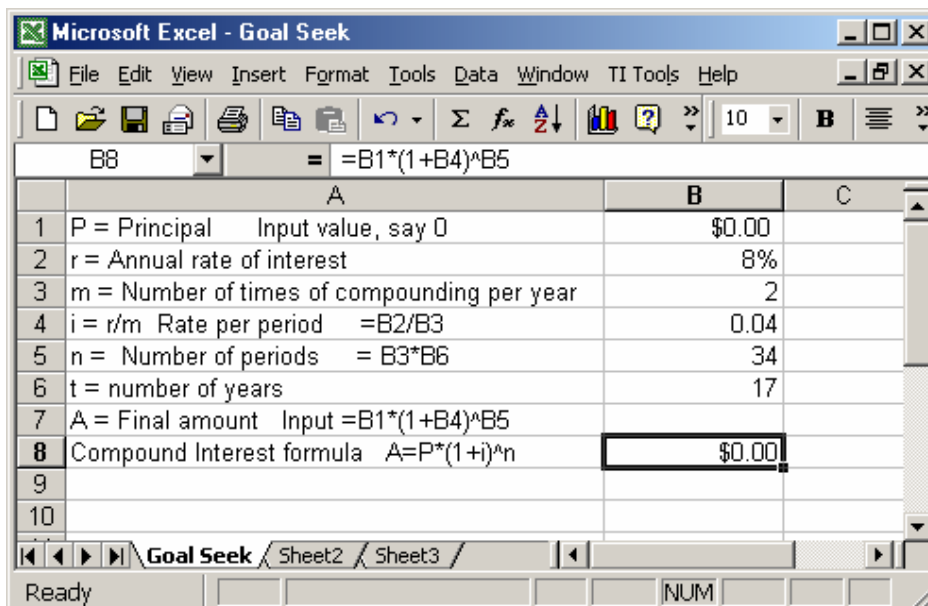
- Your solution is that the number of periods needed to have \$12,000 by investing \$10,000 at 9% compounded monthly is 25 months.
- Note that we must round 24.40 up to the next integer, otherwise we will earn slightly less than \$12,000.

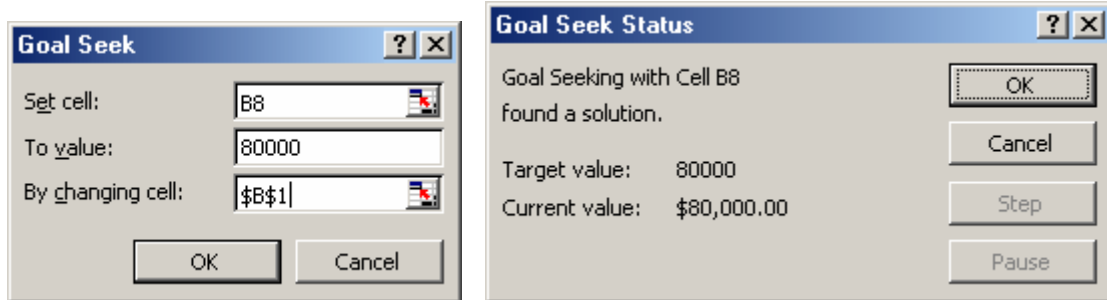


### GOAL SEEK AND PRESENT VALUE

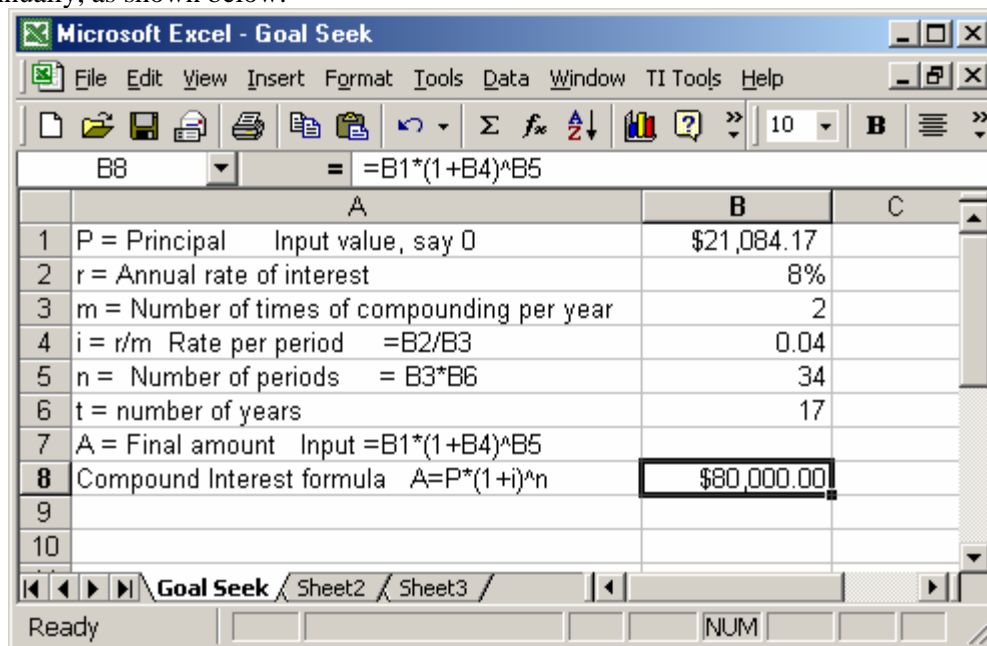
Use Goal Seek to find how much money new parents should invest now at 8% compounded semiannually to have \$80,000 toward their child's college education in 17 years? (Matched problem 2 p. 143)

- To do this, you must label another row in the compound interest list of variables for time t. (See line 6 below.)
- Input any value for the Principal. Let's use 0.
- In B5, since  $n = m * t$ , enter the formula =B3\*B6.
- With the cursor in cell B8, perform Goal Seek.





- So the new parents should invest \$21,084.17 for 17 years in an account earning 8% compounded semiannually, as shown below.



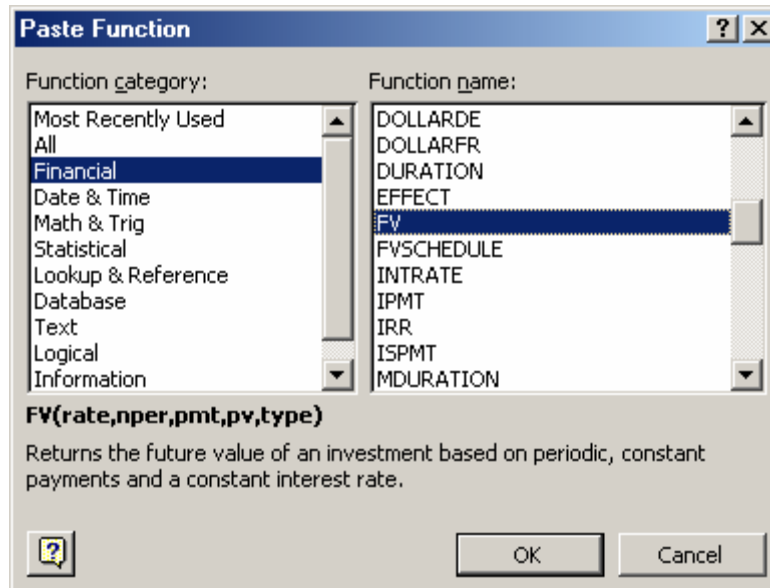
### Future value of an Ordinary Annuity using the EXCEL function FV

Jane deposits \$2,000 annually into a Roth IRA that earns 6.85% compounded annually for 10 years.

