MATHEMATICAL PROGRAMMING

Use these techniques to generate comparative totals and perform sophisticated rounding operations.

Clever Calculation Routines

BY CHARLES W. KYD

Have you ever had to generate comparative totals? Perhaps you were asked to compare the previous quarter's performance against the current quarter's to see whether the cost of sales was rising or falling. You probably accomplished this task by writing a few @SUM formulas and copying them down the worksheet. That wasn't too much work. But what if your mission were to generate an entire series of comparisons? Writing and rewriting all those @SUMs would be drudgery.

Have you ever needed a formula that always rounded a number up by a certain amount or always rounded a number down by a certain amount? Perhaps you were in charge of pricing for your company's product line and your policy was that every item's price should be marked up by a certain percent and then rounded up to the nearest $25. Performing those calculations by hand could take hours.

This article contains two clever models to help you with these scenarios. The first model automatically generates comparative totals. You enter a few @DATE formulas, indicating the beginning and end of the periods you wish to compare. Formulas in the model determine and pass the correct ranges to the @SUM formulas. Using these formulas, you can generate comparative totals as quickly as the spreadsheet recalculates. The second model contains formulas that simply round, either always up or always down. You copy the appropriate rounding formula into your spreadsheet and then enter a few parameters—for example, the amount by which you want to round—and the spreadsheet does the rest of the work for you.

GENERATING COMPARATIVE TOTALS

You can combine the @@ function and the @SUM function to create clever totaling formulas. A model using such formulas appears in figure 1, which contains financial data for the Westbay Marine company. This model allows you to generate comparative finance reports. To begin the process, you enter the performance for each month, as shown in columns E through K. Then in rows 16 and 17, you define the periods you wish to compare. When you recalculate the spreadsheet, columns B and C in the Performance Summary section summarize the columns for the dates you've entered.

For example, the spreadsheet in the figure compares the quarter ending December 1987 with the quarter ending March 1988. Formulas in range B22..B27 summarize performance for the earlier quarter, formulas in range C22..C27 summarize performance for the later quarter, and a simple subtraction formula in range D22..D27 calculates the change between these periods.

The advantage to this approach is that by changing the @DATE formulas in range B16..C17, you can compare any two periods of any length. For example, if the data were available, you could compare income for the most recent 12 months to another 12-month period ending five months earlier. You could compare income for the first seven months of a new ad campaign to income for the seven months preceding the campaign. In short, you can compare the data contained in any two contiguous sets of columns.

To build the model, begin in an empty worksheet. Press slash and select Worksheet Global Recalculation Manual (in *Symphony* press MENU and select Settings Recalculation Method Manual Quit). To set the width of column A to 20, position the pointer in cell A1, select /Worksheet Column Set-Width (in *Symphony*, MENU Width Set), enter the value 20, and press Return. Then enter the labels and dashed lines shown in rows 1 through 21 and range A22..A27. (Don't enter the dates shown in ranges B16..C17, D3..D4, and E20..K20.) To obtain the dashed lines, enter a backslash and either a hyphen or an equal sign (\- or \=) in the first cell of the range. Then copy the cell

Charles W. Kyd, a regular contributor to the LOTUS *Accounting column, is a computer consultant in Seattle.*

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Compare one season's view of the data . . .

across the row as necessary. To create the broken dashed lines in row 21, position the pointer in cell B21, type a backslash, press the Spacebar once, and enter a series, say 10 or so, of dashes. Then copy cell B21 to range C21..K21.

Enter the number 5 in cell D4 and enter the data shown in range E22..K27. You'll learn why you've entered the number 5 in a moment. Now follow the instructions in Setup Table 1 to format ranges, enter formulas, and copy ranges. Note that the formulas that initially produce ERR will calculate correctly after the copy operations.

