1. Appendix: Required Spreadsheet Skills

This appendix consists of exercises in using Microsoft Excel to perform tasks that are useful in the design work of this text. The exercises are step-by-step tutorials. The starting and ending points of each tutorial may be found in the spreadsheet titled *MS Excel Skills.xls* on the website that accompanies this text. The text will refer to these sections as the skills are required. You may come here as needed to work on these exercises.

1.1.1. Copy transpose

Creating a table in MS Excel such as Table1-1 from Chapter 1 is quite easy using the following steps.

1. Begin by listing the entities in separate rows starting in cell A2, as shown in Figure 1-1.

Figure 1-1: List of Entities for Toy Catapult

2. Select the range of cells containing the row names (cells A2:A4) and hit <ctrl>-c (Copy).
3. Select the first cell of the column range (cell B1).
4. Choose menu Edit->Paste Special… to get the dialog box shown in Figure 1-2
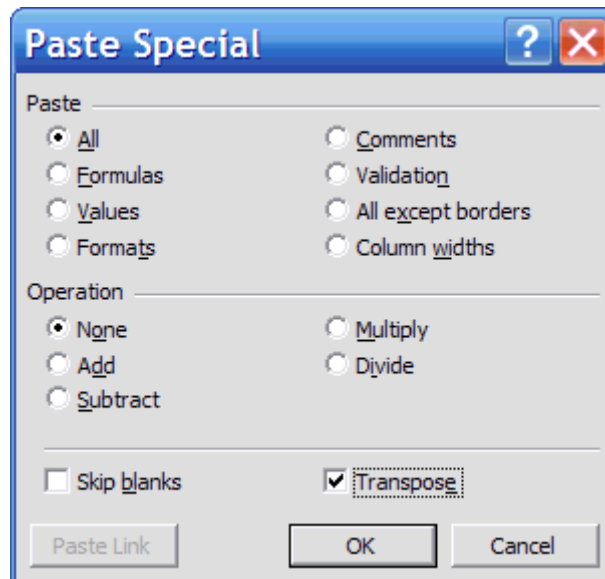

Figure 1-2: Paste Special Dialog Box

5. Check the box labeled "Transpose" as shown in Figure 1-2. Then, click "OK". The column headings should appear as shown in Figure 1-3.

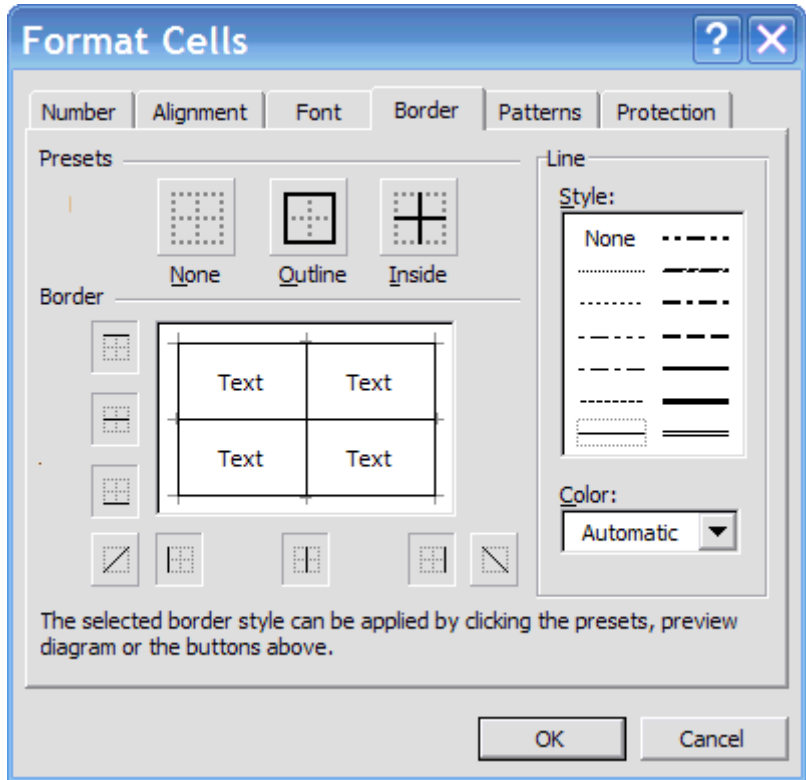|	A	B	C	D
1		Sun	Planets	Moon
2	Sun			
3	Planets			
4	Moon			

Figure 1-3: Table with Row and Column Headings

6. Select the entire range of cells defining the matrix (cells A1:D4).
7. Choose menu Format->Cells… to get the dialog box shown in Figure 1-4.
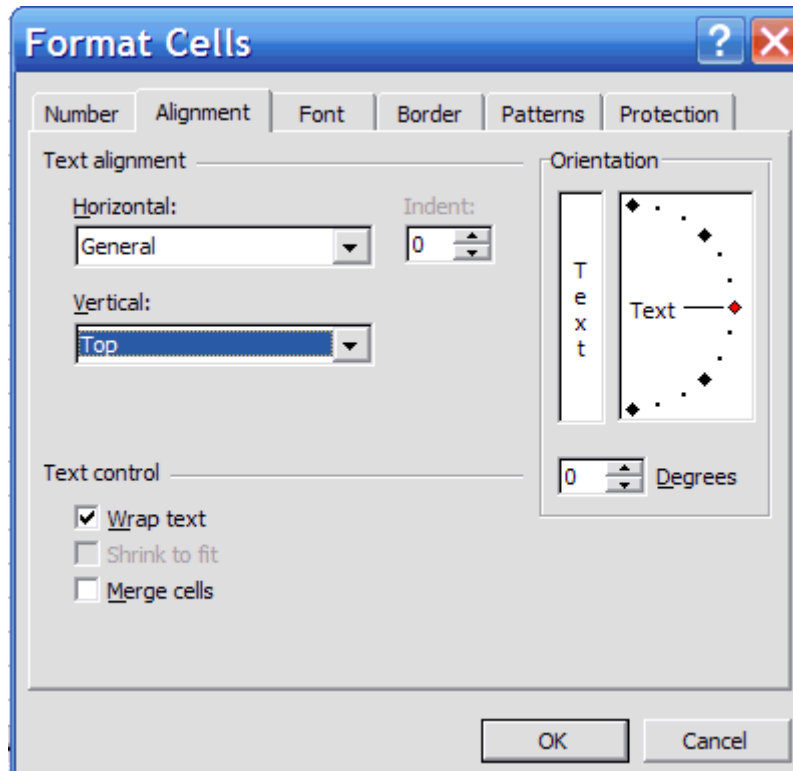
Figure 1-4: Menu Format Cells Alignment

8. Choose the tab labeled "Alignment", select "Top" from the drop-down list labeled "Vertical", and check the box labeled "Wrap text" as shown in Figure 1-4.
9. Choose the tab labeled "Border", click the Presets labeled "Outline" and "Inside", as shown in Figure 1-5.

Figure 1-5: Menu Format Cells Borders

10. Click "OK". The matrix should appear as in Figure 1-6.

Figure 1-6: Solar System Table with Formatting

Enter the verb phrases in the appropriate cells of the matrix as shown in Table 1-1. Since word-wrap was enabled in step 8 above, the resulting table should be formatted as shown in Table 1-1.

1.1.2.   Drag and Drop (The Affinity Process Using MS Excel)

For a small number of comments, MS Excel can be used to drag and drop comments into groups. Follow these steps.

11. Open a new sheet in MS Excel.
12. Select all cells in the sheet by clicking in the upper left corner of the sheet.
13. Choose menu Format->Cells, click tab "Patterns", and select a light solid color as background for every cell. Click "OK" to close the dialog. The sheet should look like Figure 1-7.

Figure 1-7: Blank Worksheet with Colored Cells

14. Type or paste the customer comments into different cells in a single column of the spreadsheet.
15. Select the cells with comments and change their background pattern to solid white, turn on word-wrap, and set their border to outline. The result should look something like Figure 1-8. Note that we have made columns A and C skinny (see the Excel help file for changing column widths) and we have changed the background color of column C to grey.

Figure 1-8: Unordered Customer Comments in Contrasting Format

16. Add dummy column names for columns to the right of column C. Change the cell formats as you wish. Figure 1-9 illustrates.

Figure 1-9: Unordered Customer Comments with Dummy Group Headings

17. Take the first customer comment and drag it to the top cell of the first group. To move a cell, first select it, then point to its lower border, then drag the cell to its new location and drop it. Figure 1-10 illustrates.

	A	B	C	D	E
1					
2					
3		Source		Group 1	Group 2
4				The problem with grandparents is that they love to buy the kids toys with lots of little pieces. Guess who has to pick up all the pieces? It's not the grandparents.	
		Once the lever or switch breaks, the toy is useless			

Figure 1-10: Creating the First Affinity Group

18. Take the next customer comment from the unordered list and drag it to one of the affinity group columns. If it is like other comments in some column, drop it in the column in a cell below the other comments. If it is unlike the comments in all other columns, drop it at the top of a new column.

19. Continue the drag and drop process until all the customer comments have been assigned to some affinity group column. Figure 1-11 illustrates three possible affinity groups that could be formed from the customer comments. Figure 1-12 is a zoomed-out view of a complete solution for all 37 customer comments. We organized the customer comments into eleven affinity groups. The details of the groupings cannot be seen in this figure. The details can be found in an appendix to Chapter 2.

B	C	D	E	F	
Source		**Group 1**	**Group 2**		
		The problem with grandparents is that they love to buy the kids toys with lots of little pieces. Guess who has to pick up all the pieces? It's not the grandparents.	Once the lever or switch breaks, the toy is useless. Usually that is the flimsiest part of the toy.	The battery-operated toys never get played with once the batteries run out. We never think to buy more batteries.	Th dr
		It is hard to teach children to pick up all their toys. At the end of the day it is often me who goes around and tidies up the toys. Some toys are easier to put away than others.	A lot of toys with latches and doors are broken. Kids are pretty rough on that sort of thing.	Most of the toys nowadays that do things are battery-powered. They are great until the batteries run out and then they are junk.	I a th Th ca
		Once you lose the pieces to a toy, it is very hard to play with. Lots of toys are made so that only one piece fits (like the driver of a truck). Usually you can find the toy or its pieces, but not both.	The most interesting toys are the ones that do things. But they are usually broken.		

Figure 1-11: Three Possible Affinity Groups

Figure 1-12: Eleven Possible Affinity Groups

20. Once the comments have been organized into affinity groups, go through each group and compose a sentence that summarizes the group. Use language that the customer or user would use. Replace the dummy group heading with the summary statement. Figure 1-13 illustrates for the first five affinity groups.

Make the toy easy to put away (and find again).	Make the toy reliable.	Avoid making a battery-powered toy.	Don't make a toy with annoying noise.	Make a toy that interests my child.
The problem with grandparents is that they love to buy the kids toys with lots of little pieces. Guess who has to pick up all the pieces? It's not the grandparents.	Once the lever or switch breaks, the toy is useless. Usually that is the flimsiest part of the toy.	The battery-operated toys never get played with once the batteries run out. We never think to buy more batteries.	The noise of that toy drives me crazy.	My son loves toys with wheels. He spends ages moving them all around and lining them up.
It is hard to teach children to pick up all their toys. At the end of	A lot of toys with latches and doors are broken. Kids are pretty	Most of the toys nowadays that do things are battery-	I am usually glad when the batteries run out. The noise of these toys	Transporting things seems to be fun. She will fill the wagon with

Figure 1-13: Affinity Group Headings

21. Rearrange the columns so that similar columns are adjacent to each other. This can be done by selecting a whole column, choosing menu Edit->Cut, select the destination column, and choose menu Insert->Cut Cells.