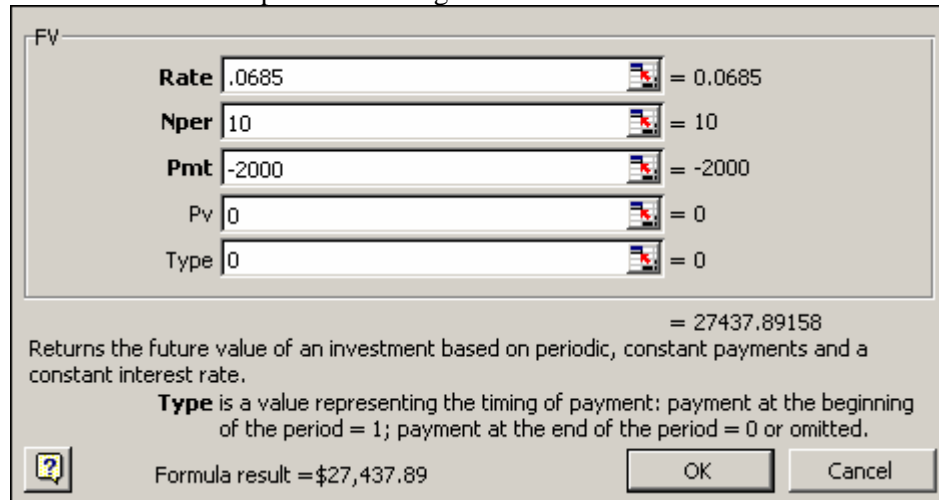
Find the future value of Jane's annuity. (Ex 3 p. 157 part 1)

- The Future value function is found in the function list on the tool bar under Financial or all.
- The format of the function is  $FV = (\text{rate}, \text{number of periods}, \text{payment per period}, \text{Present value}, \text{type})$ .
- The rate must be entered as a decimal, the present value is 0, type is 0 for ordinary annuities paid at the end of the period.
- The payment must be entered as a negative value,  $-2000$ .
- Select a cell in which to compute the Future value of this annuity, say A2.
- To find the FV function go to  $f_x$  on the toolbar.

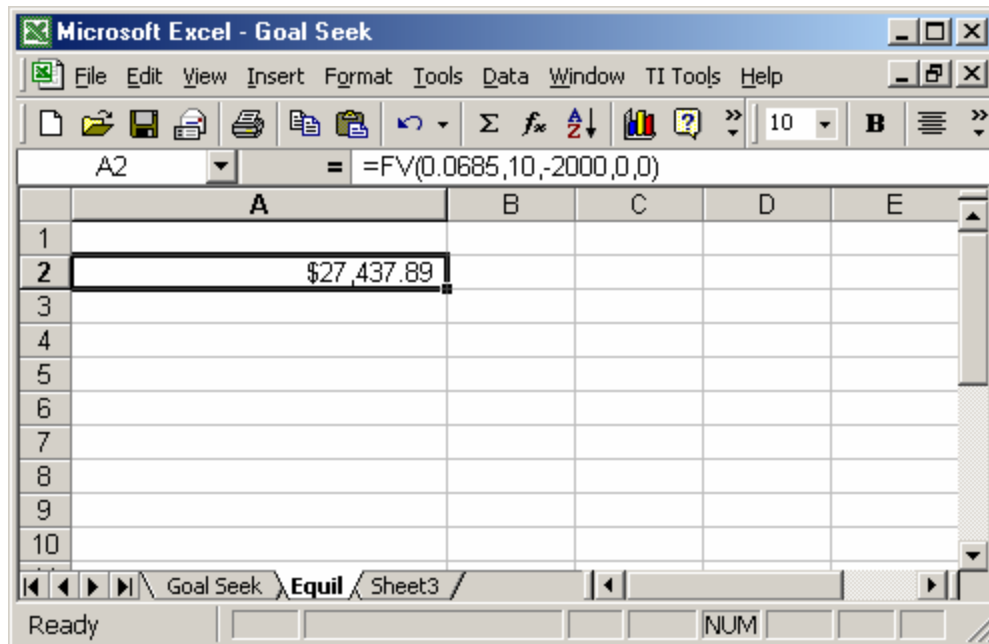
- Locate FV in the Financial set of functions. Once a function has been used, it appears in the Most Recently Used listing.



- Click OK.
- Input the values in the next dialog box as shown. The rate may also be entered as a percentage.
- Note that Pmt must be a negative number.
- Note also that there is a description of that argument at the bottom of the screen.



- Click OK.
- Note the formula for Future Value used appears in the toolbar.