THE AUTOMATIC @SUM

Let's consider how the model shown in figure 1 works. The first period for which this worksheet shows data is October 1987; therefore, cell D3 contains that month as the starting date. Cell D4 contains the number 5, which represents the number of the first column containing data. To determine this, you simply count over from column A. Column E is the fifth column over and the first column containing actual data. Once you enter the dates of the periods you wish to compare in the Performance Summary section (range B16..C17) and press the CALC key, the

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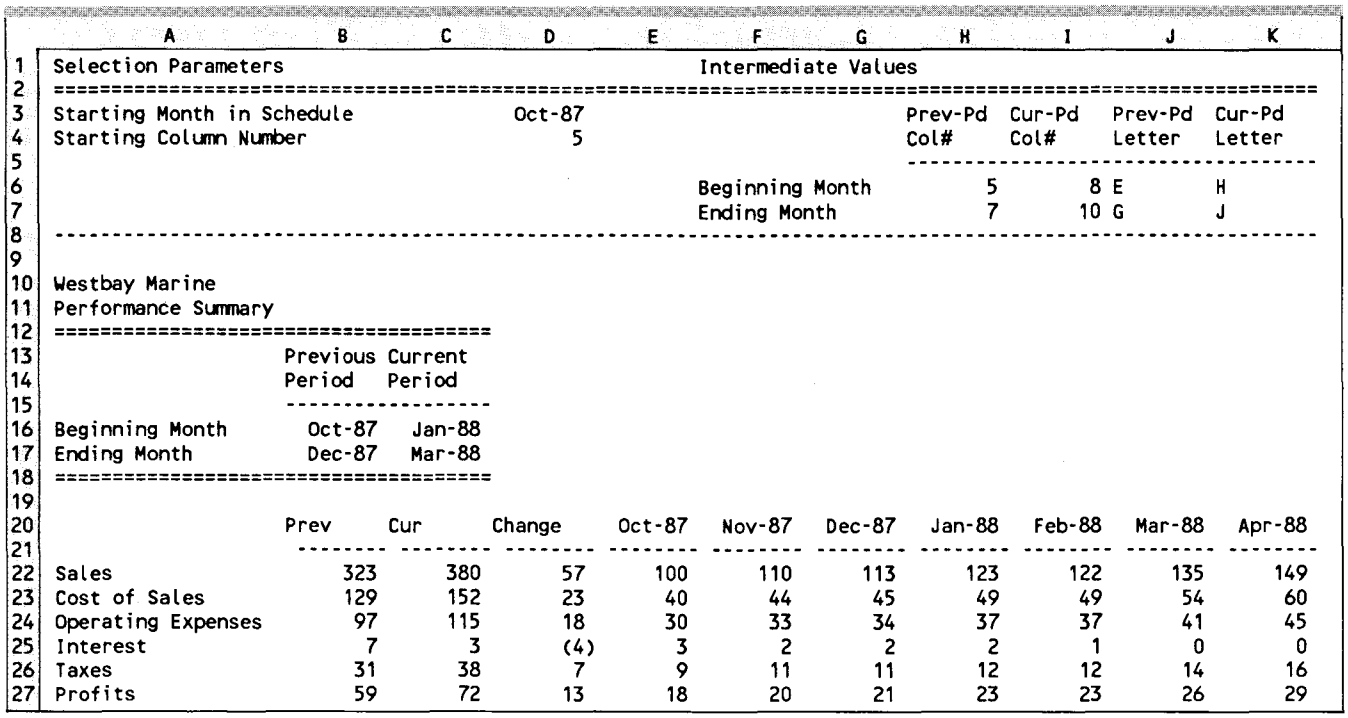