22. Group similar columns by merging the cells in row 1 and creating a heading for the group. Create headings for each group of columns. Figure 1-14 shows a partial view of the resulting hierarchy.

Make the toy fun for both parent and child			Make the toy appealing for both parent		
Make a toy that interests my child.	Make a toy that involves me, the parent.	Don't make the toy too complex.	Make a toy with personality.	Make a toy that is pleasing to the eye and to the touch.	
My son loves toys with wheels. He spends ages moving them all around and lining them	The kids love it when I get down on the floor and play with them.	Some toys are way too complicated. The kids just push the buttons randomly.	My daughter tells a story when she plays. She talks to the toys. They all have names.	I like giving them wooden toys with a natural finish. The texture and color are more soothing than plastic toys.	

Figure 1-14: A Hierarchical Group of Affinities

23. Transpose and reformat the summary. Figure 1-15 displays the complete summary of the customer comments. It is the "voice of the customer," summarized.

Make the toy fun for both parent and child	Make a toy that interests my child.
	Make a toy that involves me, the parent.
	Don't make the toy too complex.
Make the toy appealing for both parent and child	Make a toy with personality.
	Make a toy that is pleasing to the eye and to the touch.
	Don't make a toy with annoying noise.
Make the toy safe.	Don't let the toy injure my child.
Make the toy easy to put away.	Make the toy easy to put away (and find again).
	Make a toy that is easy to store.
Make the toy playable for a long time.	Make the toy reliable.
	Avoid making a battery-powered toy.

Figure 1-15: The Voice of the Customer

1.1.3.   Drag and drop cells

In Chapter 2, we describe a process of organizing concepts by their affinities (similarities or attractions) toward each other. If each concept is captured in a cell of a spreadsheet, this so-called "affinity process" consists of dragging and dropping cells into different columns. Here, we illustrate both the affinity process and the drag and drop feature of MS Excel using an example from Chapter 3. In that chapter, we start with a general requirement for a system such as "The system shall store or accept external energy" and we generate a list of concept fragments that might be relevant (Figure 1-16). At this point, there is no order to the list. They were ideas that surfaced during a brainstorming session.

Figure 1-16. Unordered Concept Fragments

In the following steps, we format these cells and organize them into columns of similar concepts.

24. Select the entire sheet by clicking in the upper-left-most corner of the spreadsheet (Figure 1-17).

Figure 1-17. Select Entire Sheet

25. Using menu Format->Cells->Patterns, choose a light pastel color to serve as a visual background.
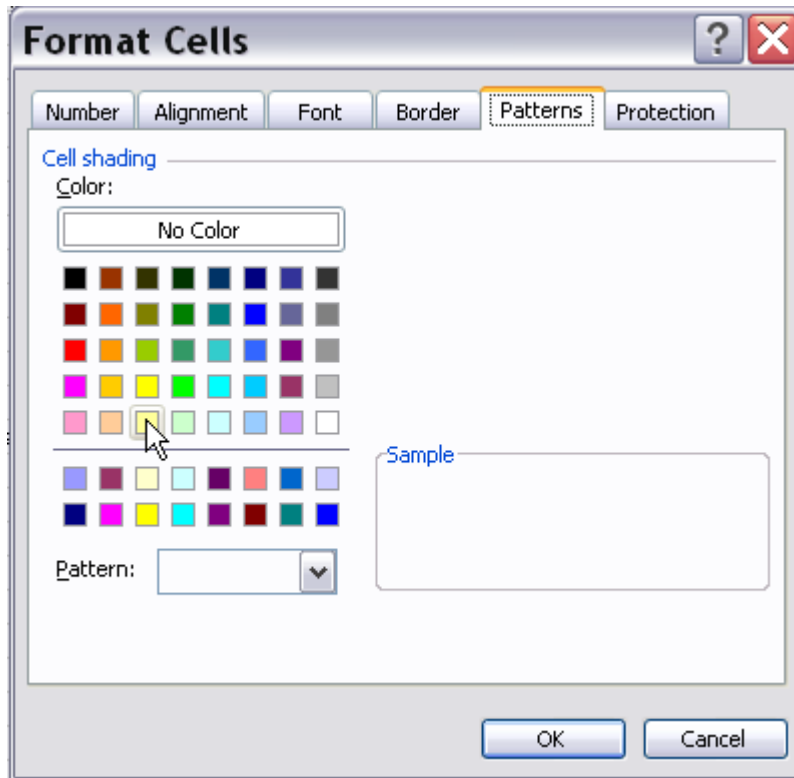
Figure 1-18. Color Background Cells

26. Select just the cells with text and use Format->Cells->Patterns to set the color to white since these cells will be in the foreground.

Figure 1-19. Color Foreground Cells

27. With these same cells selected use Format->Cells->Alignment to set vertical alignment to "top", set "Wrap text" to true, and use Format->Cells->Border to set Outline to true and Inside to true.

Figure 1-20. Formatted Foreground Cells

28. Place the cursor on the hairline between column labels "A" and "B" and drag right until the text appearance in each line of the cells is pleasing, at least until whole words are not split onto multiple lines.

Figure 1-21. Adjust Column Width

29. With the text cells selected, use menu Format->Rows->Autofit to fit the row height to largest number of wrapped lines in each row.

	A	B
1		
2	The system shall store or accept external energy.	
3	Spring	
4	Battery	
5	Flywheel	
6	Human power	
7	Wind	
8	Explosives	
9	Compressed air	
10	High pressure fluid	
11	Internal combustion	
12	Solar electric cells	
13	Compressed carbon dioxide	
14	Electric motor	
15	Chemical reaction resulting in high-pressure gas	
16	Pendulum	
17		

Figure 1-22. Text Cells Formatted for Drag and Drop (Affinity) Exercise

30. Select columns B-K and use Format->Column->Width to set all the column widths to be the same as the width of column A (15.43 in the case of Figure 1-21).

	A	B	C
1			
2	The system shall store or accept external energy.		
3	Spring		
4	Battery		
5	Flywheel		
6	Human power		
7	Wind		
8	Explosives		
9	Compressed air		
	High pressure fluid		

Figure 1-23. Equal Column Widths

31. To move a text cell, first select it, then position the cursor over one of the cell boundaries (top, bottom, left, or right) until the shape of the cursor changes to a cross made of four arrow heads. When that shape cursor appears, you may drag the cell to a new location. Be sure not to drop it on an existing text cell.
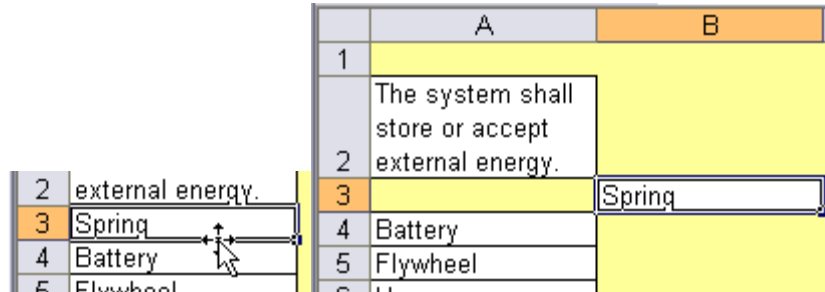
Figure 1-24. Drag and Drop, Before and After

32. Using drag and drop, move the text cells around so that each column contains similar concepts but there is something conceptually different between the columns. That is, the concepts in the columns have an affinity for other concepts in the same column.

Figure 1-25. Concept Fragments Organized by Affinities

33. Type a heading label at the top of each column to describe the affinity. Use cell formatting to make the heading distinguishable from the concept cells.

Figure 1-26. Concept Fragments Labeled by Affinity

1.1.4.   Merge cells

In this section, we continue the example of organizing concept fragments by affinity from the previous section. In Figure 1-26, we perceive a difference between columns B-E and columns F-H, from the perspective of the system we are developing (a toy catapult). The first set of columns describes concepts that might provide the external source of power for our catapult. The second set describes ways in which energy might

be stored. To group these columns into sets, we want a heading label that extends over multiple columns. The following steps show how to merge cells to create such labels.

34. Select cells B1:E1. Using Format->Cells->Alignment, set Horizontal alignment to "Center", Vertical alignment to "Center", and set "Merge cells" to true.
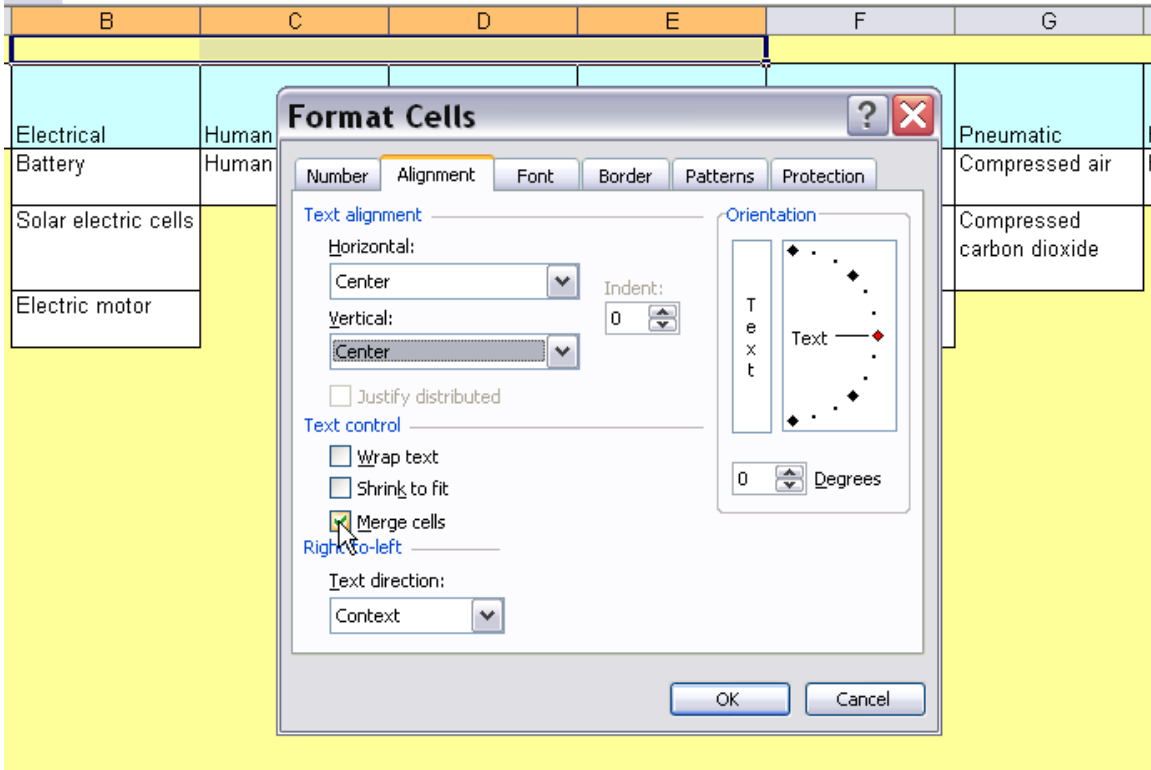
Figure 1-27. Merge Selected Cells

35. With the same cells selected, use Format->Cells->Border to set Outline to true and use Format->Cells->Patterns to set the background color to a slightly darker color. Type a group label into the merged cell.