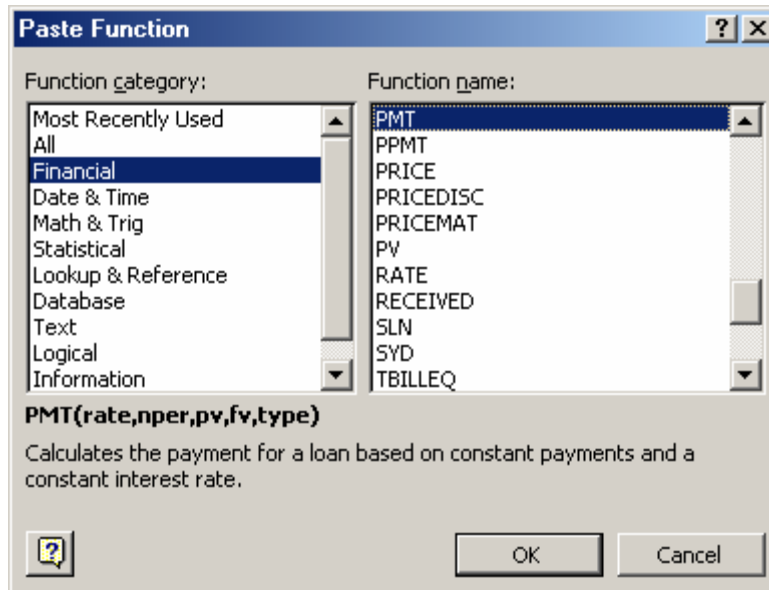


### Use PMT to Compute Payment for a Sinking Fund

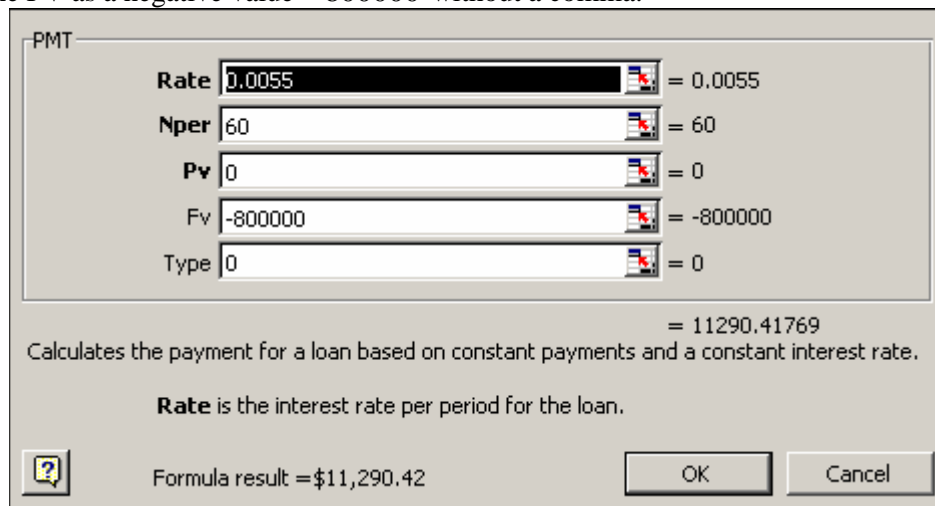
*A company estimates that it will have to replace a piece of equipment at a cost of \$800,000 in 5 years. To have this money available in 5 years, a sinking fund is established by making equal monthly payments into an account paying 6.6% compounded monthly. Find how much each payment should be.*

*(Ex 2 p.156 part A.*

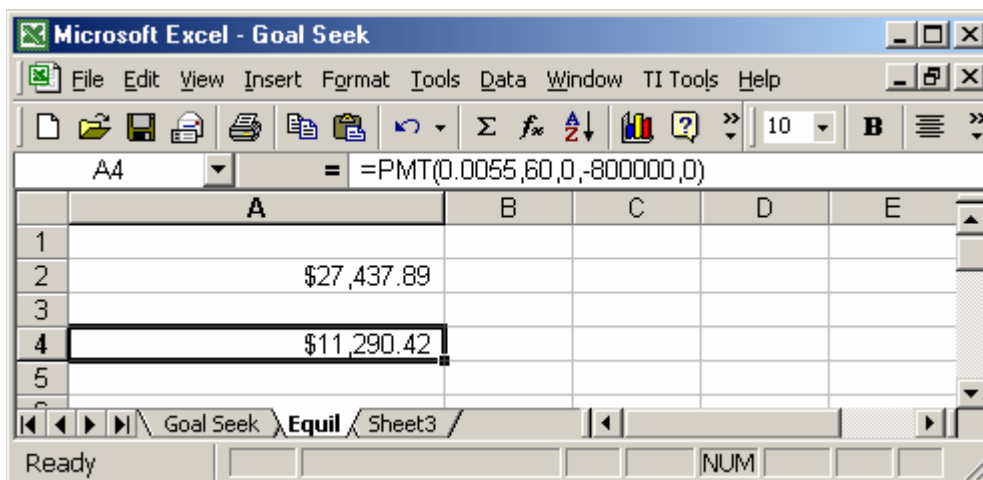
- The PMT function is found in the function list on the tool bar under Financial or all.
- The format of the function is  $PMT = (\text{rate}, \text{number of periods}, \text{present value}, \text{future value}, \text{type})$ .
- The rate must be entered as a decimal, the present value is 0, type is 0 for ordinary annuities paid at the end of the period.
- The future value must be entered as a negative value,  $-800000$ .
- Select a cell in which to compute the PMT of this annuity, say A4.
- To find the PMT function, go to  $f_x$  on the toolbar.
- Locate PMT in the Financial set of functions. Once a function has been used, it appears in the Most Recently Used listing.
- Click OK.



- Input the values as shown.
- Rate is rate per period, so compute  $i = \frac{.066}{12} = 0.0055$
- Compute the number of periods  $n = 12 \cdot 5 = 60$ .
- Enter the FV as a negative value  $-800000$  without a comma.



- Click OK.
- Note that the formula for PMT appears in the toolbar.



### Equilibrium Price

#### CREATE A SCATTER PLOT FROM DATA (Ch2 Review Exercises # 64)

A company is planning to introduce a 10-piece set of nonstick cookware. A marketing company established price-demand and price-supply tables for the selected prices (Tables 1 and 2), where  $x$  is the number of cookware sets people are willing to buy and the company is willing to sell each month at a price of  $p$  dollars per set.