	A	B	C	D	E	F	G	H	I	J	K
1	Selection Parameters					Intermediate Values					
2	==========										
3	Starting Month in Schedule			Oct-87				Prev-Pd Col#	Cur-Pd Col#	Prev-Pd Letter	Cur-Pd Letter
4	Starting Column Number			5							
5											
6						Beginning Month		5	8	E	H
7						Ending Month		7	10	G	J
8	----------										
9											
10	Westbay Marine										
11	Performance Summary										
12	==========										
13		Previous Current									
14		Period Period									
15		----------									
16	Beginning Month	Oct-87 Jan-88									
17	Ending Month	Dec-87 Mar-88									
18	==========										
19											
20		Prev	Cur	Change	Oct-87	Nov-87	Dec-87	Jan-88	Feb-88	Mar-88	Apr-88
21		--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
22	Sales	323	380	57	100	110	113	123	122	135	149
23	Cost of Sales	129	152	23	40	44	45	49	49	54	60
24	Operating Expenses	97	115	18	30	33	34	37	37	41	45
25	Interest	7	3	(4)	3	2	2	2	1	0	0
26	Taxes	31	38	7	9	11	11	12	12	14	16
27	Profits	59	72	13	18	20	21	23	23	26	29

FIGURE 1. A model for generating comparative totals. All you do is enter the dates of the periods you wish to compare in range B16..C17 and press CALC; formulas automatically generate the proper range addresses to pass to the @SUM formulas in range B22..C27.

SETUP TABLE 1

Format	Range
Date 3	D3
Date 3	B16..C17
Date 3	E20..F20
Comma (Punctuated), Ø decimals	B22..K27

Cell	Formula
D3	@DATE(87,10,15)
B16	@DATE(87,10,15)
B17	@DATE(87,12,15)
C16	@DATE(88,1,15)
C17	@DATE(88,3,15)
H6	@ROUND((B16 − D3)/30.4375,Ø) + D4
J6	@IF(H6>26,@CHAR(64 + @INT ((H6 − 1)/26)),"")& @CHAR(64 + @MOD (H6 − 1,26) + 1)
E20	+ D3
F20	+ E20 + 30.4375
B22	@SUM(@@(J$6&@STRING(@CELL ("row",$E22..$E22), Ø)&"."&J$7&@STRING (@CELL("row",$E22..$E22),Ø)))
D22	+ C22 − B22

Copy From	Copy To
H6	H6..I7
J6	J6..K7
F20	G20..K20
B22	B22..C27
D22	D22..D27

model generates the comparative totals.

Determining the ranges that each @SUM formula will total is actually a three-step, or three-formula, process. The first phase is carried out by formulas in range H6..I7, which calculate the numbers of the columns containing data corresponding to the dates you enter in range B16..C17. For example, the following formula, in cell I6, returns the value 8:

@ROUND((C16 − D3)/30.4375,Ø) + D4

This formula subtracts the serial value of October 1987 from the serial value of January 1988 to determine the number of elapsed days. Then the formula divides that total by 30.4375, which is the average number of days in a month. When it rounds the result to zero decimal places, the formula derives a whole integer that represents the number of elapsed months. This whole integer is added to the starting column number in cell D4 to determine the column number containing the data for January 1988.

Knowing a column number is nice, but it's no help when you're trying to feed a range to an @SUM formula. @SUMs don't deal in column numbers; they want letters. The second set of formulas, located in range J6..K7, converts the column numbers into column letters, which @SUM can understand. Let's look at the formula that converts the number 8, which we just derived, into column letter H. (If you look at the Performance Summary section, you'll see that the data for January 1988 does appear in column H.)

The following formula resides in cell K6:

. . . with the view in another season.

```
@IF(I6>26,@CHAR(64+@INT((I6-1)/26)),
  "")&@CHAR(64+@MOD(I6-1,26)+1)
```

This formula relies upon the @CHAR function, which returns the ASCII/LICS (Lotus International Character Set) character associated with the number specified as an argument in the function. In ASCII and LICS, the uppercase letters are assigned to numbers 65 through 90. That means that the formula @CHAR(64+1) would return the letter A. Try it for yourself and see. But because a *1-2-3* or *Symphony* spreadsheet has 230 columns labeled from A to IV and you might build a model that uses columns AA and beyond, you need an @CHAR formula that can handle two-letter column labels. (Note that the model in figure 1 doesn't use columns AA and beyond; however, the formula provided can handle cases in which you do create a model that creeps into those areas of the worksheet. To test this, enter 256 in cell D4 and press the CALC key. Cell J6 will return IV. Remember to reenter the number 5 in cell D4 and press the CALC key.)