Figure 1-28. Group Label Using Merged Cells

36. Repeat these steps with cells F1:H1.

Figure 1-29. Second Group Label

37. Select row 1, select Insert->Rows, and then select cells B1:H1. Repeat steps 1 and 2 to create a label for the overall grouping. Note that we have used a bold font in xx to create contrast with the background color.

B	C	D	E	F	G	H
The system shall store or accept external energy.						
Energy Source				Energy Storage		
Electrical	Human power	Chemical	Other	Mechanical	Pneumatic	Hydraulic
Battery	Human power	Explosives	Wind	Spring	Compressed air	High pressure fluid
Solar electric cells		Chemical reaction resulting in high-pressure gas		Pendulum	Compressed carbon dioxide	
Electric motor		Internal combustion		Flywheel		

Figure 1-30. Multi-Level Group Labels

1.1.5.   Reorder rows and columns of a matrix

In working with tables and matrices it is sometimes useful to reorder the rows and columns. For example, Figure 1-31 displays what is called a "precedence matrix" for the major activities in constructing a house. The "X" entries in the matrix indicate that the row activity corresponding to the "X" must be completed before work on the corresponding column activity can begin. For example, the upper-left most "X" indicates that the "excavate foundation" activity (the row) must be completed before the activity "pour concrete footings." The diagonal entires, where row and column are the same, are shaded a different color. You would never place an "X" in one of these cells. The order of the columns matches the order of the rows. The order mostly makes sense but there is a problem with listing "install roof and shingles" as the second-to-last activity. The "X"'s in that row indicate that many other activities, such as "install heating" and "install plumbing", cannot begin until after the roof is complete. We would like to move the activity "install roof and shingles" so that it appears in the list before these other dependent activities. In fact, whenever we find an "X" lying below the diagonal, we want to rearrange the order so that doesn't happen. If we change the row order, then we must also change the column order to match. The steps below will result in all of the "X"'s lying above the diagonal.

	Excavate foundation	Pour concrete footings	Pour concrete foundation	Frame walls	Install electrical	Install heating	Install plumbing	Install insulation	Add exterior walls and siding	Add interior walls	Build rafters	Install roof and shingles	Finish
Excavate foundation		X											
Pour concrete footings			X										
Pour concrete foundation				X									
Frame walls											X		
Install electrical										X			
Install heating										X			
Install plumbing										X			
Install insulation										X			
Add exterior walls and siding										X			
Add interior walls													X
Build rafters												X	
Install roof and shingles					X	X	X	X	X	X			
Finish													

Figure 1-31. Precedence Matrix for House Construction

38. Observe that the row "install roof and shingles" must be moved so that it is above "install electrical" since this is the column of the left-most "X" associated with that row. To move a row, select the whole row by clicking on the row number(Figure 1-32), and hit <ctrl>x (or use Edit->Cut).

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
		Excavate foundation	Pour concrete footings	Pour concrete foundation	Frame walls	Install electrical	Install heating	Install plumbing	Install insulation	Add exterior walls and siding	Add interior walls	Build rafters	Install roof and shingles	Finish	
1															
2	Excavate foundation		X												
3	Pour concrete footings			X											
4	Pour concrete foundation				X										
5	Frame walls											X			
6	Install electrical										X				
7	Install heating										X				
8	Install plumbing										X				
9	Install insulation										X				
10	Add exterior walls and siding										X				
11	Add interior walls											X			X
12	Build rafters												X		
13	Install roof and shingles					X	X	X	X	X	X				
14	Finish													X	
15															

Figure 1-32. Select a Whole Row

39. Select the "install electrical" row by clicking on the row number as in Figure 1-33,

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1		Excavate foundation	Pour concrete footings	Pour concrete foundation	Frame walls	Install electrical	Install heating	Install plumbing	Install insulation	Add exterior walls and siding	Add interior walls	Build rafters	Install roof and shingles	Finish	
2	Excavate foundation		X												
3	Pour concrete footings			X											
4	Pour concrete foundation				X										
5	Frame walls											X			
6	Install electrical										X				
7	Install heating						X				X				
8	Install plumbing							X			X				
9	Install insulation								X		X				
10	Add exterior walls and siding									X	X				
11	Add interior walls											X		X	
12	Build rafters												X		
13	Install roof and shingles					X	X	X	X	X	X		X		
14	Finish													X	
15															

Figure 1-33. Prepare to Insert Cut Cells

40. Use the menu Insert->Cut Cells, to insert the row above the selected row. Figure 1-34 shows the result. Note that the symmetry has been altered. The colored cells are no longer all on the diagonal. That is because the column order does not match the row order. We need to move the column "install roor and shingles" so that it comes just before the column "install electrical."

41. Select the column "install roor and shingles" by clicking on the letter in the column heading (Figure 1-2).

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1		Excavate foundation	Pour concrete footings	Pour concrete foundation	Frame walls	Install electrical	Install heating	Install plumbing	Install insulation	Add exterior walls and siding	Add interior walls	Build rafters	Install roof and shingles	Finish
2	Excavate foundation		X											
3	Pour concrete footings			X										
4	Pour concrete foundation				X									
5	Frame walls											X		
6	Install roof and shingles					X	X	X	X	X	X			
7	Install electrical										X			
8	Install heating										X			
9	Install plumbing										X			
10	Install insulation										X			
11	Add exterior walls and siding										X			
12	Add interior walls													X
13	Build rafters												X	
14	Finish													
15														
16														

Figure 1-34. Select a Whole Column

42. With the whole column selected, click <ctrl>x or use menu Edit->Cut.
43. Select the whole column for "install electrical" by clicking on the letter in the column heading (Figure 1-35).

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1		Excavate foundation	Pour concrete footings	Pour concrete foundation	Frame walls	Install electrical	Install heating	Install plumbing	Install insulation	Add exterior walls and siding	Add interior walls	Build rafters	Install roof and shingles	Finish
2	Excavate foundation	■	X											
3	Pour concrete footings		■	X										
4	Pour concrete foundation			■	X									
5	Frame walls				■							X		
6	Install roof and shingles					X	X	X	X	X	X		■	
7	Install electrical					■					X			
8	Install heating						■				X			
9	Install plumbing							■			X			
10	Install insulation								■		X			
11	Add exterior walls and siding									■	X			
12	Add interior walls										■			X
13	Build rafters											■	X	
14	Finish													■
15														

Figure 1-35. Ready to Insert Column of Cut Cells

44. Use menu Insert->Cut Cells. Figure 1-36 shows the result. Observe that the column order matches the row order and the diagonal cells are all colored. Also observe that we are not done yet: there is still one "X" below the diagonal. The "build rafters" activity must come before the "install roof and shingles" activity.

	Excavate foundation	Pour concrete footings	Pour concrete foundation	Frame walls	Install roof and shingles	Install electrical	Install heating	Install plumbing	Install insulation	Add exterior walls and siding	Add interior walls	Build rafters	Finish
Excavate foundation		X											
Pour concrete footings			X										
Pour concrete foundation				X									
Frame walls												X	
Install roof and shingles						X	X	X	X	X	X		
Install electrical											X		
Install heating											X		
Install plumbing											X		
Install insulation											X		
Add exterior walls and siding											X		
Add interior walls													X
Build rafters				X									
Finish													

Figure 1-36. Matrix with Reordered Rows and Columns

45. Repeat the previous steps so that activity "build rafters" comes just before activity "install roof and shingles". Be sure that the resulting column order matches the row order (that is, keep the colored cells on the diagonal). Figure 1-37 shows the result. Now the precedence matrix has no entries below the diagonal. Such a matrix is said to be in "upper triangular form" since all of the entries lie in the upper triangle, above the diagonal. For a precedence matrix, this results in an ordering of the activities that is feasible: if the activities are performed in this order, no activity will have to wait for some activity that is further down the list.

	Excavate foundation	Pour concrete footings	Pour concrete foundation	Frame walls	Build rafters	Install roof and shingles	Install electrical	Install heating	Install plumbing	Install insulation	Add exterior walls and siding	Add interior walls	Finish
Excavate foundation		X											
Pour concrete footings			X										
Pour concrete foundation				X									
Frame walls					X								
Build rafters						X							
Install roof and shingles							X	X	X	X	X	X	
Install electrical												X	
Install heating												X	
Install plumbing												X	
Install insulation												X	
Add exterior walls and siding												X	
Add interior walls													X
Finish													

Figure 1-37. Precedence Matrix in Upper Triangular Form

1.1.6.   Sum rows or columns

The great power of a spreadsheet program is the ability to insert formulas in cells that compute their values depending on values in other cells in the spreadsheet. Complex engineering and financial models can be constructed using this feature. Because of our focus on design, rather than engineering, we make only minimal use of this feature. At a minimum, however, we need to compute sums of numbers in matrices.

In Figure 1-38, we display a matrix from Chapter 3, in which we have tallied the preferences of two parents between pairs of product objectives. For example, cell B3 indicates that both parents prefer "make the toy fun for the child" (the row) to "make the toy fun for the parent" (the column). Of course that means that the entry in cell C2 must be zero since it would represent the contrary preference. Similarly, cell D6 has one parent preferring "make the toy easy to put away" (the row) to "make the toy appealing to the parent" (the column). That is consistent with cell F5 which has one parent with the contrary preference. The cells in the upper triangular portion of the matrix are shaded because they can be determined automatically, once the cells in the uncolored, lower triangular portion have been determined.

In summarizing the preferences, we want to compute the total number of votes each attribute received. That is, we want to compute the total of the tallies for each row of the matrix. The steps below will show how to accomplish this.

(row) is preferred to (column)	Make the toy fun for the parent	Make the toy fun for the child	Make the toy appealing to the parent	Make the toy appealing to the child	Make the toy easy to put away.	Make the toy playable for a long time.	Make the toy easy to repair	Make the toy affordable	
Make the toy fun for the parent		0	2	0	0	0	0	2	
Make the toy fun for the child	2		2	2	2	2	2	2	
Make the toy appealing to the parent	0	0		2	1	0	2	2	
Make the toy appealing to the child	2	0	0		1	0	2	2	
Make the toy easy to put away.	2	0	1	1		0	2	2	
Make the toy playable for a long time.	2	0	2	2	2		2	2	
Make the toy easy to repair	2	0	0	0	0	0		2	
Make the toy affordable	0	0	0	0	0	0	0		

Figure 1-38. Tallied Preferences of Two Parents

46. In cell J2, enter the text "=sum(B2:I2)". The "=" sign signals to the spreadsheet program that this cell contains a formula. The uses a built-in function called "sum()". The argument of this function is the range of cells to include in the sum. In this case, we want all of the cells in the second row from column B to columnI ("B2:I2"). Hit the enter key to enter the formula. Select cell J2 again.

J2 f_x =SUM(B2:I2)

(row) is preferred to (column)	Make the toy fun for the parent	Make the toy fun for the child	Make the toy appealing to the parent	Make the toy appealing to the child	Make the toy easy to put away.	Make the toy playable for a long time.	Make the toy easy to repair	Make the toy affordable	
Make the toy fun for the parent		0	2	0	0	0	0	2	4
Make the toy fun for the child	2		2	2	2	2	2	2	
Make the toy appealing to the parent	0	0		2	1	0	2	2	
Make the toy appealing to the child	2	0	0		1	0	2	2	
Make the toy easy to put away.	2	0	1	1		0	2	2	
Make the toy playable for a long time.	2	0	2	2	2		2	2	
Make the toy easy to repair	2	0	0	0	0	0		2	
Make the toy affordable	0	0	0	0	0	0	0		

Figure 1-39. The Sum Function in a Cell Formula

47. Observe that the result of the summation is displayed in cell J2. Observe also that it treated the blank in cell B2 as a zero when making the computation. Also observe that the formula of the currently selected cell is displayed above

in the formula line, after the "**f_x**" symbol. You can edit the formula on that line if you want to make changes. Just remember to keep the "=" sign at beginning.

