Excel Guided Tour: Cell References, Dates, and Functions

Overview

This tutorial expands on our author’s discussion of relative and absolute cell references. You’ll also revisit the PMT, IF, and TODAY functions. You will also work with dates, including formatting dates and performing date-based calculations.

This tutorial makes use of a workbook that contains three partially-completed worksheets. Open it now.

1. Open the file \CIS114 Data Files\Bonus\MegaTelCo.xlsm.
2. If you see a Security Warning, click Enable Content to enable the workbook’s features.
3. Click File, click Save As, type your name after the filename (eg: MegaTelCo – Tom Trollen.xlsm), then click Save to save your workbook.

Cell References

Whenever you build a formula to perform calculations the formula will refer to values contained in other cells. For example, if a cell contains the formula =$B4*C3, Excel multiplies the value found in cell B4 by the value found in cell C3. This example formula contains two cell references.

Whenever you copy a formula that contains cell references, the resulting copies depend on the type of cell references used in the original formula. Excel has two main types of cell references, absolute and relative. Each type of cell reference is extremely useful, when used properly. Unfortunately, each can also be used improperly.

Absolute cell references are used to maintain a reference to a specific cell whenever the formula is copied to another cell. They are indicated by placing a $ in front of both the column letter and the row number. You’ll work with them later in this tutorial.

Relative cell references are ones that Excel interprets as a location relative to the formula’s own location. Using them allows you to copy the formula to other cells in a way that maintains the same logical intent as the original formula.

Using Relative Cell References

4. Click the Budget tab, if necessary. Your Budget worksheet is a partially completed version of the finished product, which is shown below.

![Figure 1 Budget Worksheet (completed)](image)
Notice Column D in Figure 1, which contains the *Variance* for each line item. *Variance* is computed by taking the *Budget* amount and subtracting the *Actual* amount. This difference represents the amount by which MegaTelCo overspent or underspent on the item. For example, the *Budget* amount for Buildings was only $860,000 but they actually spent $975,000. The *Variance* of -115,000 (which appears in parentheses because of its formatting) is calculated as *Budget – Actual* ($860,000 – $975,000) and represents the amount by which they *overspent* on Buildings. Similarly, Computer Equipment shows a *Variance* of 37,057, indicating MegaTelCo *underspent* in this area.

You’ll begin by building the formula in D6.

5. **Click cell D6.** Now, **type** `=`, **click cell B6**, **type** `–`, **click cell C6**. Complete the formula by **clicking the Formula Bar’s Enter button**. Cell D6 should now show (115,000), the difference between the *Actual* and *Budget* amounts.

6. **Double-click cell D6.** Doing so places you in Edit mode (notice the left side of the Status Bar) and allows you to view/edit the cell. Notice how Excel color-codes each cell reference and also colors each cell’s border.

7. Since neither cell reference contains a $, each is a *relative* cell reference that Excel interprets as a location relative to the formula’s own location. This formula is in cell D6 and it references cell B6 (which is *two columns to the left in the same row*) and cell C6 (which is *one column to the left in the same row*). Excel interprets the formula as though it says “Take the value found *two columns to the left in this same row* and subtract the value found *one column to the left in this same row*.”

8. **Press [Esc]** to stop editing and return to Ready mode. Excel now displays the *result* of the formula, not the formula itself.

The calculation needed in each of the remaining rows is virtually identical to the formula you just built: take the *Budget* amount for the row and subtract the *Actual* amount for the row. This is exactly the logic expressed by the formula (“take the value found *two columns to the left in this same row* and subtract the value found *one column to the left in this same row*”).

When you copy a formula, any relative cell references are *adjusted* in each of the resulting copies. This is done to preserve the logic of the original formula. You’ll verify this in the next few steps.

9. With cell D6 still selected, **drag the Fill Handle from D6 down to cell D9**. Doing so copies the formula to the other cells.