If cell I6 contains a value that is greater than 26, the formula subtracts 1 from the value and divides the

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result by 26. This generates a value that @CHAR can convert into the first letter of the two-letter label. Then the formula processes the second @CHAR function as described below and uses the ampersand (&) to join the two letters into a label that represents the column number.

If cell I6 contains a value that is less than 26, the formula returns a null string, as indicated by the pair of quotation marks. The ampersand joins the null string to the result of the second @CHAR function. The @MOD function in this part of the formula divides 26 by 7 and returns the value 7. Then @CHAR adds 64 to the result of the @MOD (64 + 7), then adds another 1, and returns the ASCII/LICS character associated with character 72; the result is letter H.

Now that you've got a way to generate the column letters of the ranges to be summed, you need an @SUM formula to which you can pass the letters. Cell B22 contains the formula that cleverly pairs @@ and @SUM. Let's take a look at it:

```
@SUM(@@(J$6&@STRING(@CELL("row",
  $E22..$E22),Ø)&"."&J$7&@STRING(@CELL
  ("row",$E22..$E22),Ø)))
```

The formula succeeds in returning the appropriate sum of range E22..G22, but let's look at how it does so. The @CELL portion of the formula returns the row number specified as an argument (in this case, row number 22). Then @STRING converts the number into a label so that it can be concatenated with the contents of cell J6 to generate the first cell of the range address, E22. The second half of the formula follows a similar process to generate the second cell of the range address, G22. Both cells are joined by a period to create the range address E22..G22, which is fed to the @SUM formula via the @@ function.

When you have completed this model, you may want to extend it by building a more complete financial data bank, containing your balance sheet data, the number of employees in your firm, your stock price, certain financial ratios, and so on. When you do so, you may find it convenient to expand the number of columns that summarize data. When you reference the balance sheet data, for example, you will want to calculate the changes that have occurred during each period, not the totals as shown in columns B and C. When you calculate these changes, you will find that @SUM and @@ will assist you in this task as well.

ROUNDING TO THE NEAREST VALUE OF A NUMBER

The @ROUND function, of course, rounds a number to the nearest power of 10. The formula @ROUND (123.456,2), for example, returns the value 123.46, while the formula @ROUND(123.456,−1) returns 120. But what formula should you use to round this number to the nearest 25 cents or to the nearest 50 dollars? And what do you do if you want to always round up or always round down?

The general answer is an easy one. Suppose you want to round $123.45 to the nearest $5. If you round down, you'll get $120; if you round up, you'll get $125. Notice that the $5 divides into the first result ($120) 24 times, while it divides into the second result ($125) 25 times. These facts make the answer somewhat obvious. To round any number to the nearest $5, divide that number by 5, round the result up or down as desired, and then multiply the rounded number by 5.

Suppose you have a small model like the one shown below. (Note that the format of column A has been set for currency with two decimal places.)

	A	B	C	D	E	F
1	$5.00		Formulas in Column A			
2	$123.45					
3	$125.00		@ROUND(A2/A1,0)*A1			
4	$120.00		@INT((A2-(A2<0)*(A1-0.00001))/A1)*A1			
5	$125.00		@INT((A2+(A2>0)*(A1-0.00001))/A1)*A1			

You want to round $123.45 to the nearest $5. To round the number, you'd use the formula @ROUND (A2/A1,Ø)*A1, which would return the value $125.00, shown in cell A3. In this case, all you want is to round the number to the nearest $5; you don't care whether the program rounds up or down. Now suppose you want to round the number down to the nearest $5. You must use a more complex formula:

@INT((A2 − (A2<Ø)*(A1 − 0.00001))/A1)*A1

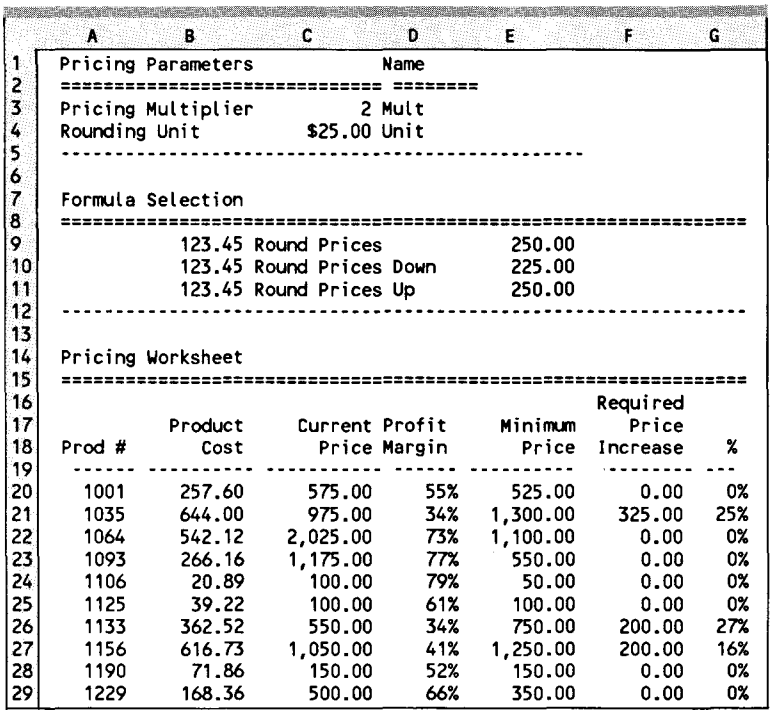
This formula, entered in cell A4, returns the value $120.00. Indeed, $123.45 rounded down to the nearest $5 is $120.00. To round the number up to the nearest $5, you'd use the following formula:

@INT((A2 + (A2>Ø)*(A1 − 0.0001))/A1)*A1

This formula, entered in cell A5, tells you that $123.45 rounded up to the nearest $5 is $125.00.

Keep in mind the difference between rounding a value to the nearest amount and ending a value with a particular number. For example, if you wanted all values to end in .95, you would not round to the nearest .95. After all, the amount $1.90 is rounded to the nearest .95 but doesn't end in .95. To round amounts so that they end in .95, round them to the nearest dollar and then subtract .05. You can use a similar approach for other ending values.

When you use these formulas that always round up or down, remember that both formulas contain the constant 0.00001, which you may have to adjust in certain circumstances. This constant correctly rounds numbers between one-tenth of a cent and one billion dollars. But if you plan to round values either larger or smaller than this range, be sure to test your formulas at the extreme values before you finish your spreadsheet.



	A	B	C	D	E	F	G
1	Pricing Parameters			Name			
2	==========			========			
3	Pricing Multiplier			2 Mult			
4	Rounding Unit			$25.00 Unit			
5	----------						
6							
7	Formula Selection						
8	==========						
9		123.45 Round Prices			250.00		
10		123.45 Round Prices Down			225.00		
11		123.45 Round Prices Up			250.00		
12	----------						
13							
14	Pricing Worksheet						
15	==========						
16						Required	
17		Product	Current	Profit	Minimum	Price	
18	Prod #	Cost	Price	Margin	Price	Increase	%
19	------	---------	----------	------	----------	--------	---
20	1001	257.60	575.00	55%	525.00	0.00	0%
21	1035	644.00	975.00	34%	1,300.00	325.00	25%
22	1064	542.12	2,025.00	73%	1,100.00	0.00	0%
23	1093	266.16	1,175.00	77%	550.00	0.00	0%
24	1106	20.89	100.00	79%	50.00	0.00	0%
25	1125	39.22	100.00	61%	100.00	0.00	0%
26	1133	362.52	550.00	34%	750.00	200.00	27%
27	1156	616.73	1,050.00	41%	1,250.00	200.00	16%
28	1190	71.86	150.00	52%	150.00	0.00	0%
29	1229	168.36	500.00	66%	350.00	0.00	0%