48. Place the cursor over the lower right hand corner of selected cell J2. It should change to a simple "+" sign. Drag the corner down to cell J9 and release. (Alternatively, select cell J2 and choose Edit->Copy, then select cells J3:J9 and choose Edit->Paste.) Figure 1-40 shows the result. The formula has been copied into each cell of the range, but with a difference. Observe in cell J3 that the formula now refers to the cells in range B3 to I3 (recall that the formula for the selected cell is displayed in the formula line at the top of the figure). Microsoft Excel has guessed that that is the formula you want for that row.

J3		f_x =SUM(B3:I3)								
	A	B	C	D	E	F	G	H	I	J
1	(row) is preferred to (column)	Make the toy fun for the parent	Make the toy fun for the child	Make the toy appealing to the parent	Make the toy appealing to the child	Make the toy easy to put away.	Make the toy playable for a long time.	Make the toy easy to repair	Make the toy affordable	
2	Make the toy fun for the parent		0	2	0	0	0	0	2	4
3	Make the toy fun for the child	2		2	2	2	2	2	2	14
4	Make the toy appealing to the parent	0	0		2	1	0	2	2	7
5	Make the toy appealing to the child	2	0	0		1	0	2	2	7
6	Make the toy easy to put away.	2	0	1	1		0	2	2	8
7	Make the toy playable for a long time.	2	0	2	2	2		2	2	12
8	Make the toy easy to repair	2	0	0	0	0	0		2	4
9	Make the toy affordable	0	0	0	0	0	0	0		0

Figure 1-40. Dragging a Cell Formula

49. Give the new column in the table a heading, outline the cells, and change the background color to suggest that this column is somewhat different than the other columns in the table. Figure 1-41 shows the result.

(row) is preferred to (column)	Make the toy fun for the parent	Make the toy fun for the child	Make the toy appealing to the parent	Make the toy appealing to the child	Make the toy easy to put away.	Make the toy playable for a long time.	Make the toy easy to repair	Make the toy affordable	Preference Count
Make the toy fun for the parent		0	2	0	0	0	0	2	4
Make the toy fun for the child	2		2	2	2	2	2	2	14
Make the toy appealing to the parent	0	0		2	1	0	2	2	7
Make the toy appealing to the child	2	0	0		1	0	2	2	7
Make the toy easy to put away.	2	0	1	1		0	2	2	8
Make the toy playable for a long time.	2	0	2	2	2		2	2	12
Make the toy easy to repair	2	0	0	0	0	0		2	4
Make the toy affordable	0	0	0	0	0	0	0		0

Figure 1-41. Tallied Preference Matrix with Row Sums

1.1.7.　Sort rows

Continuing the example from the previous section, suppose we wanted to report a ranking of the product objectives based on the number of votes they received. Follow these steps.

50. Copy the final matrix from the previous section (Figure 1-41) to a new worksheet but choose Edit->Paste Special and choose to paste "Values" (Figure 1-42).

Figure 1-42. Paste Values

51. On this sheet, since we pasted values, column J no longer has formula cells that refer to columns B through I. Select columns B through I and delete them. The result should look likeFigure 1-43. We want to sort the rows of this new table

	A	B
1	(row) is preferred to (column)	Preference Count
2	Make the toy fun for the parent	4
3	Make the toy fun for the child	14
4	Make the toy appealing to the parent	7
5	Make the toy appealing to the child	7
6	Make the toy easy to put away.	8
7	Make the toy playable for a long time.	12
8	Make the toy easy to repair	4
9	Make the toy affordable	0

Figure 1-43. Unordered Product Objectives with Preference Counts

52. Select the entire table, A1 through B9 and choose Data->Sort from the menu. Use the first drop down box to pick the column to base the sort on ("Preferred Count" and indicate that we want to sort the rows in descending order. Since we included the header row of table in the selection, indicate that "Header row" is true. The sort dialog should look like Figure 1-44.

	A	B	C	D
1	(row) is preferred to (column)	Preference Count		
2	Make the toy fun for the parent	4		
3	Make the toy fun for the child	14		
4	Make the toy appealing to the parent			
5	Make the toy appealing to the ch[ild]			
6	Make the toy easy t[o] put away.			
7	Make the toy playable for a long time.			
8	Make the toy easy t[o] repair			
9	Make the toy affordable			
10				
11				
12				

Sort ? ✕

Sort by
[Preference Count ▼]   ○ Ascending ⦿ Descending

Then by
[▼]   ⦿ Ascending ○ Descending

Then by
[▼]   ⦿ Ascending ○ Descending

My data range has
⦿ Header row   ○ No header row

[Options...]   [OK]   [Cancel]

Figure 1-44. The Sort Dialog

53. Click "OK" on the sort dialog. The table is automatically sorted (Figure 1-45).

(row) is preferred to (column)	Preference Count
Make the toy fun for the child	14
Make the toy playable for a long time.	12
Make the toy easy to put away.	8
Make the toy appealing to the parent	7
Make the toy appealing to the child	7
Make the toy fun for the parent	4
Make the toy easy to repair	4
Make the toy affordable	0

Figure 1-45. Product Objectives Ordered By Preference Count

1.1.8.   Create charts

Microsoft Excel provides a wide array of preformatted charts for displaying your data. For this section we will use competitive benchmarking data from Chapter 4. Figure 1-46 lists customer scores for two competitive products ("Catapult Kit" and "Catapult Replica") in seven product objective categories ranging from "visual appeal" to "affordability." All the scores are normalized to lie between 1 and 5. We would like to display these data in a chart.

In the language of MS Excel charts, the number in each cell is a "data point" and each column of numbers is a "data series".

|	A	B	C
1		Catapult Kit	Catapult Replica
2	Visual Appeal (1: Unattractive - 5: Very Attractive)	2	5
3	Performance (1: Poor - 5: Excellent)	5	1
4	Safety (1: Age 12+ - 5: Age 3+)	1.5	4.5
5	Reliability (1: Poor - 5: Excellent)	1.5	5
6	Ease of Repair (1: Poor - 5: Excellent)	4.5	2.5
7	Ease of Storage (1: Poor - 5: Excellent)	3.5	4
8	Affordability (1: Poor - 5: Excellent)	3	4

Figure 1-46. Customer Attribute Scores for Two Benchmarked Products

54. The row headers are quite descriptive but they are too long to serve well as labels in a chart. Create a simpler set of row labels off to the side (Figure 1-47).

|	A	B	C	D	E
1		Catapult Kit	Catapult Replica		
2	Visual Appeal (1: Unattractive - 5: Very Attractive)	2	5		Visual appeal
3	Performance (1: Poor - 5: Excellent)	5	1		Performance
4	Safety (1: Age 12+ - 5: Age 3+)	1.5	4.5		Safety
5	Reliability (1: Poor - 5: Excellent)	1.5	5		Reliability
6	Ease of Repair (1: Poor - 5: Excellent)	4.5	2.5		Ease of repair
7	Ease of Storage (1: Poor - 5: Excellent)	3.5	4		Ease of storage
8	Affordability (1: Poor - 5: Excellent)	3	4		Affordability
9					

Figure 1-47. Simplified Row Headers

55. Select the entire table, including heading rows and columns (cells A1 through C8).
56. Choose menu Insert->Chart to launch the chart wizard (Figure 1-48)
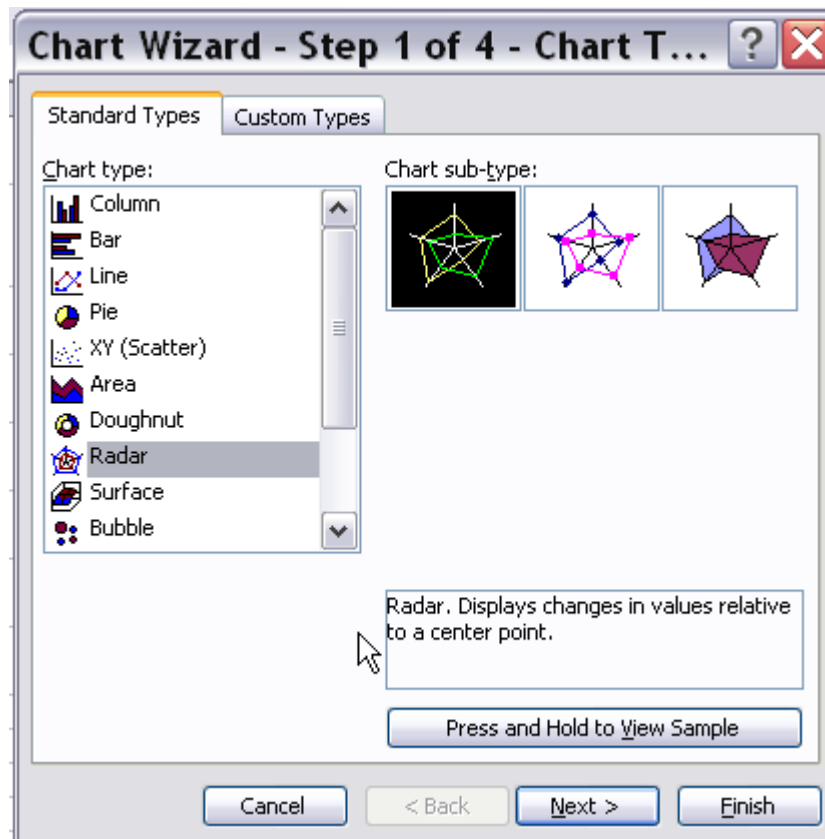
**Figure 1-48. Chart Wizard: Choose Chart Type**

57. As shown in Figure 1-48, choose the Radar chart type and the lines only sub-type. Click Next.
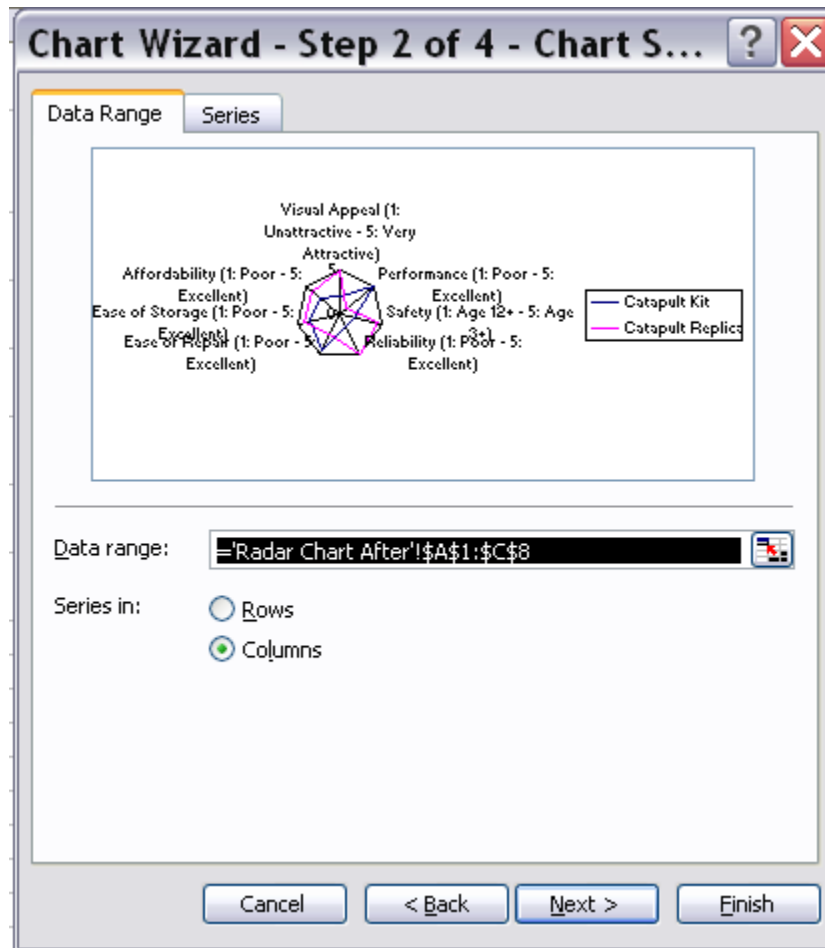
Figure 1-49. Chart Wizard: Data Source