10. **Double-click cell D7.** It contains the formula `=B7-C7`. Notice this new formula is *not* an identical copy of the original formula (`=B6-C6`)! The reason is that the original formula employed *relative* cell references (i.e., there were no $) so Excel copied the original formula’s relative location of cells. Excel copied
“take the value found two columns to the left in this same row and subtract the value found one column to the left in this same row.” When this was copied to cell D7, “two columns to the left in this same row” refers to cell B7 and “one column to the left in this same row” refers to cell C7. Thus the formula created in cell D7 is =B7-C7. Excel automatically adjusted the row numbers by 1 (from 6 to 7) in order to preserve the logic of the original formula.

11. **Press [Esc]** to stop editing and return to Ready mode.

12. **Double-click cell D8.** This cell should contain the formula =B8-C8. When you look at the color-coded cells, does the intent of this formula (“take the value found two columns to the left in this same row and subtract the value found one column to the left in this same row”) make sense?

13. **Press [Esc]** to stop editing and return to Ready mode.

14. When a formula is copied, any relative cell references are interpreted as a relative description of which cells to use, rather than copying the literal cell addresses. This makes it possible to duplicate the logic of the original formula in other cells. Although the intent of the formulas is the same (“take the value found two columns to the left in this same row and subtract the value found one column to the left in this same row”), different cells are referenced (=B6-C6 becomes =B7-C7) because the copies were placed in different rows.

Now you’ll develop the totals in row 10. Cell B10 is to display the total of the Budget amounts. You’ll use the SUM function to obtain the total. **Functions** are predefined formulas that Excel knows how to solve. You simply call the function by name and supply any necessary information in parentheses. For example, to obtain a total of all the numeric cells within the range B6:B9, use =SUM(B6:B9). Notice that you specify the range of cells to be summed. The information you supply in parentheses as you call a function are called the function’s **arguments**.

15. **Click cell B10.** Type =SUM( , now drag to select the range B6:B9, then type ) and click the Enter button.[1] Cell B10 should now show the total of the Budget amounts, as illustrated in Figure 1 (page 1, above).

16. **Double-click cell B10.** Cell B10 contains =SUM(B6:B9). Each cell is a relative cell reference that Excel interprets as a location relative to the formula’s location. So Excel interprets the function as though it says “sum the values in the cells found in the range four rows up in this same column through one row up in this same column.”

17. **Press [Esc]** to return to Ready mode.

Now think about cells C10 and D10. They each need to calculate the sum of their respective columns, just as cell B10 does. Since the logic is so similar (**sum the four numbers immediately above in this same column**) and since you used relative references in the formula, you can simply copy the original formula to cells C10 and D10. Since the cells are adjacent, you’ll use the Fill Handle.

18. **Drag the Fill Handle from B10 rightward to cell E10.** Doing so copies the original formula to the other cells.
19. **Double-click cell C10.**

Because the original formula in B10, =SUM(B6:B9), used *relative* references, this new formula is not an identical copy of the original. Rather, this new formula copies the *intent* of the original formula ("sum the values in the cells found in the range four rows up in this same column through the cell one row up in this same column."). When copied to cell C10, the cell four rows higher in this same column is C6 and the cell one row higher in this same column is C9, so the new formula reads =SUM(C6:C9). So although the logic is the same, different cells are referenced because the new formula is in a different column. Excel automatically adjusted the column letters (from B to C) to preserve the logic of the original formula.

20. **Press [Esc] to return to Ready mode.**

21. **Save your workbook.**

### Using Absolute Cell References

Recall that an *absolute cell reference* maintains a reference to a specific cell whenever the formula is copied to another cell. Thus each of the copies will refer to the same cell as the original formula. Absolute cell references are indicated by placing a $ in front of both the column letter and the row number. For example, in the formula =C4*$J$1, cell C4 is a *relative* reference whereas $J$1 is an *absolute* reference. If this formula was copied to another cell, the second cell reference of each copy would continue to refer to cell $J$1.