TABLE 1 Price-Demand

$x$	$p = D(x)$ (\$)
985	330
2145	225
2950	170
4225	105
5100	50

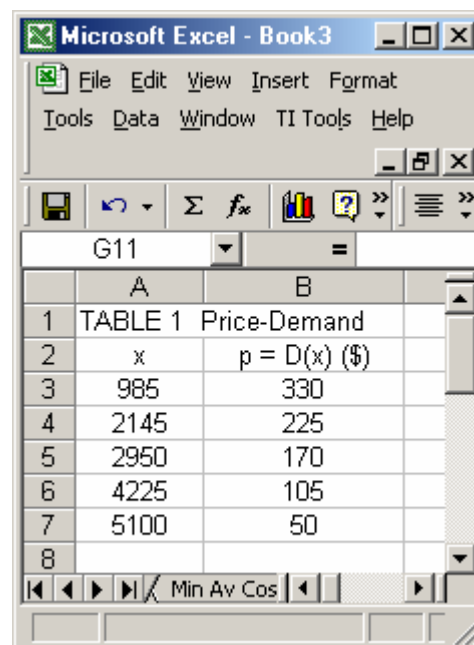
TABLE 2 Price-Supply

$x$	$p = S(x)$ (\$)
985	30
2145	75
2950	110
4225	155
5100	190

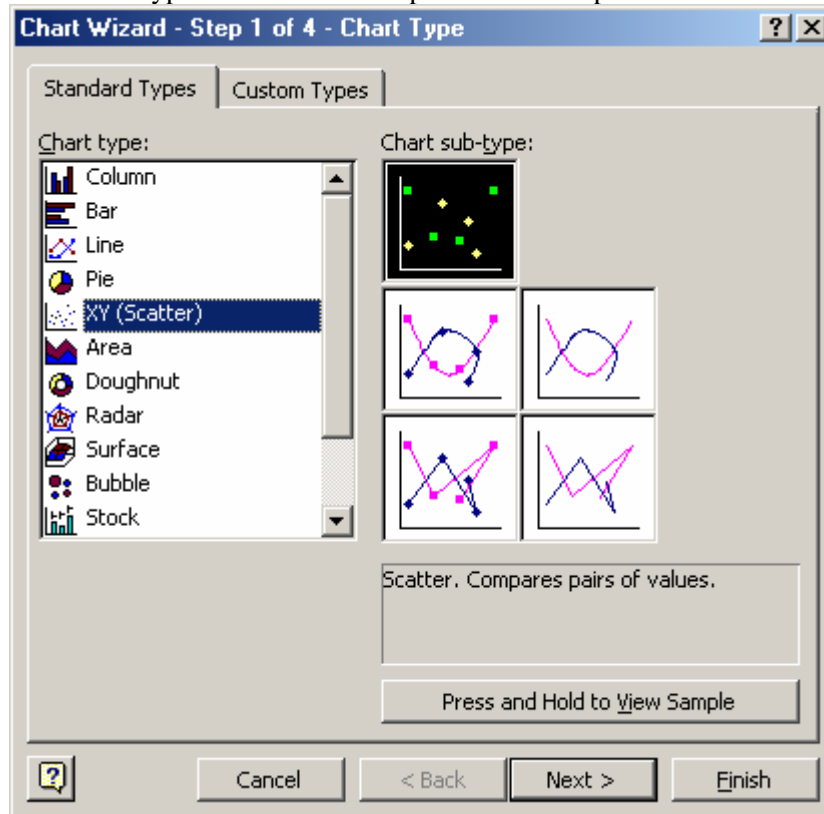
- Find a quadratic regression model for the data in Table 1.
- Find a linear regression model for the data in Table 2.
- Use the models in parts (A) and (B) to find the equilibrium point. Write the equilibrium price to the nearest cent and the equilibrium quantity to the nearest unit.

#### Create a scatter plot of Table 1

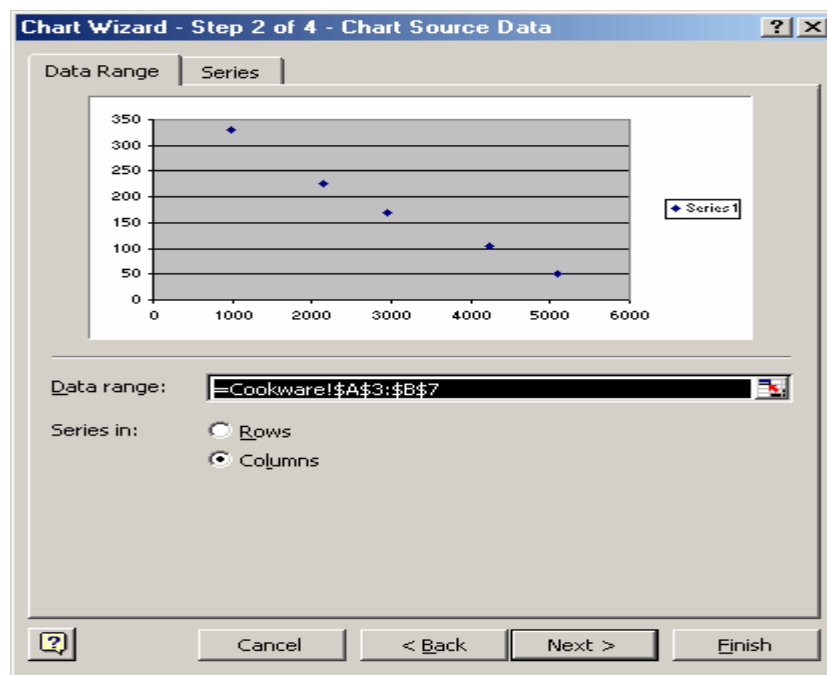
- Enter the data set as shown.
- Select the data set. To do this, left click on cell A3 and hold the left mouse button down until you highlight the entire table that contains the data.

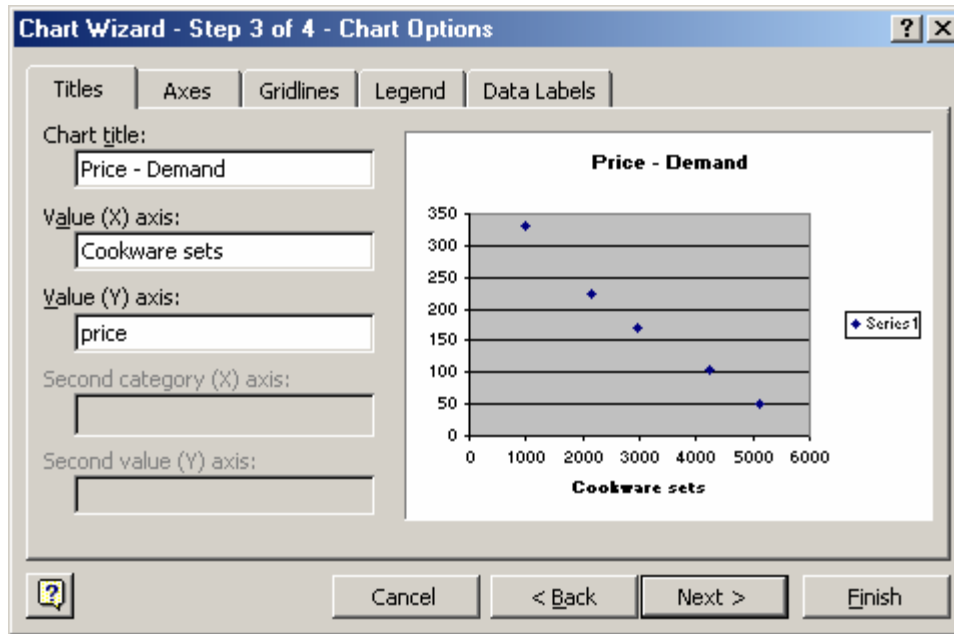


- Select **Chart Wizard** on the menu bar. The chart wizard looks like a bar graph and is colored.
- Select **XY Scatter**.
- Select the first chart sub-type to show a Scatter plot of the data points.

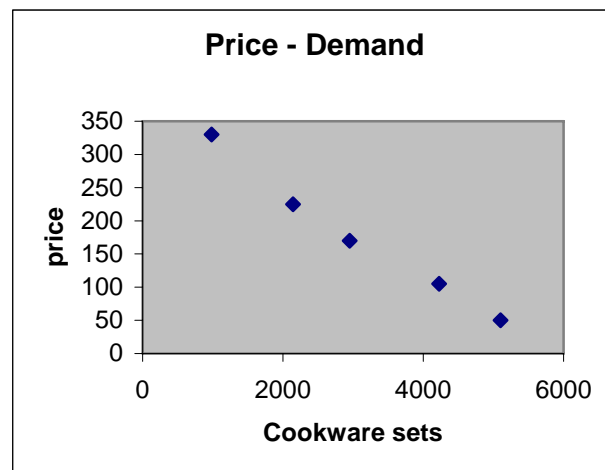


- Click on **NEXT**.
- Data range should be the range of cells you highlighted.
- Check Series in columns.
- Click on **NEXT**.
- Click on the **Titles** tab and fill in the titles for the chart and the x and y axes.