58. Observe that the range A1 to C8 is the source data for the chart and that MS Excel has correctly deduced that our data series are in columns. Click the Series tab of this Wizard step. Figure 1-50 results.
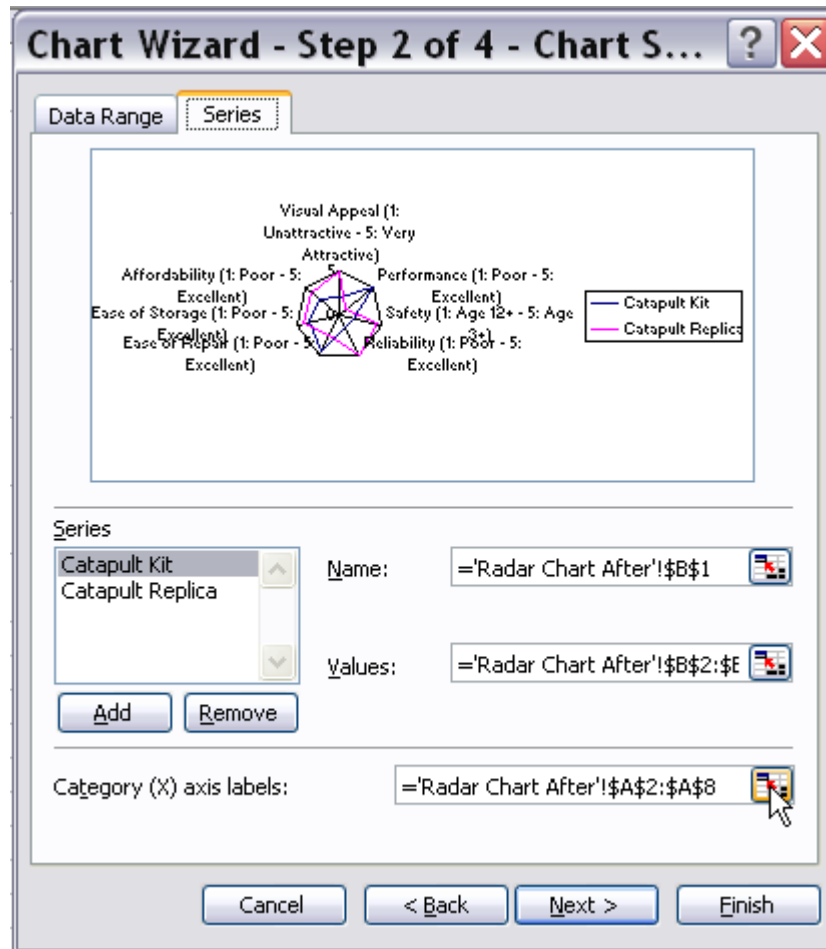
Figure 1-50. Chart Wizard: Series Detail

59. Observe that MS Excel has correctly discovered our two data series and located the name of the series in row 1 and the values in rows 2 through 8. For the X-axis labels it picked column A but, as you recall, these heading are quite verbose. We will change that choice. Click the spreadsheet symbol as shown in Figure 1-50.
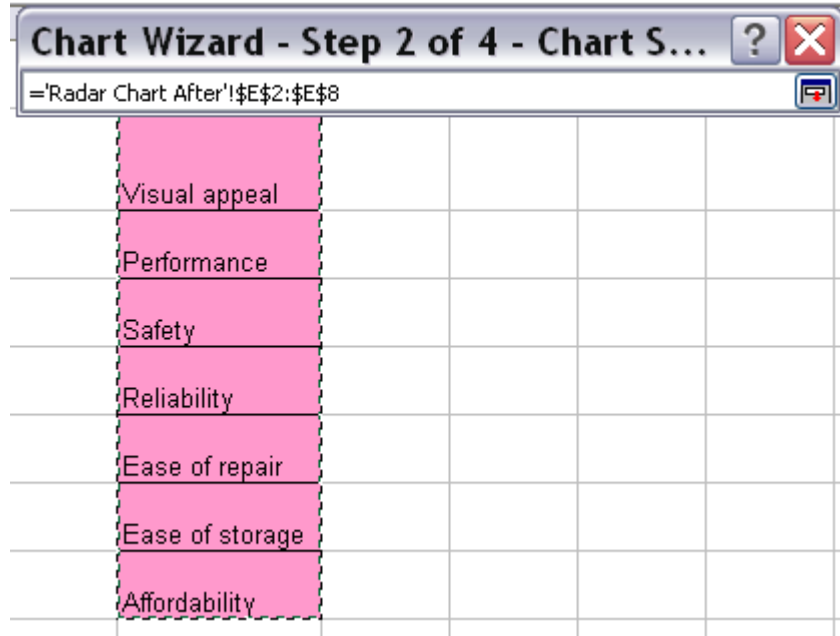
Figure 1-51. Chart Wizard: Selection Tool

60. Select cells E2 through E8, which have the simplified row headings. Click the "finish selection" button in the wizard as shown in Figure 1-52.

Figure 1-52. Chart Wizard: Finish Selection Button

61. The Category X Labels will now be taken from cells E2 to E8 as shown in Figure 1-53.
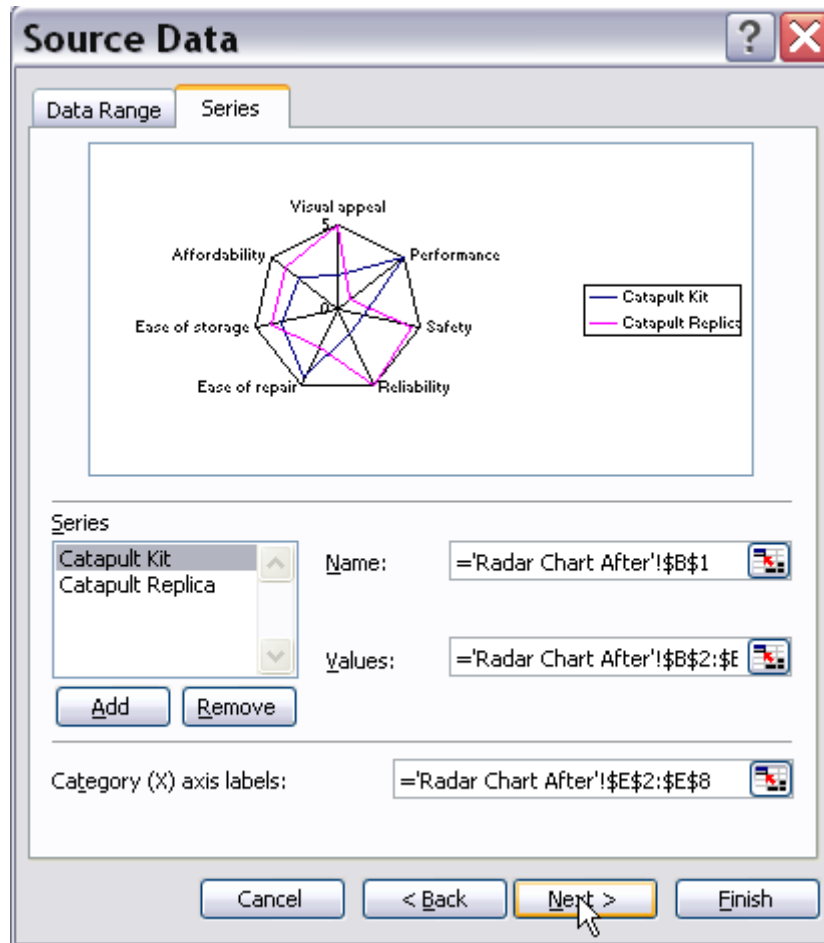
Figure 1-53. Chart Wizard: Corrected Series Detail

62. Click Next, as shown in Figure 1-53. Enter a suitable title for the Chart Title (Figure 1-54).
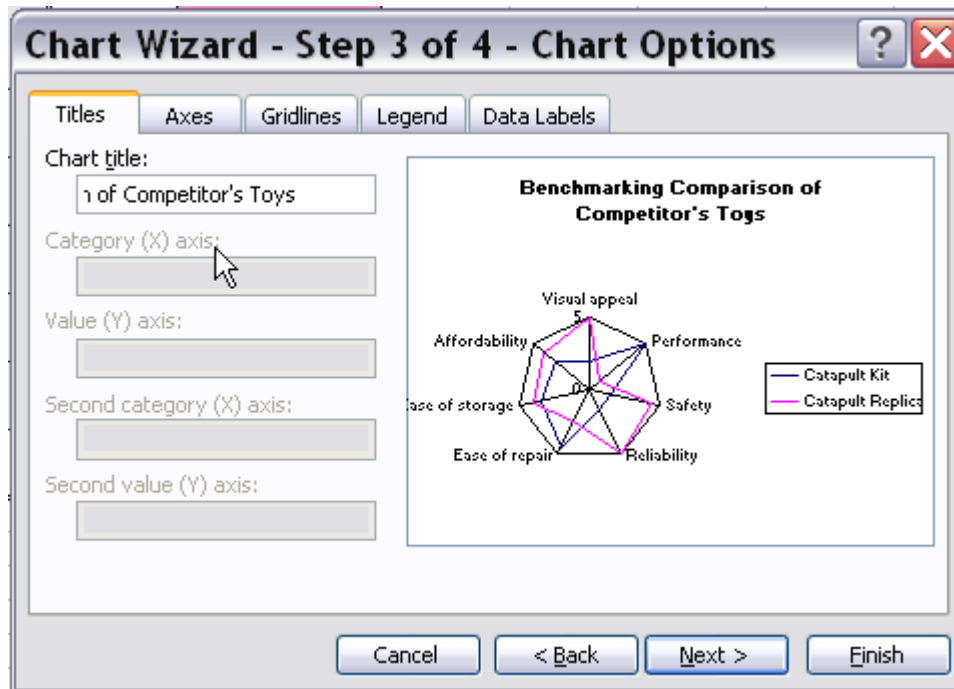
Figure 1-54. Chart Wizard: Titles