It is time to build the formulas for column E. This column will show the Forecasted budget, determined by taking the current *Budget* amount (column B) and adding the growth amount specified in cell E3 (currently 2%). For example, cell E6 shows a forecasted buildings budget of 877,200. This is obtained by taking the current budget (cell B6) and adding 2% (calculated as B6*E3). You need to build the formula =B6+(B6*E3). Do you understand how this formula, when placed in cell E6, will take the current buildings budget and add 2% more? The formula would essentially compute as =860000+(860000*.02), which produces the result 877,200.

22. **Click cell E6. Type =, then click cell B6, then type +, then click cell B6, then type *, then click cell E3, then type ) , then click the Enter button .** Your formula should be =B6+(B6*E3). Check that your result matches Figure 1 (page 1) ignoring any formatting differences such as commas or decimal digits.

23. **Double-click cell E6.** Each cell reference in this formula is a *relative* reference. *Excel* interprets the formula as "take the value in the cell that is 3 columns to the left in this same row and add to it the product of the value in the cell 3 columns to the left in this same row and the value in the cell three rows up in this same column."

Since this formula produces the correct result, you are probably tempted to copy it to cells E7:E9 to calculate the forecasted budget for the remaining line items.
24. **Drag the Fill Handle from E6 down to cell E9** to copy the formula to the other cells. Do your results in cells E7:E9 match Figure 1 (page 1)? Read on to discover what went wrong!

At this point your results in cells E7:E9 are a *disaster* (below). Think about what you asked *Excel* to do. The original formula in cell E6, *\=B6+(B6*E3)*, uses three *relative* references When you copied this original formula to the cell below, *Excel* created copies that each say “take the value in the cell 3 columns to the left in this same row and add to it the product of the value in the cell 3 columns to the left in this same row and the value in the cell three rows up in this same column.” You’ll verify this in the next few steps.

25. **Double-click cell E7.** The formula reads \textit{=B7+(B7*E4)}). Cell B7 is “three columns to the left in this same row” and cell E4 is “three rows up in this same column.” This confirms that when *Excel* copied the formula, it preserved the *relative* locations of which cells to use.

26. The problem with this formula is that cell E4 is empty! As a result, the latter part of the formula multiplies B7 by 0 (instead of the 2% growth factor in cell E3), producing the wrong result (250,000 instead of 255,000). Instead of using the cell that is “three rows up in the same column”, the formula should use cell E3—that’s where the growth factor is!

27. **Press [Esc] to return to Ready Mode.**

28. **Double-click cell E8.** Do you understand why we obtained this formula? The original formula said “take the value in the cell that is *three columns to the left in this same row* and add the product of that same cell and the cell that is *three rows up in this same column*.”

29. Let’s figure out why the formula in E7 doesn’t work correctly (recall that it displayed #VALUE!, not 35,700). The formula is \textit{=B8+(B8*E5)} but cell E5 contains a text label, not a number, so this formula can’t be solved! Instead of multiplying by the cell that is “three rows up in this same column” it should multiply by cell E3… the growth factor!

30. **Press [Esc] to return to Ready Mode.**

Although the original formula in E6 was correct, none of the copies work because they don’t multiply by the growth factor in cell E3. How can you modify the original formula so any copies also multiply by cell E3? You need to modify the formula to use an *absolute* reference to cell E3 (i.e., $E$3).
31. **Double-click cell E6.** You can now edit the original formula. **Click between the E and the 3 in the E3 cell reference.** Now **tap the [F4] key** in the top row of the keyboard. This places a $ in front of both the column letter and the row number, providing an absolute reference to cell E3. Your formula now reads =B6+(B6*$E$3). **Click ✅.**

Your modified formula now means “take the value in the cell that is three columns to the left in the same row and add the product of the cell three columns to the left in the same row and cell E3.” When this formula is copied, each resulting formula will refer to cell E3. You’ll finish up this worksheet by copying the modified formula to the cells below.

32. **Drag the Fill Handle from E6 down to cell E9.** Your results should now match Figure 1 (page 1).