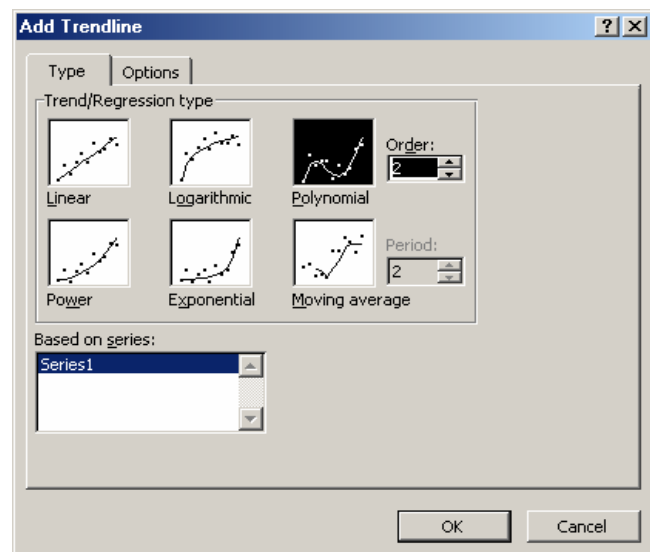


- Click on the **Gridlines** tab and *uncheck* **major gridlines**.
- Click on **Legends** tab and *uncheck* **Show Legend**.
- Click on **NEXT**.
- Select As object in.
- Click on **FINISH**. The scatter plot will appear in EXCEL.
- You may right click on the chart to format the chart at any time.
- Click on the graph and move it wherever you want on the screen. You can also change the dimensions of the box and the plot itself by clicking on it and using the eight tabs to re-size it.
- All the labels on the graph can be reformatted and re-sized as well.

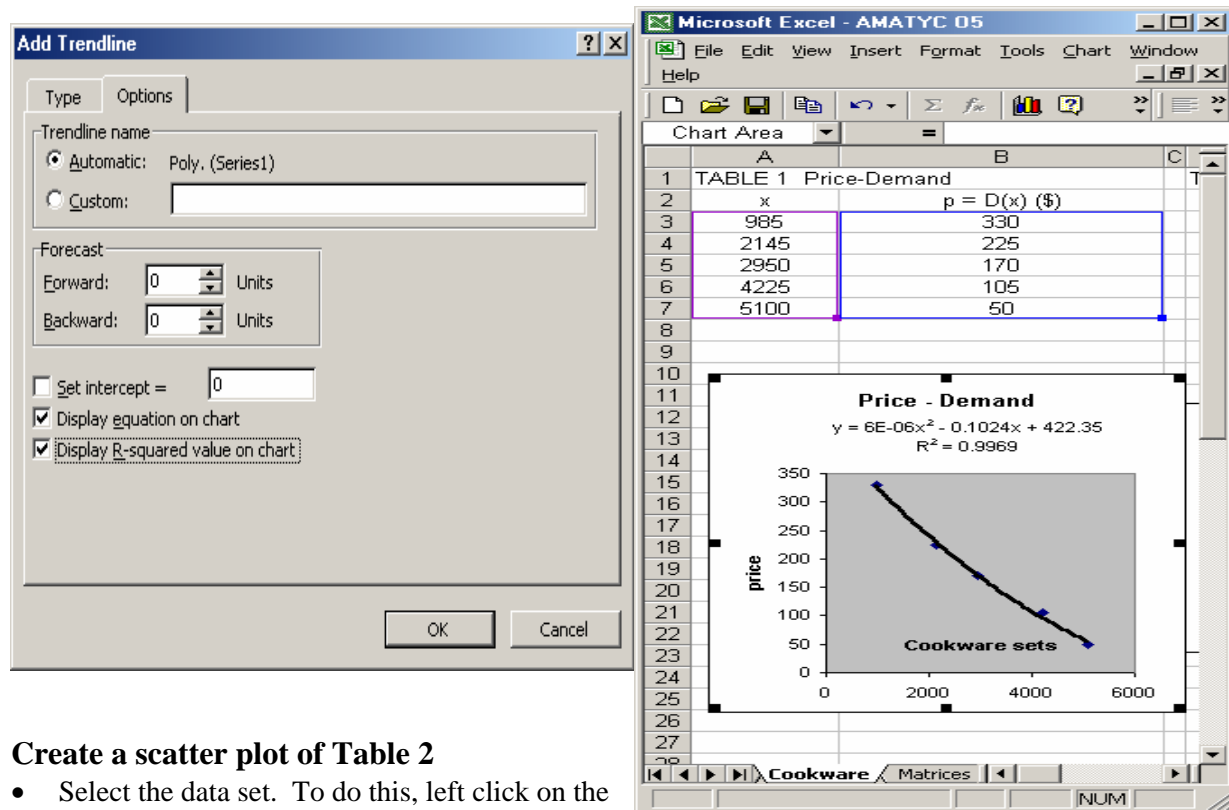


### Find the QUADRATIC regression equation.

- Click on the scatter plot.
- The word Chart is now shown on the toolbar.
- Click on Chart.
- Select Add Trendline.
- A dialog box appears and allows you to choose the type of regression equation you want. Select POLYNOMIAL of degree 2.
- Click on the Options Tab.
- Check Display equation on chart.
- Check Display R-squared value on chart.

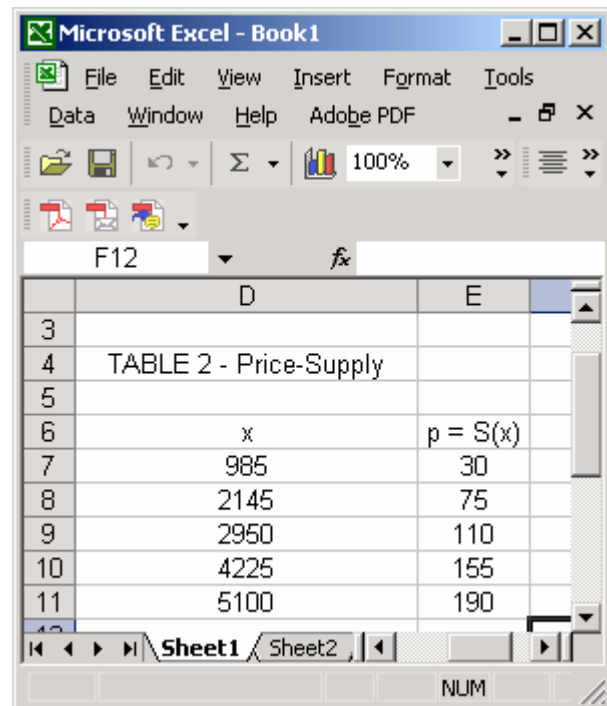


- Click OK to see the quadratic regression graph and equation.
- Move the equation to where it is more visible, such as just below the title of the graph.