63. On the legend tab of this wizard step, set "bottom" to true. This places the legend under the chart (Figure 1-55
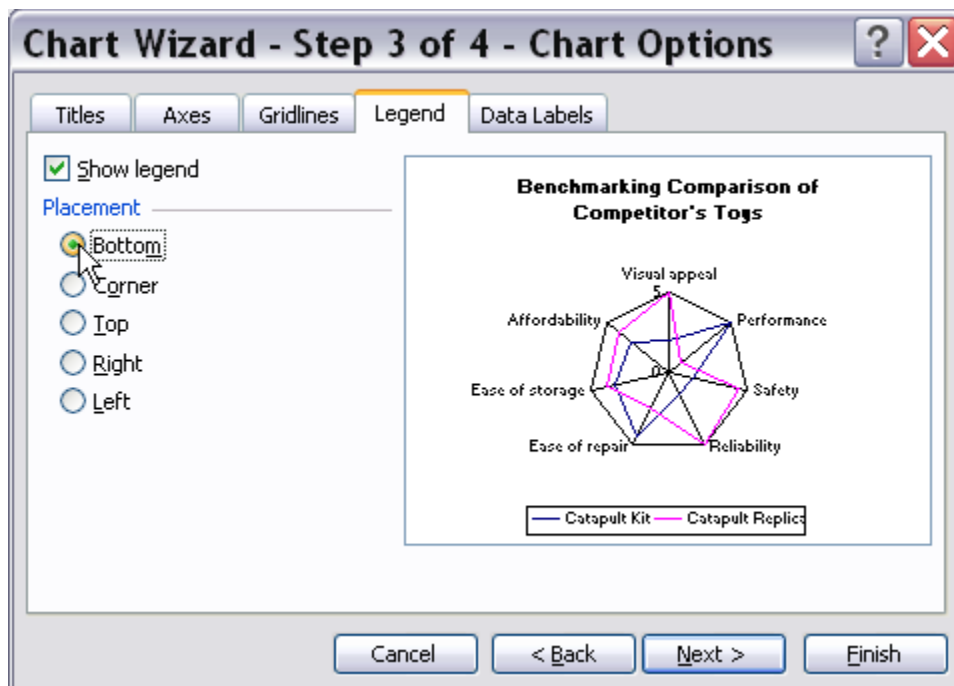
Figure 1-55. Chart Wizard: Legend

64. Click "Finish". Figure 1-56 shows the initial rendering of the chart. It is too small and the data series are hard to see. We will improve the formatting.

Benchmarking Comparison of Competitor's Toys

Visual appeal

Affordability   Performance

Ease of storage   Safety

Ease of repair   Reliability

— Catapult Kit — Catapult Replica
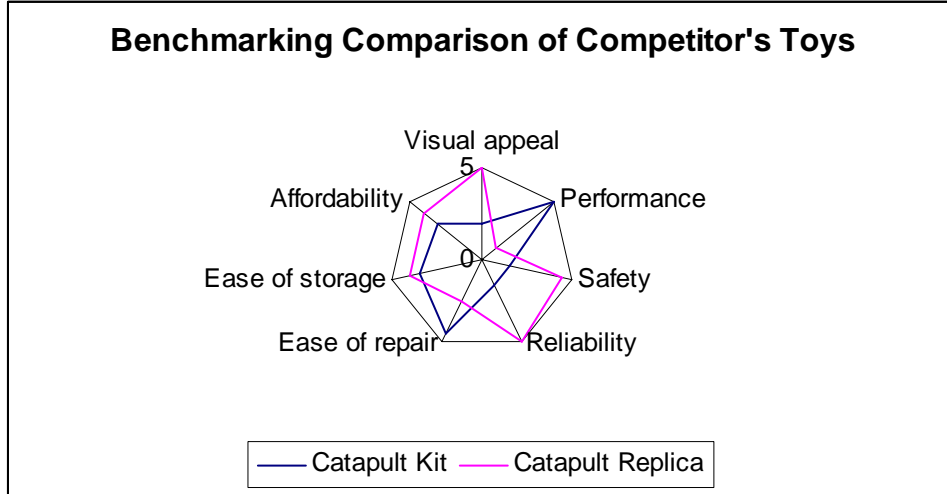
Figure 1-56. Initial Chart Rendering

65. Drag the lower right corner of the chart to enlarge it. Then select one of the data series by clicking on one of the lines connecting the datapoints, as shown in Figure 1-57.

Benchmarking Comparison of Competitor's Toys

Visual appeal

Affordability   Performance

Series "Catapult Replica" Point "Visual appeal"

Ease of storage   Safety

Ease of repair   Reliability

— Catapult Kit — Catapult Replica
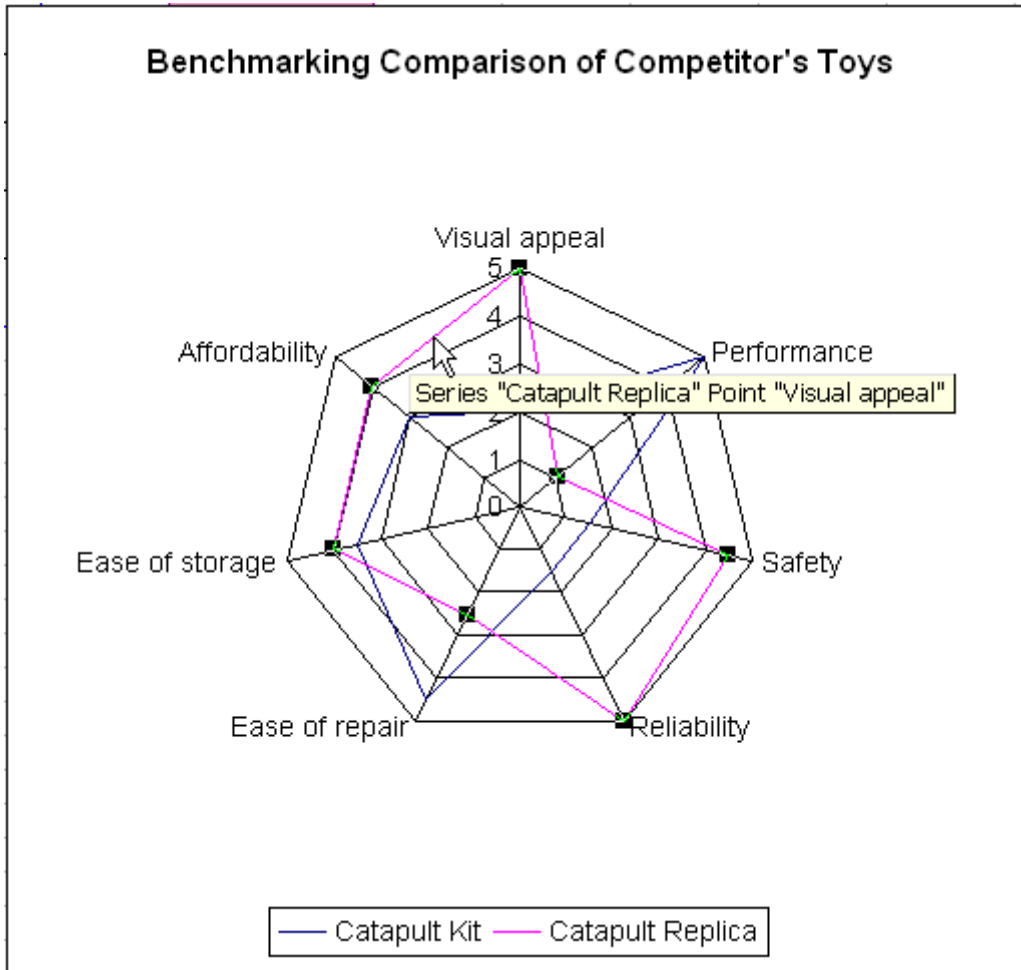
Figure 1-57. Selected Chart Data Series

66. Right-click on the data series and select "Format data series" from the pop-up menu, as shown in Figure 1-58.
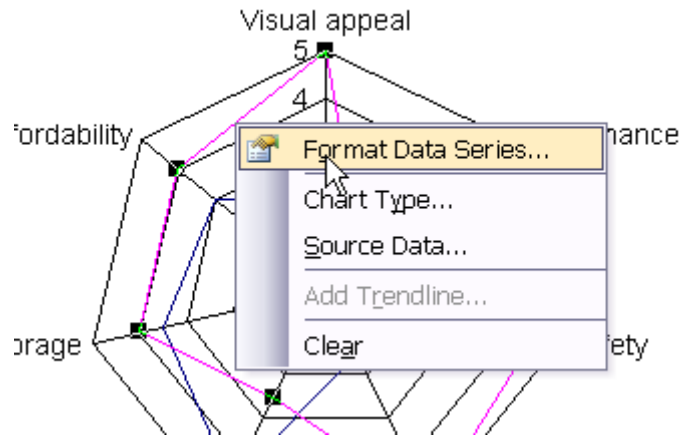
Figure 1-58. Pop-up Menu for Data Series

67. In the dialog box that appears (Figure 1-59), choose a bold color and a thick line weight, as shown.
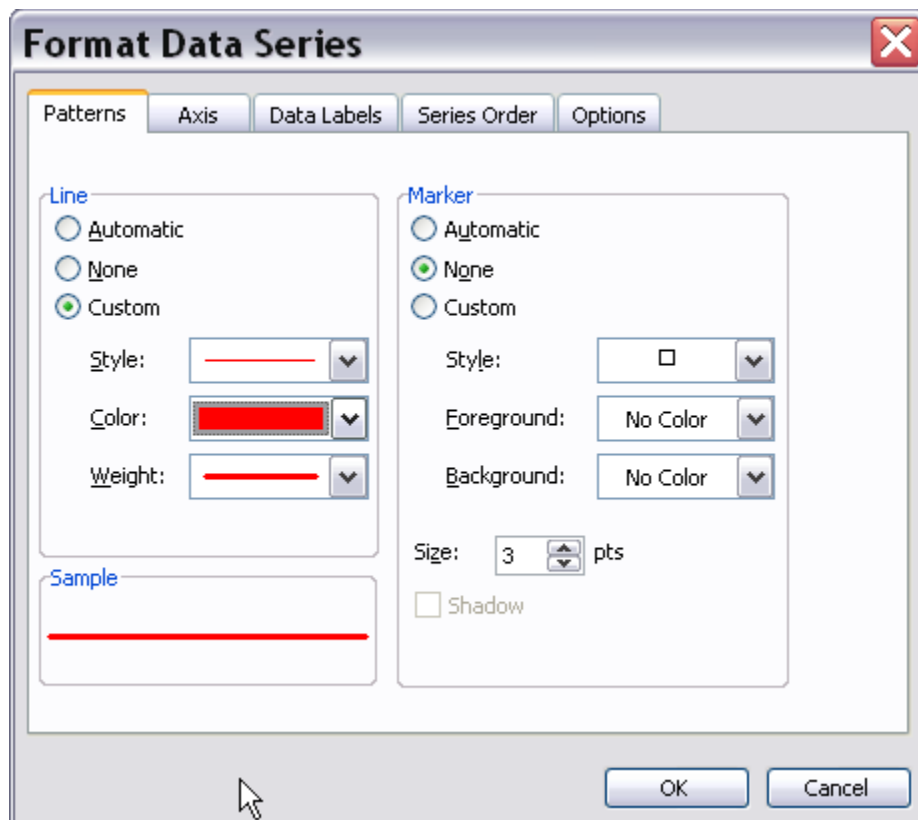
Figure 1-59. Format Data Series

