# APPENDIX A

MODELING ANALYSIS WITH EXCEL

A-1 INTRODUCTION

This appendix explores some of the Excel features that can be used to create simple mathematical and statistical models. It starts with a discussion of relative, absolute, and mixed addressing, then presents several financial and statistical functions. The IF function is explained as a decision-making tool, then the Lookup functions are reviewed. Finally, a couple of what-if analysis features offered by Excel are presented.

A-2 RELATIVE ADDRESSING

Every cell in Excel has four different addresses: one relative, one absolute, and two mixed addresses. These addresses are explained in the next three sections. When you use cell addresses in Excel formulas, you need to be aware of the fact that Excel remembers a cell by its position in the spreadsheet. In relationship to cell E10, for example, cell G4 is two columns to the right and six rows above. An example of a relative address procedure is shown in Exhibit A.1.

Exhibit A.1
Relative addressing
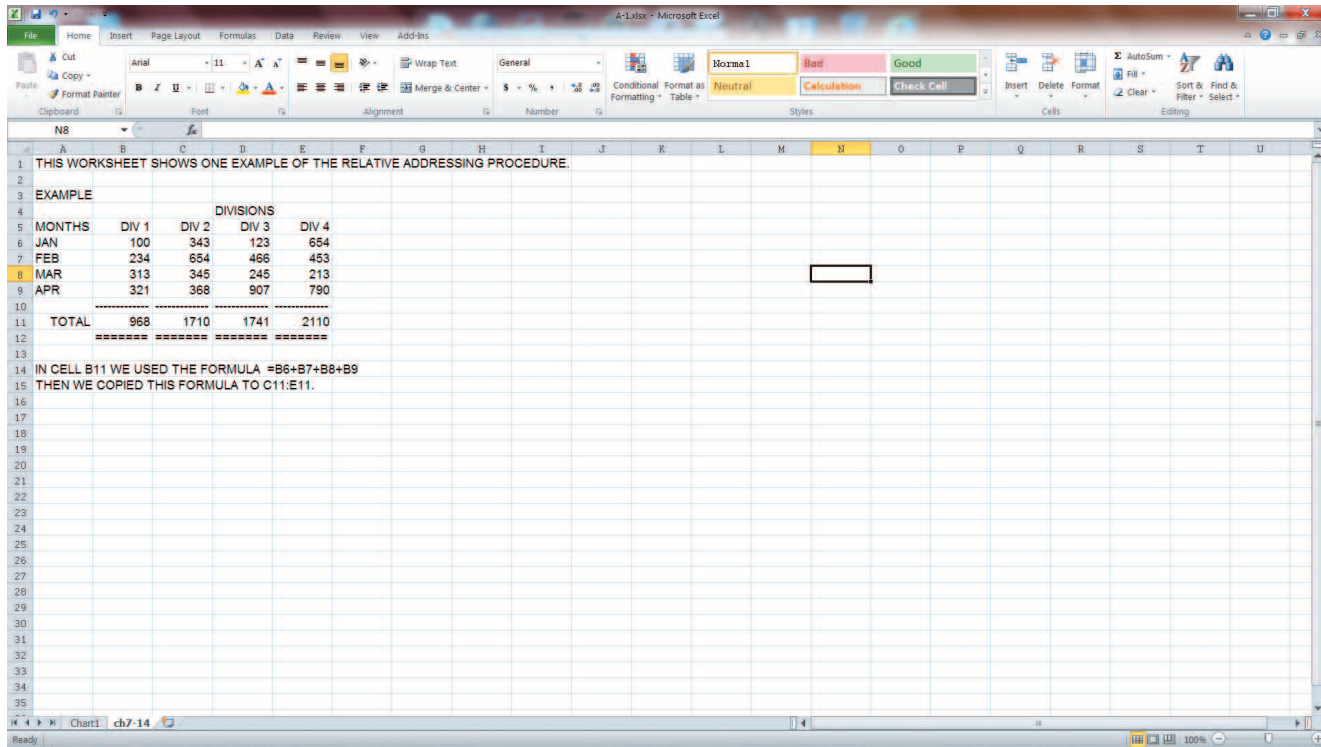
In cell B11, the formula is as follows: =B9+B8+B7+B6

If you copy this formula to cell C11, Excel changes the formula to read as follows:

=C9+C8+C7+C6

The new cell addresses in the formula maintain the same relationship to cell C11 as the old addresses did to cell B11.