Now that they work correctly, take a quick peek at the copies. Instead of double-clicking each cell and looking at each formula individually, we’ll view them all together.

33. **Click the Formulas tab, and then click Show Formulas** The cell formulas should now be displayed.

34. **Scroll to the right until column E is visible,** if necessary. Notice the third cell reference in each formula refers to cell $E$3. By using an **absolute** reference we maintain a reference to cell E3 in each of the copies. It is absolutely unchanged in each of the copies. The other cell references in each formula were **relative,** so the row numbers were automatically adjusted (from 6 to 7 to 8 to 9) as the formula was copied to different rows.

To recap, before you copy a formula you must first consider whether each of the formula’s cell references should be relative or absolute. Use a **relative** reference to use the same relative locations as the original formula. Use an **absolute** reference when each copy needs to refer to the same exact cell.

35. **To stop displaying formulas (and resume displaying results) click Show Formulas.**

**Using the PMT Function**

You used the Insert Function dialog box to help build the correct function when you used the PMT and IF functions in Tutorial. Here you’ll focus on the functions and their syntax so you’ll better understand how each works.

36. **Click the Financing tab.** Your Financing worksheet is a partially completed version of the finished product, which is shown below.
Figure 2 Financing Worksheet (completed)

Cell B3 contains the loan amount. Rows 6-8 contain three loan alternatives. Columns B and C contain the interest rate (APR) and the length of time the loan is to be repaid (Term). Column D calculates the monthly payment for each alternative. Although the amount borrowed is the same for each loan, the monthly payments vary because each loan has a different interest rate and term.

Excel’s PMT function calculates the payment required to repay a loan. When you use it you provide the three factors described above. The general syntax of the function is:

\[ \text{=PMT(interest\_rate\_per\_payment,\ number\_of\_payments,\ amount\_borrowed)} \]

Notice the PMT function requires three arguments and that commas appear between the arguments. It is important that you supply the arguments in the exact order shown. In addition, it is important that the time periods involved in the first two arguments be equivalent. In our worksheet, each loan is to be repaid with a series of monthly payments, so the interest rate specified in the first argument must be a monthly interest rate and the number of payments specified in the second argument must be also expressed in months.

In column B, each interest rate is expressed as an annual percentage rate (APR). Since our worksheet will compute monthly payments, we’ll divide the annual rate by 12 (i.e., B6/12) to obtain the monthly interest rate. Since column C cites the term of the loan in years, we’ll need to multiply that value by 12 in order to obtain the number of monthly payments that will be made. So, the contents of cell D6 will need to be \text{=PMT(B6/12, C6*12, B3)}. Manually build the first PMT function now, using cell pointing whenever a cell is to be referenced in the function:

37. In cell D6 type \text{=PMT( now click cell B6, now type /12, then click cell C6 and type *12, and click cell B3}. Finally, type ). Click \text{ } to complete the entry.

Notice that Excel automatically applies Currency formatting to a cell containing the PMT function and that the payment is formatted in red and is wrapped within parentheses. This occurs because Excel’s PMT function returns a negative value, since a payment is an outflow of funds. In order to have PMT return a non-negative value, we can place a minus sign (–) in front of the function (“the negative of a negative is a positive”).

38. Double-click cell D6, then type a minus sign immediately before the PMT function, as illustrated. Then click \text{ }
Now that your worksheet calculates the payment for the first loan alternative, it is time to copy this PMT function to calculate the payment for the other loan alternatives. Recall that before you copy a formula, you must consider whether to employ any absolute cell references. Consider the structure of this worksheet. Each loan alternative is in its own row, with the interest rate in column B and the term in column C. As you copy the original PMT function to each row below, you’ll want the payment to use that row’s own interest rate and term (two to the left in this same row and one to the left in this same row, respectively), so relative cell references are appropriate for the first two arguments. The third argument, the amount borrowed, is in B3 for each loan alternative. Its location does not change for any of the loan alternatives, so an absolute cell reference must be used.