68. Click "OK" and then repeat the process for the other data series, choosing a different bold color. Figure 1-60 is the resulting chart.
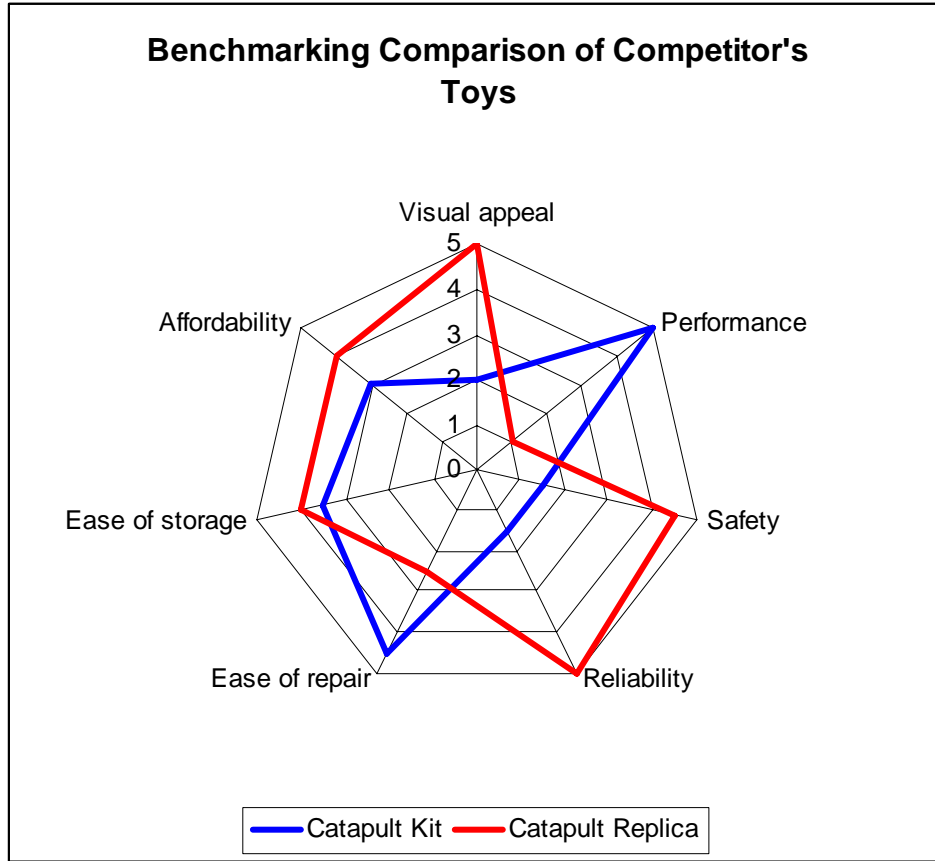
Figure 1-60. Radar Chart of Benchmarking Data

69. Other chart types are possible. Copy the chart to a new location. Then right-click the chart and select "Chart Type" from the pop-up menu (Figure 1-61).
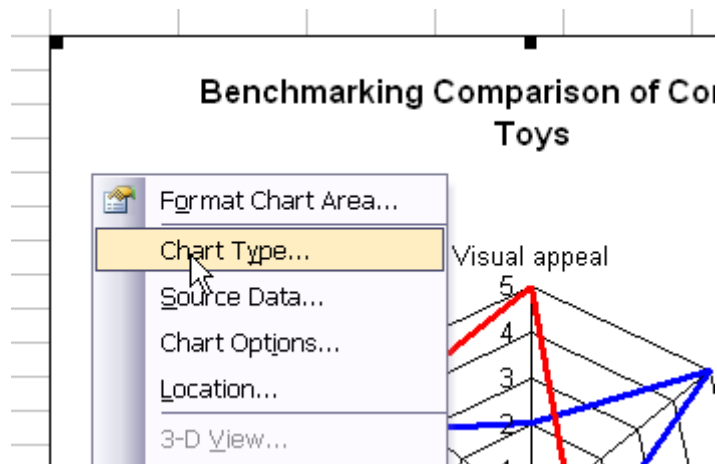
Figure 1-61. Chart Popup Menu

70. Select the "Column" type of chart and click "OK". Figure 1-62 results. Which chart conveys the data best to your audience? That is for you and your audience to decide.
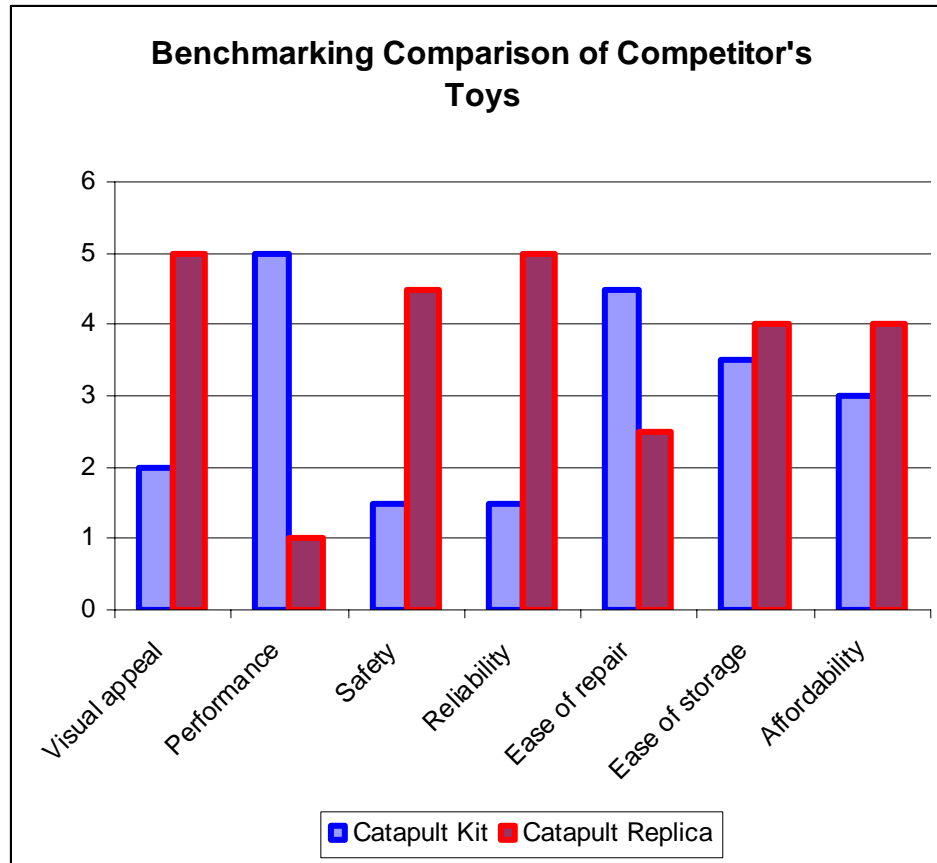
Figure 1-62. Column Chart Type

1.1.9.   Use lookup formulas

It is often useful in MS Excel to create formulas that get their values by looking up in a table for some matching name or number. We use that feature when we introduce project scheduling in Chapter 7. In that case, the reference table is a list of activities, giving the name of the activity, the duration in hours, how many hours have been completed and how many hours remain to be completed (Figure 1-63). Each activity has been given a unique number, such as A.01, and the table is sorted alphabetically by these activity numbers.

	Activity Number	Activity Name	Duration (Hrs)	Percent Complete (0-100)	Work Completed	Work Remaining
2	A.01	Develop Subsystem Requirements	1	50	0.5	0.5
3	A.02	Design Projectile Launch System	0.5	0	0	0.5
4	A.03	Build Projectile Launch System	0.5	0	0	0.5
5	A.04	Test Projectile Launch System	0.1	0	0	0.1
6	A.05	Design Energy Storage System	0.5	0	0	0.5
7	A.06	Build Energy Storage System	0.5	0	0	0.5
8	A.07	Test Energy Storage System	0.1	0	0	0.1
9	A.08	Design Projectile Containment System	0.5	0	0	0.5
10	A.09	Build Projectile Containment System	0.4	0	0	0.4
11	A.10	Test Projectile Containment System	0.1	0	0	0.1
12	A.11	Design Lock and Trigger System	0.5	0	0	0.5
13	A.12	Build Lock and Trigger System	0.75	0	0	0.75
14	A.13	Test Lock and Trigger System	0.3	0	0	0.3
15	A.14	Design Body (Enclosure System)	0.4	0	0	0.4
16	A.15	Build Body (Enclosure System)	0.5	0	0	0.5
17	A.16	Test Body (Enclosure System)	0.1	0	0	0.1
18	A.17	Integrate Launch and Storage Systems	0.2	0	0	0.2
19	A.18	Integrate Launch, Storage and Containment Systems	0.2	0	0	0.2
20	A.19	Integrate Working System	0.4	0	0	0.4
21	TP.01	Test Procedure: Child plays with toy	0.5	0	0	0.5
22	TP.02	Test Procedure: Child fails to arm toy.	0.2	0	0	0.2
23	TP.03	Test Procedure: Child releases armed toy near face of self or another child	0.4	0	0	0.4
24	TP.04	Test Procedure: Child aims projectile at eyes of self or of another child	0.4	0	0	0.4
25	TP.05	Test Procedure: Child uses pet rodent as projectile	0.4	0	0	0.4
26	TP.06	Test Procedure: The child drops or throws the toy.	0.4	0	0	0.4
27	TP.07	Maximum launch velocity	1	0	0	1
28	TP.08	Maximum mass launch capability	0.2	0	0	0.2
29	TP.09	Storage volume	0.1	0	0	0.1
30	TP.10	Mean cycles to failure	5	0	0	5
31	TP.11	Breaking force of critical components	1	0	0	1
32	TP.12	Repair part cost	0.1	0	0	0.1
33	TP.13	Tensile strength of home-applied adhesive bond	1	0	0	1
34	TP.14	Time for disassembly and reassembly	0.1	0	0	0.1
35	TP.15	Material cost	0.1	0	0	0.1
36	TP.16	Time to manufacture	0.1	0	0	0.1
37		Total	18.55		0.5	18.05

Figure 1-63. Reference Table Describing Activities

Also in Chapter 7 we describe a process by which we can assign start times to each activity so that the overall project is finished as quickly as possible. For the example in Chapter 7, that led to the schedule of activity start times shown in Figure 1-64. Not all activities can start at once because of precedence relationships (for example, you cannot test a subsystem until you have first built it).

	A	B
1		**Start**
2	**Activity**	
3	A.01	0
4	A.02	1
5	A.03	1.5
6	A.04	2
7	A.05	1
8	A.06	1.5
9	A.07	2
10	A.08	1
11	A.09	1.5
12	A.10	1.9
13	A.11	1
14	A.12	1.5
15	A.13	2.25
16	A.14	1.5
17	A.17	2.1
18	A.18	2.3
19	TP.07	2.5
20	TP.08	2.5
21	A.15	3.5
22	A.16	4
23	A.19	2.55
24	TP.02	2.5
25	TP.03	2.5
26	TP.04	2.5
27	TP.01	2.95
28	TP.05	2.95
29	TP.06	2.95
30	TP.09	1.9
31	TP.10	2.95
32	TP.11	2.1
33	TP.12	1.9
34	TP.13	2.1
35	TP.14	1.9
36	TP.15	1.9
37	TP.16	1.9

Figure 1-64. Schedule of Activity Start Times

Now, what we want to do is to compute the finish times of each activity and to attach the activity names to the schedule of start times. This would be an easy matter of copying data from the reference table (Figure 1-63), except that the activities in the schedule are ordered differently. One solution would be to sort the schedule in Figure 1-64 so that the activity numbers are in alphabetical order to match the reference table. Let us say, however, that we have good reason not to change the order of Figure 1-64. The following steps show how to use table lookups to get all the data we need.