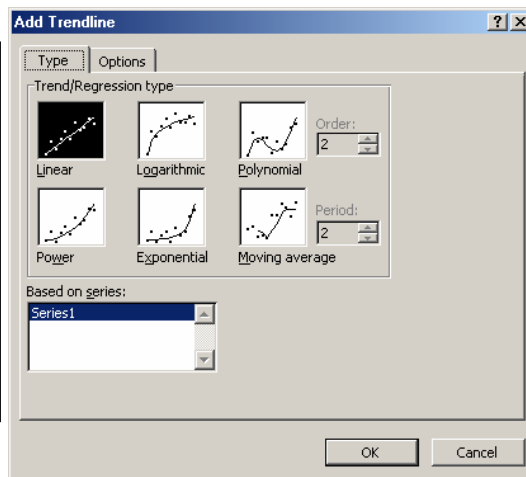
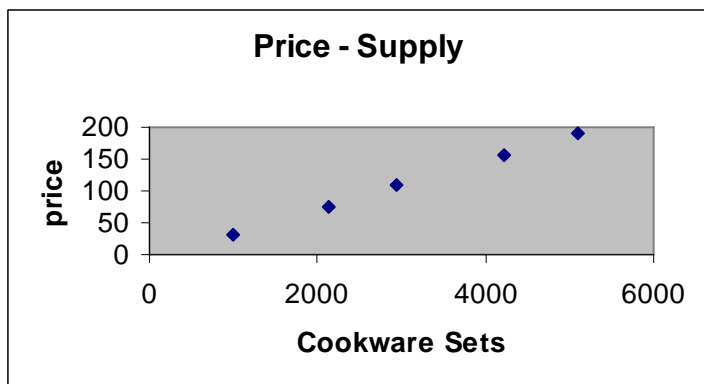
### Create a scatter plot of Table 2

- Select the data set. To do this, left click on the first cell of the table and hold the left mouse button down until you highlight the entire table that contains the data.
- Select **Chart Wizard** on the menu bar. The chart wizard looks like a bar graph and is colored.
- Select **XY Scatter**. Select the first chart sub-type to show a Scatter plot of the data points.
- Click on **NEXT**.
- Data range should be the range of cells you highlighted. Check Series in columns.
- Click on **NEXT**.
- Click on the **Titles** tab and fill in the titles for the chart and the x and y axes.
- Click on the **Gridlines** tab and *uncheck* **major gridlines**.
- Click on **Legends** tab and *uncheck* **Show Legend**.
- Click on **NEXT**. Select As object in.
- Click on **FINISH**. The scatter plot will appear in EXCEL.
- You may right click on the chart to format the chart at any time.
- Click on the graph and move it wherever you



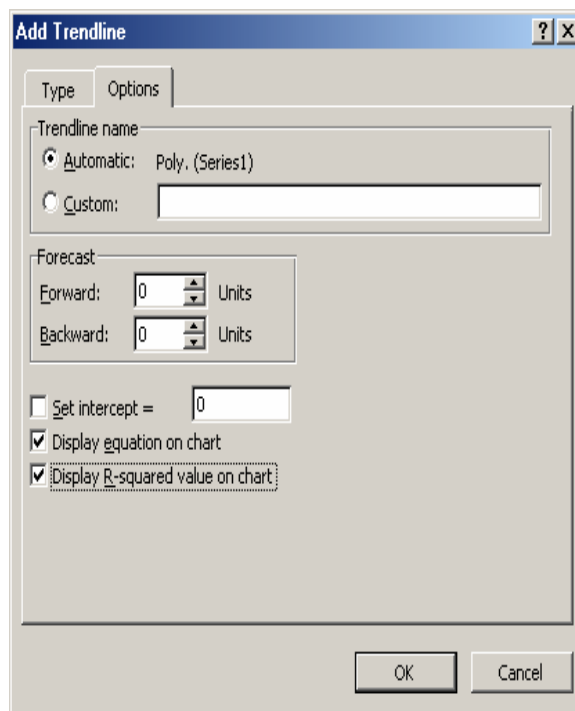
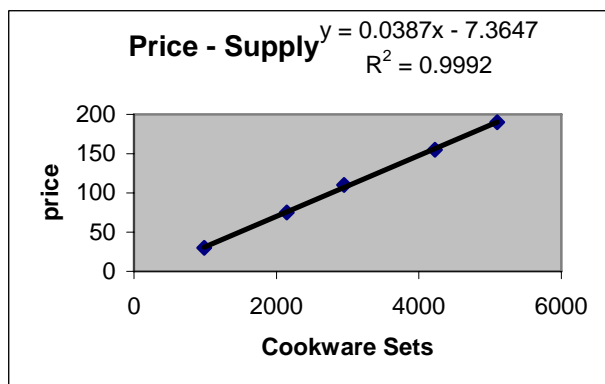
want on the screen. You can also change the dimensions of the box and the plot itself by clicking on it and using the eight tabs to re-size it.

- All the labels on the graph can be reformatted and re-sized as well.



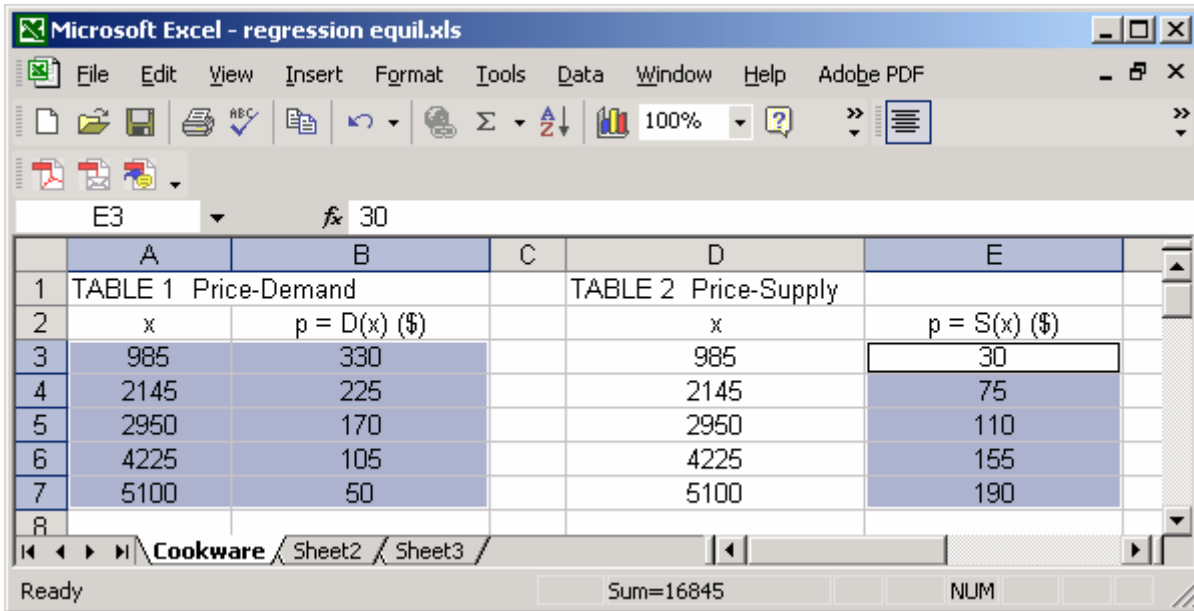
### Find the LINEAR regression equation.