39. Modify the function to use an absolute cell reference to B3, then click .

40. Copy the modified PMT function to cells D7:D8. Do their values match Figure 2 on page 7?

In column E, Total Payments will be calculated by multiplying Monthly Payment by Term and then multiplying by 12, since 12 payments are made each year. Build the first Total Payments formula now.

41. Click cell E6, then use cell pointing to build the formula =D6*C6*12. Click when the formula is complete.

42. Compare your result with Figure 2 (page 7). If the value doesn’t match, modify your formula in cell E6.

You need to copy this formula to obtain the Total Payments for the other loan alternatives. Before copying, consider whether each cell reference should remain relative or should be made absolute.

43. If necessary, modify your formula to use any absolute cell references.

44. Copy the formula in E6 to cells E7:E8.

45. Compare your Total Payments results with Figure 2 (page 7). If the values don’t match, modify your formula in E6, and then re-copy it to E7:E8.

In column F, Total Interest Expense will be calculated as the difference between Total Payments and Loan Amount. Build the first formula now:

46. Click cell F6. Use cell pointing to build the formula =E6-B3.

47. Compare your result with Figure 2 (page 7). If the value doesn’t match, modify your formula in F6.

Now you need to copy the formula to obtain the Total Interest for the other loan alternatives. Before copying, consider whether each cell reference should remain relative or should be made absolute.

48. If necessary, modify your formula to use any absolute cell references.

49. Copy the formula in F6 to cells F7:F8.

50. Compare your Total Interest Expense results with Figure 2 (page 7). If the values don’t match, modify your formula in F6, and then re-copy it to F7:F8.

51. Save your workbook.
Working with Dates

Dates are important in many business applications. Internally, Excel translates each date into a serial number. The date January 1, 1900 is represented by the serial number 1, January 2, 1900 is serial number 2, and so on. By representing a date as a serial number it is possible to perform date-based calculations.

When you type a date into a cell Excel stores that date’s serial number. Although Excel displays the date, it actually stores the date’s serial number. Try it now:

52. Click the Payments tab, then click cell B3. Now type 1/1/1900, and then click .

53. To demonstrate that Excel uses serial numbers to represent dates, format the cell as a plain number. Right-click cell B3, then click Format Cells..., click the Number tab, in the Category: list box, click General, and then click OK. Excel now displays 1, confirming that 1 is the serial number for 1/1/1900.

54. With cell B3 still selected, type 32, and then click . Which date should this serial number correspond to?

55. Format the cell as a date and find out. Right-click cell B3, then click Format Cells..., in the Category: list box, click Date, in the Type: list box scroll down and click March 14, 2001, and then click OK. What date do you see? Does it make sense that February 1, 1900 corresponds to date serial number 32?

Excel’s TODAY function returns the serial number for the current day. The TODAY function is a bit unusual in that it does not take any arguments. You simply call it with an empty set of parentheses.

56. Click cell B3 and type =today(). Now press [Enter]. Today’s date should be displayed.

57. Type your own name in cell B4.

The completed Payments worksheet appears below. It contains one year’s billing history for one of MegaTelCo’s customers. Take a few moments to browse the worksheet’s columns.

![Figure 3 Payments Worksheet (completed)](image)

You’ll begin in column D. Lag is calculated as the number of days between Paid Date and the Bill Date. In row 16, notice the paid date was 27-May-11 and the bill was 6-May-11. Thus the Lag was 21 days.
Since Excel stores each date as a serial number, you can build a formula to calculate the number of days between the Paid Date and Bill Date.

58. Click cell D8, then type =, click cell C8, type -, click cell A8. Click \(\square\) to finish the formula.

Before you copy this formula, consider whether any absolute cell references are required. In the current formula, \(=C8-A8\), each cell is a relative reference so Excel interprets the formula as “take the value in the cell that is one column to the left in this same row and subtract the value that is three columns to the left in the same row.” Since this same logic will also work for the remaining cells in the Lag column, no absolute cell references will be needed.