FIGURE 2. A model for rounding. This model allows you to specify the pricing multiplier (in this case, two times the product cost), the amount of rounding desired (in this case, to the nearest $25), and the type of rounding (in this case, up to the nearest $25). If the company changes its pricing policy, it can simply adjust the pricing parameters and copy the desired rounding formula to column E.

SETUP TABLE 2

Format	Range
Currency, 2 decimals	C4
Comma (Punctuated), 2 decimals	B9..E11
Comma (Punctuated), 2 decimals	B20..F29
Percent (%), 0 decimals	D20..D29
Percent (%), 0 decimals	G20..G29

Formula	Cell
E9	@ROUND(B9*$mult/$unit,Ø) *$unit
E10	@INT(($B10*$mult−($B10<Ø) *($unit−0.00001))/$unit)*$unit
E11	@INT(($B11*$mult+($B11>Ø) *($unit−0.00001))/$unit)*$unit
D20	1−B20/C20
F20	@MAX(E20−C20,Ø)
G20	+F20/E20

Copy From	Copy To
B9	B10..B11
D20	D20..D29
F20..G20	F21..F29
E11	E20..E29

The Pricing Worksheet section in figure 2 illustrates a practical use for the rounding formulas. The company shown uses a combination of methods to set their prices. Whenever possible, the company charges as much as customers are willing to pay. At minimum, however, the company charges twice the cost of the product, rounding the price up to the nearest $25. If customers are unwilling to pay this amount, the company drops the product.

Range E20..E29 of this worksheet contains a formula that multiplies the current unit costs by the pricing multiplier in cell C3 and then rounds this amount up to the nearest $25 to calculate a minimum price. Column F returns the value of the required price increase whenever the minimum price exceeds the current price.

To create this model, begin in a blank worksheet. Select /Worksheet Global Recalculation Manual (in *Symphony*, MENU Settings Recalculation Method Manual Quit). Set the following column widths by positioning the pointer in the appropriate column, selecting /Worksheet Column Set-Width (in *Symphony*, MENU Width Set), entering the new width, and pressing Return: A–7, B–11, C–12, D–7, E–12, F–10, and G–4. Then enter the labels and dashed lines shown in rows 1 through 19. To create the dashed lines, enter a backslash and either a hyphen or an equal sign (\– or \=) in the first cell in the row, and then copy that cell across as necessary. To create the broken dashed lines in row 19, enter a backslash in cell A19, press the Spacebar once, and then enter 12 dashes. Then copy cell A19 across the row as shown. Also enter the data in range A20..C29. Enter the value 2 in cell C3, 25 in cell C4, and 123.45 in cell B9. Position the pointer in cell D3 and assign the labels in range D3..D4 as range names for the cells to the left by pressing slash (in *Symphony*, MENU) and selecting Range Name Labels Left. To right-align the labels in range A16..G18, select /Range Label Right (in *Symphony*, MENU Range Label-Alignment Right) and specify range A16..G18. Now follow the instructions in Setup Table 2 to format ranges, enter formulas, and copy ranges.

The Pricing Parameters section allows you to quickly change the minimum prices in column E of the Pricing Worksheet. To set a minimum price that is three times the cost, change the value in cell C3 to 3; to round these prices to the nearest $5, change the value in cell C4 to $5.

Column E of the Formula Selection section provides the three variations of the formula discussed previously. Column B provides values for these formulas to round. When you create the pricing worksheet, copy the rounding method formula you wish to use to the appropriate range in column E. In the figure shown, column E contains the formula from the Formula Selection section that rounds prices up. ■