- Click on the scatter plot.
- Chart is now shown on the toolbar.
- Click on Chart.
- Select Add Trendline.
- A dialog box appears and allows you to choose the type of regression equation you want. Select LINEAR.
- Click on the Options Tab.
- Check Display equation on chart.
- Check Display R-squared value on chart.
- Click OK.

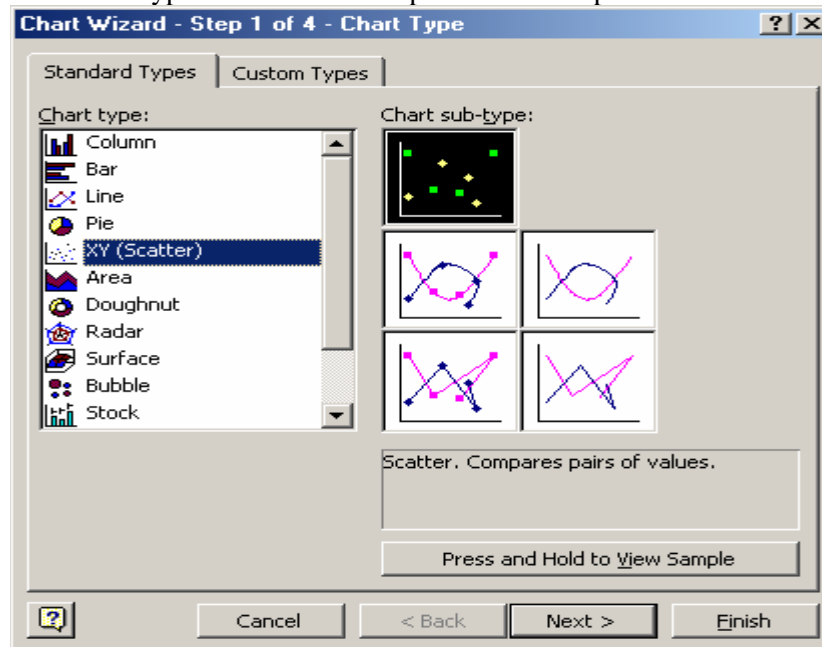


### Put both Graphs on the Same Grid

- Highlight the three sets of data labeled x,  $p=D(x)$  (\$), and  $p=S(x)$  (\$).
- To do this, hold the Ctrl key down and highlight the three columns of data as shown. Note that the columns must all be in the same rows, rows 3 thru 7 in this example.

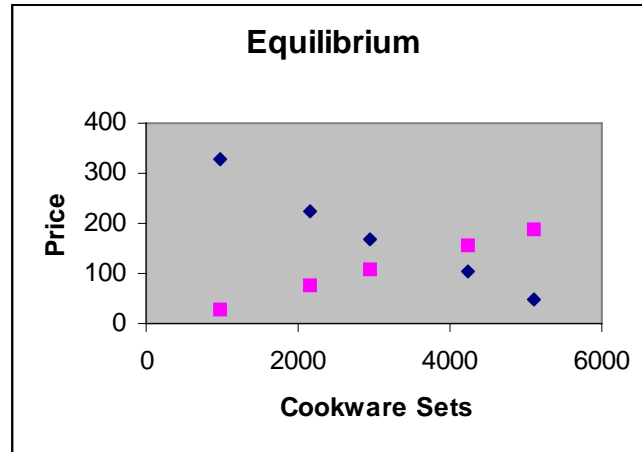


- Select **Chart Wizard** on the menu bar. The chart wizard looks like a bar graph and is colored.
- Select **XY Scatter**.
- Select the first chart sub-type to show a Scatter plot of the data points.

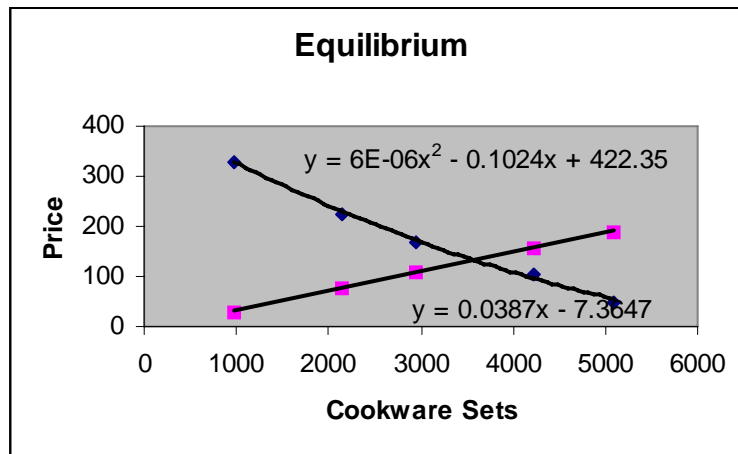


- Click on **NEXT**.
- Data range should be the range of cells you highlighted.
- Check Series in columns.
- Click on **NEXT**.
- Click on the **Titles** tab and fill in the titles for the chart and the x and y axes.
- Click on the **Gridlines** tab and *uncheck* **major gridlines**.
- Click on **Legends** tab and *uncheck* **Show Legend**.
- Click on **NEXT**.
- Select As object in.

- Click on **FINISH**. The scatter plot will appear in EXCEL.
- You may right click on the chart to format the chart at any time.
- Click on the graph and move it wherever you want on the screen. You can also change the dimensions of the box and the plot itself by clicking on it and using the eight tabs to re-size it.
- All the labels on the graph can be reformatted and re-sized as well.