59. Copy the formula in D8 to cells D9:D19.

60. Compare your Lag results with Figure 3. If they don’t match, modify your formula in D8, and then re-copy it to D9:D19.

Using the IF Function

MegaTelCo’s policy states that payments received more than 21 days after the bill date are considered late. In row 10 of the completed Payments worksheet (Figure 3, page 9), notice the payment lagged by 33 days, so it was considered 12 days late. The payment in row 8 lagged by 17 days, so it was not considered late and nothing is shown in column E for that row. In summary, column E is to contain one of two results: when a payment lags by more than 21 days, column E is to show how many days late the payment was, otherwise column E is to be empty.

Excel’s IF function returns one of two results depending on whether a specified condition is true or false. Its syntax is

\[
\text{IF}(\text{logical	extunderscore test}, \text{value	extunderscore if	extunderscore true}, \text{value	extunderscore if	extunderscore false})
\]

Notice the IF function takes three arguments and that commas appear between the arguments. The first argument is an expression that can be evaluated as either true or false. If the test is true, Excel returns the result of the second argument. If the test is false, Excel returns the result of the third argument.

To paraphrase MegaTelCo’s policy, “if a payment lags by more than 21 days, then column E is to show how many days late the payment is, otherwise column E is to be empty.” Translating the policy into the corresponding IF function yields \(\text{IF}(D8>D5, D8-D5,"\)\). The first argument tests whether the lag is greater than D5’s value (21 days). If this test is true, the second argument will calculate and display how many days over 21 the payment lagged. If the test is false, the third argument displays nothing (“\"\" is a pair of double-quotes with nothing in between). Build this IF function now.

61. Click cell E8. Now use cell pointing to build the function \(\text{IF}(D8>D5, D8-D5,"\)\). Click \(\square\). Does your function return the correct result? (Don’t panic… the cell looks empty but it really does contain your IF function!) Since the first month’s lag does not exceed 21, the cell should not display anything.
Of course, you’d like to copy this function to the remaining months. Each cell reference in the original formula is a relative reference so Excel considers the formula as IF the value in the cell one column to the left in this same row is greater than the value in the cell one column to the left and 3 rows up, THEN take the value that is one column to the left in this same row and subtract the value in the cell one column to the left and 3 rows up, OTHERWISE display an empty cell.” Will this same logic work in each of the cells below?

62. If necessary, modify your formula to use any absolute cell references.

63. **Copy the formula in E8 to cells E9:E19.**

64. Compare your *Days Late* results with the *Payments* worksheet (Figure 3, page 9). If the values don’t match, modify your formula in E8, and then re-copy it to E9:E19.

**What If…**

MegaTelCo is evaluating their late payment policy and wants to explore the implications of reducing the lag allowance from 21 days to 14. Let’s explore this proposed policy change.

65. **Click cell D5, enter the value 14, and then press [Enter].**

Notice the dramatic change in the *Days Late* results! Under the proposed policy this person’s account would have been considered late every month!

66. **Click Undo** to revert to the 21 day lag allowance. The account now appears late 4 times during the year.

It was easy to investigate the effect of the proposed policy change. When you changed the value in cell D5, Excel recalculated every formula that referenced cell D5, and the new results were displayed.

This change-a-value-and-see-the-new-results is known as a **What If Analysis** (a.k.a. *Sensitivity Analysis*). It was possible because we dedicated a cell (D5) to store the value we wanted to change (lag days allowed), and our formulas (E8:E19) each contain cell references to the cell whose value we will be changing. Whenever the referenced cell’s value changes, the formulas are automatically recalculate and the new results are displayed.

**Wrap Up**

67. **Save your workbook.**

68. **Exit Excel.**

69. **Launch Windows Explorer and backup your MegaTelCo.xlsxm workbook file** by copying it to the **CIS114 Data Files\Bonus** folder on your USB flash drive.