71. Select all the cells of the reference table except the heading and the total rows. That is, select cells A2 to F36.
72. Choose menu Insert->Name->Define. The dialog for defining names for cell ranges should appear (Figure 1-65).

Figure 1-65. Define Cell Range Name Dialog

73. Observe that the cell range is A2 to F36, as desired but the default name for this range, "Activity_Number", is not descriptive of the contents. Change the name to "ActivityTable" and then click "Add". Then click "OK". We can now refer to this collection of cells by the name "ActivityTable" instead of having to remember the range as "A2:F36".

74. In cell C3 of the schedule spreadsheet, enter the formula "=Vlookup(A3,ActivityTable,5)". This instructs the spreadsheet program to take the contents of cell A3, currrently "A.01" and find the matching row (a "vertical lookup") in the ActivityTable cell range, and return the value found in the fifth column. The fifth column of the ActivityTable corresponds to the "Work Completed" value.

Figure 1-66. Look up "Work Completed" Entry for Activity A.01

75. Observe that the value returned in cell C3, zero, does not appear to be correct. It should be 0.5 (see cell E2 in Figure 1-63). The problem is that the cell format in column C is not set to display decimal fractions. Use Format->Cells->Number to set the number to one decimal place.

76. Add heading labels to cells C1 and D1, and enter the formula "=vlookup(A3,ActivityTable,6) into cell D3, as shown in Figure 1-67.

D3	▼		fx =VLOOKUP(A3,ActivityTable,6)			
	A	B	C	D	E	F	G
1		Start	Work Completed	Work Remaining			
2	Activity						
3	A.01	0	0.5	0.5			
4	A.02	1					
5	A.03	1.5					

Figure 1-67. Look up "Work Remaining" Entry for Activity A.01

77. Add a heading label in cell E1 and add a formula to cell E3 to compute the finish time of the activity. The finish time is the start time plus the work completed plus the work remaining. So, enter the formula "=sum(B3:D3)." Figure 1-68 illustrates.

E3	▼		fx =SUM(B3:D3)		
	A	B	C	D	E	F
1		Start	Work Completed	Work Remaining	Finish	
2	Activity					
3	A.01	0	0.5	0.5	1.0	
4	A.02	1				

Figure 1-68. Compute Finish Time

78. Add a heading label in cell F1 and add a formula to cell F3 to look up the ActivityName of the activity. The formula is "=vlookup(A3,ActivityTable,2)" since the ActivityName is the second column of the ActivityTable. Figure 1-69 shows the result.

F3	▼		fx =VLOOKUP(A3,ActivityTable,2)		
	A	B	C	D	E	F
1		Start	Work Completed	Work Remaining	Finish	Description
2	Activity					
3	A.01	0	0.5	0.5	1.0	Develop Subsystem Requirements
4	A.02	1				
5	A.03	1.5				

Figure 1-69. Look up "ActivityName" Entry for Activity A.01

79. Copy cells B3:F3 down to fill out the table. Figure 1-70 is the result.

	A	B	C	D	E	F
1		Start	Work Completed	Work Remaining	Finish	Description
2	Activity					
3	A.01	0	0.5	0.5	1.0	Develop Subsystem Requirements
4	A.02	1	0.0	0.5	1.5	Design Projectile Launch System
5	A.03	1.5	0.0	0.5	2.0	Build Projectile Launch System
6	A.04	2	0.0	0.1	2.1	Test Projectile Launch System
7	A.05	1	0.0	0.5	1.5	Design Energy Storage System
8	A.06	1.5	0.0	0.5	2.0	Build Energy Storage System
9	A.07	2	0.0	0.1	2.1	Test Energy Storage System
10	A.08	1	0.0	0.5	1.5	Design Projectile Containment System
11	A.09	1.5	0.0	0.4	1.9	Build Projectile Containment System
12	A.10	1.9	0.0	0.1	2.0	Test Projectile Containment System
13	A.11	1	0.0	0.5	1.5	Design Lock and Trigger System
14	A.12	1.5	0.0	0.75	2.3	Build Lock and Trigger System
15	A.13	2.25	0.0	0.3	2.6	Test Lock and Trigger System
16	A.14	1.5	0.0	0.4	1.9	Design Body (Enclosure System)
17	A.17	2.1	0.0	0.2	2.3	Integrate Launch and Storage Systems
18	A.18	2.3	0.0	0.2	2.5	Integrate Launch, Storage and Containment Systems
19	TP.07	2.5	0.0	1	3.5	Maximum launch velocity
20	TP.08	2.5	0.0	0.2	2.7	Maximum mass launch capability
21	A.15	3.5	0.0	0.5	4.0	Build Body (Enclosure System)
22	A.16	4	0.0	0.1	4.1	Test Body (Enclosure System)
23	A.19	2.55	0.0	0.4	3.0	Integrate Working System
24	TP.02	2.5	0.0	0.2	2.7	Test Procedure: Child fails to arm toy.
25	TP.03	2.5	0.0	0.4	2.9	Test Procedure: Child releases armed toy near face of self or another child
26	TP.04	2.5	0.0	0.4	2.9	Test Procedure: Child aims projectile at eyes of self or of another child
27	TP.01	2.95	0.0	0.5	3.5	Test Procedure: Child plays with toy
28	TP.05	2.95	0.0	0.4	3.4	Test Procedure: Child uses pet rodent as projectile
29	TP.06	2.95	0.0	0.4	3.4	Test Procedure: The child drops or throws the toy.
30	TP.09	1.9	0.0	0.1	2.0	Storage volume
31	TP.10	2.95	0.0	5	8.0	Mean cycles to failure
32	TP.11	2.1	0.0	1	3.1	Breaking force of critical components
33	TP.12	1.9	0.0	0.1	2.0	Repair part cost
34	TP.13	2.1	0.0	1	3.1	Tensile strength of home-applied adhesive bond
35	TP.14	1.9	0.0	0.1	2.0	Time for disassembly and reassembly
36	TP.15	1.9	0.0	0.1	2.0	Material cost
37	TP.16	1.9	0.0	0.1	2.0	Time to manufacture

Figure 1-70. Completed Schedule

1.1.10. Display Gantt chart

In this section, we continue the example from the previous section and show how to display the completed schedule (Figure 1-70) as a Gantt chart.

Gantt charts are not one of the chart types supported by MS Excel. However, there is a simple trick that can be employed to use the stacked bar chart in MS Excel to display Gantt charts. We describe the trick briefly here. Further help can be found using "Microsoft Office Online." The steps to create a Gantt chart from Figure 1-70 are as follows:

Select cells B3:D37 in Figure 1-70.
80. Click the Chart Wizard on the MS Excel toolbar.
81. Select the Bar chart type and the Stacked Bar chart sub-type.
82. Click "Next" and then click the "Series" tab.
83. For the category (X) axis labels, select range F3:F37.
84. For the name of Series2, select C1.
85. For the name of Series3, select D1.

86. Click "Next".
87. On the titles tab, enter a chart title such as "Gantt Chart of Toy Catapult Design, Build, and Test"
88. On the Gridlines tab, select Minor gridlines for the category (X) axis.
89. On the Legend tab, select "Bottom" placement for the legend.
90. Click "Finish".
91. After the chart appears, click one of the horizontal bars representing Series1.
92. Right click the same bar and choose "Format Data Series" from the popup menu.
93. On the Patterns tab, select "None" for Border and "Node" for area.
94. Click "OK". This makes Series1 disappear.
95. Right click the vertical axis and choose "Format axis" from the popup menu.
96. On the scale tab, set the "Number of categories between tickmark labels" to 1 and check the box for "Categories in reverse order".
97. Select the text "Series1" in the legend and delete it.
98. Finish formatting the chart using standard techniques (adjust font sizes, clear background color, etc.). Figure 1-71 is the final result.

The trick is to make Series1 (representing the start times) disappear, leaving the remaining stacked bars visible starting at the appropriate start times against the horizontal axis.
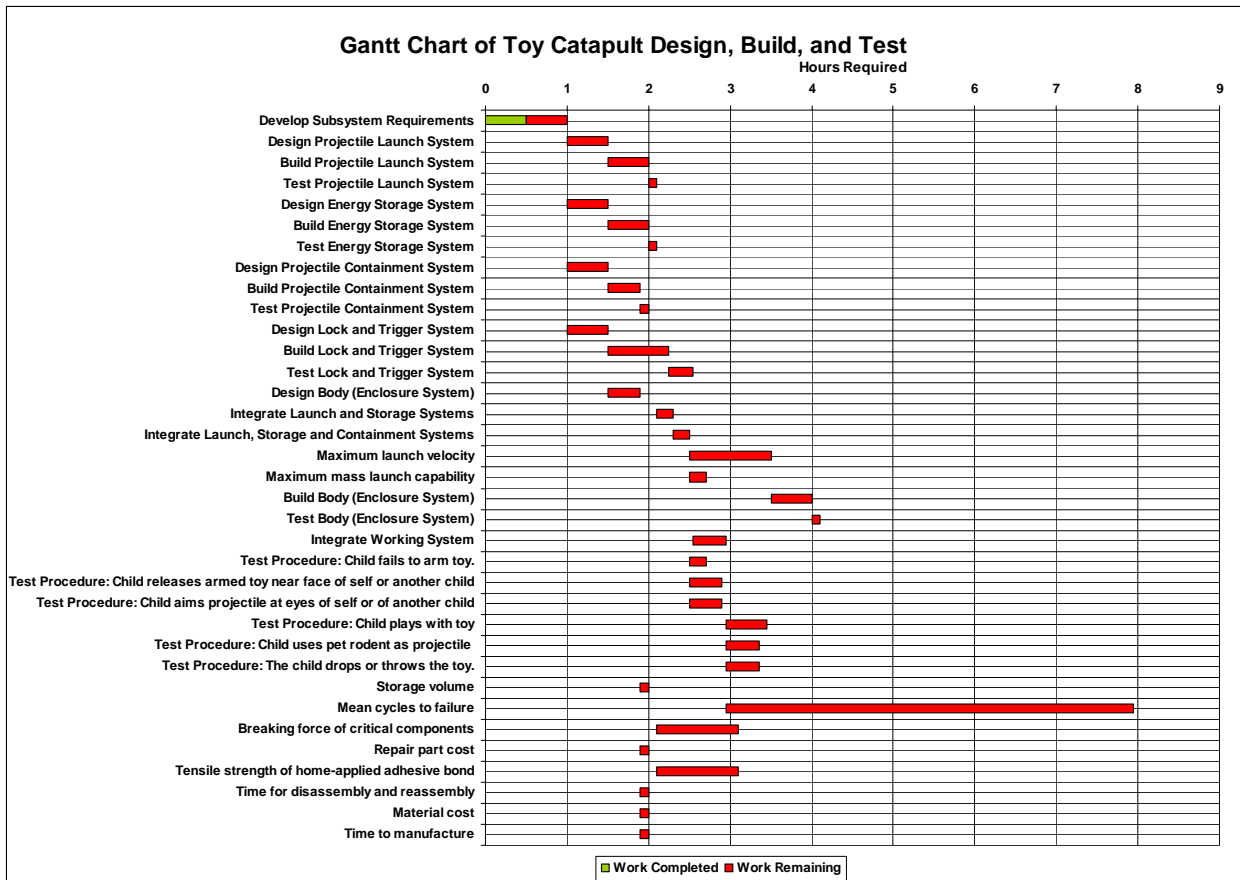

Figure 1-71: Gantt Chart of Toy Catapult Design, Build, and Test