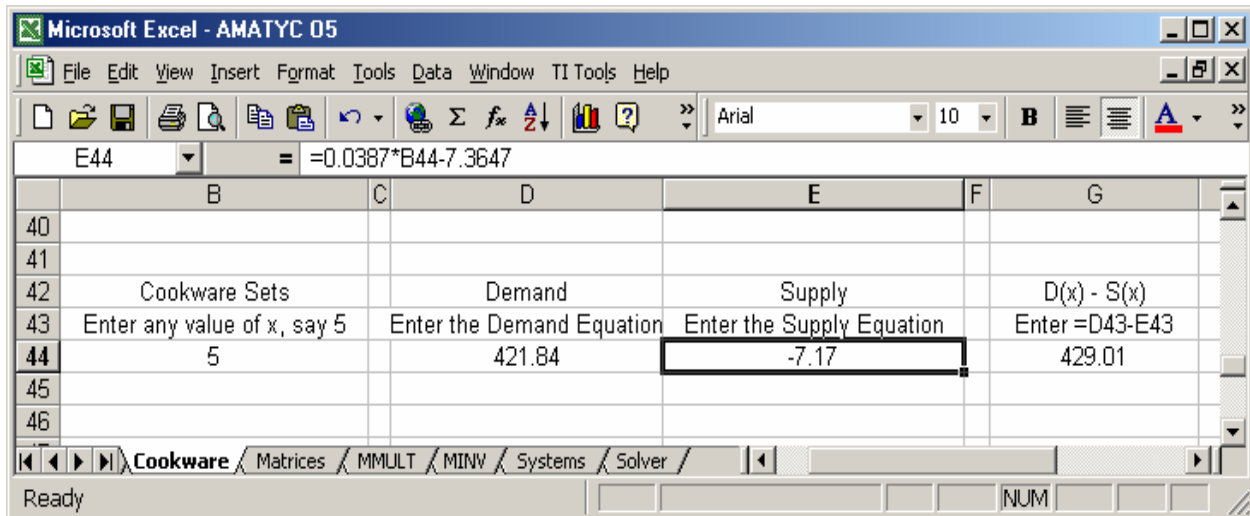
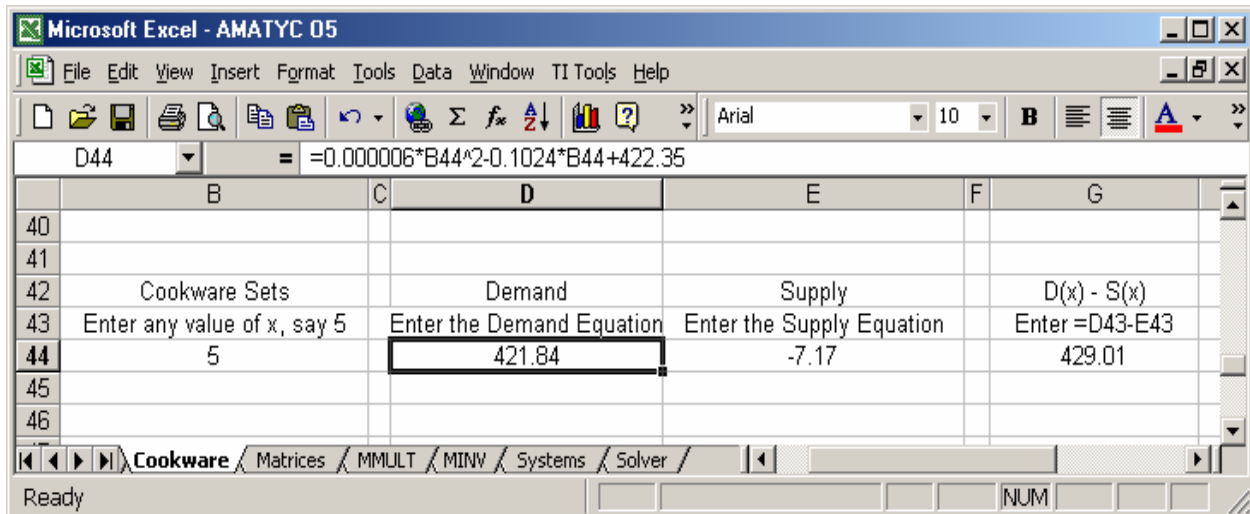


- Right click on one of the points of one of the functions. Recall that we were asked to model Table 1, Demand, by a quadratic function and Table 2, Supply, by a linear function.
- Click on Add Trendline.
- On the Options tab, check display equation.
- Repeat for the other function.

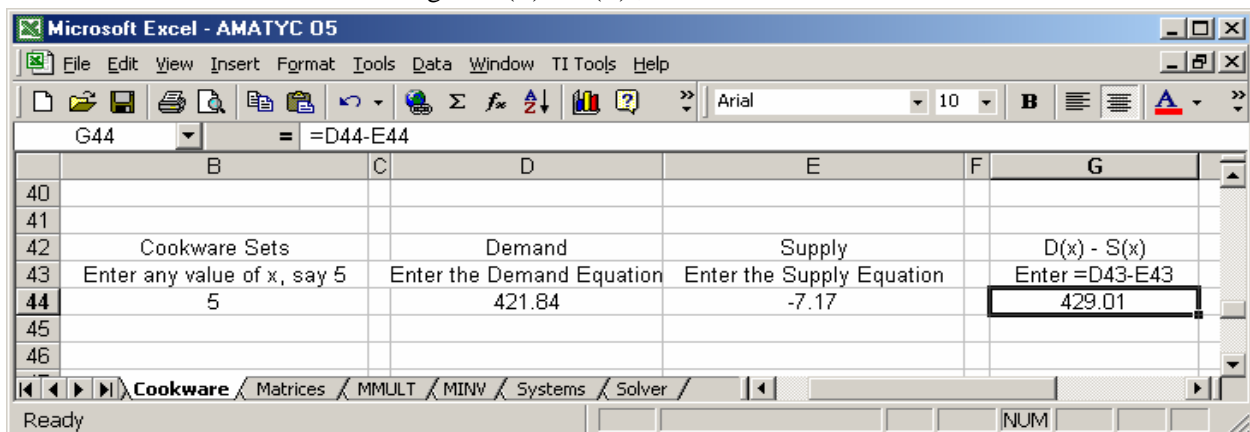


### Use GOAL SEEK to find the Equilibrium Point

- Enter some value for the number of cookware sets, x, say 5.
- Enter the quadratic Demand equation found earlier. The quadratic equation is found below in the formula bar when the cursor is in cell D44.
- Enter the linear Supply equation found earlier. The linear equation is found below in the formula bar when the cursor is in cell E44.



- Enter the formula  $= D(x) - S(x)$  as shown below in cell G44 by clicking in the cells containing these formulas. Press ENTER.
- Click back on the cell containing  $= D(x) - S(x)$ , G44 below.



- Go to Tools.
- Select Goal Seek.

- Fill in the dialog box as shown. Set cell that contains  $= D(x) - S(x)$  to value 0 by changing the cell that contains  $x$ , the number of cookware sets.
- The  $x$  cell changes to the equilibrium value, 3595, as shown below. Note that this cell is formatted to round to the nearest integer.
- The supply and demand cells show the equilibrium price.
- Format the cells if needed.