This powerful feature is called relative addressing. You can use relative addressing with the copy command to facilitate calculations. Suppose you have sales data related to 100 different businesses in the first 100 columns of a worksheet. To calculate the sum of each column, all you need to do is type a formula for one column and then copy the same formula to the other 99 columns. Excel automatically changes the cell addresses for you.
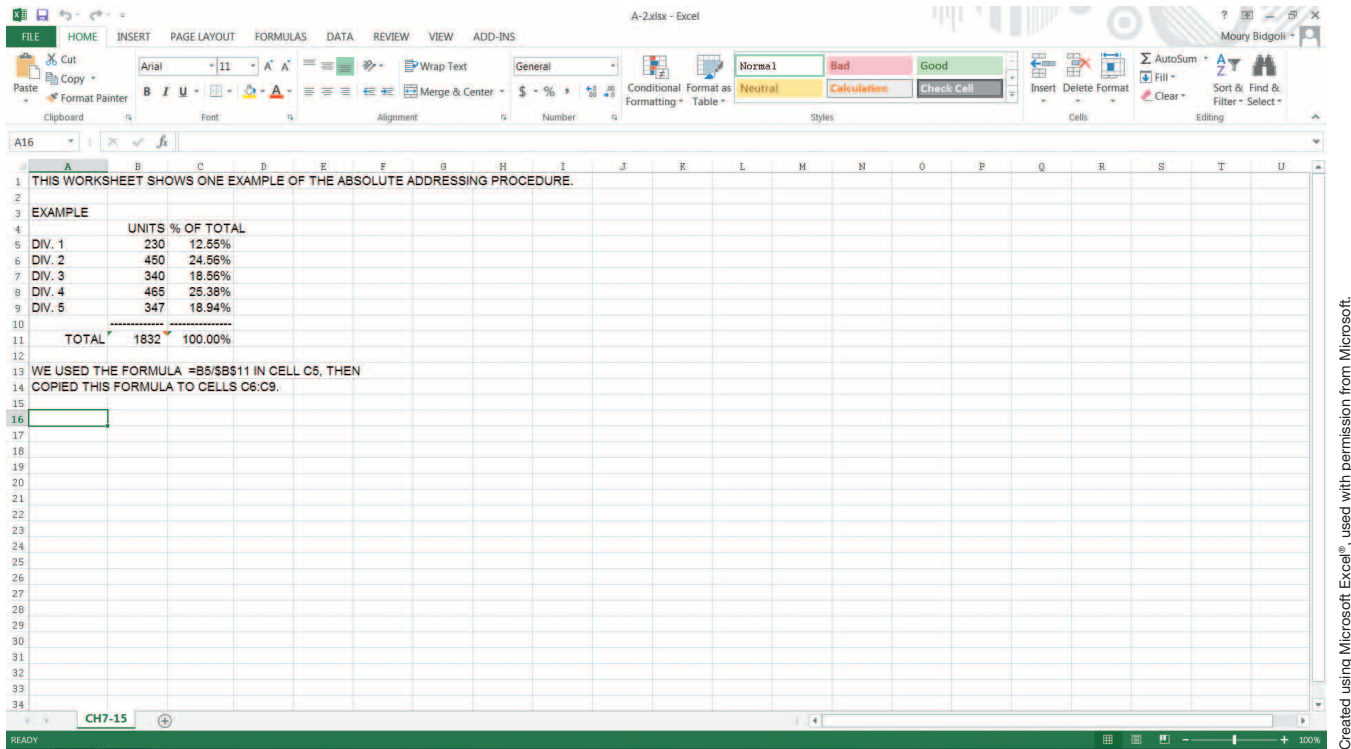
A-3 ABSOLUTE ADDRESSING

Relative addressing is a powerful feature. However, there will be many times when you will want to refer to an exact location with an exact value. You may even want to use predefined numbers or ratios. In these instances, you must use absolute addressing.

In Exhibit A.2, five divisions of the XYZ Company have sold different numbers of a particular product. Your task is to calculate each division's percentage of total sales, and you have used the formula **=B5/11** in cell C5. However, if you copy this formula to cells C6:C9, you will receive an error message because in each case the division's units must be divided by the total units in cell B11. When you copy the formula, cell B11's address changes to reflect the formula's new location, which produces the error. You must make the reference to cell B11 absolute (fixed). You do this by placing a dollar sign in front of the column letter and another dollar sign in front of the row number ($B11). In Exhibit A.2, we first entered **=B5/B11** in cell C5, then copied this formula into cells C6:C9.

Exhibit A.2
Absolute addressing

A-4 MIXED ADDRESSING

Sometimes, you will want to use relative and absolute addressing at the same time. You might make the row reference absolute and leave the column reference free to change as you copy the formula, or vice versa. For example, $A10 means the column remains the same but the row changes. Likewise, B$10 means the column changes but the row is fixed.

Exhibit A.3 illustrates two examples of mixed addressing. The first example shows the discounted prices under different discount rates for two products with original prices of $12 and $30. The second example in the exhibit shows the same information in a different format. Can you tell what the difference is between the two?

Exhibit A.3
Mixed addressing
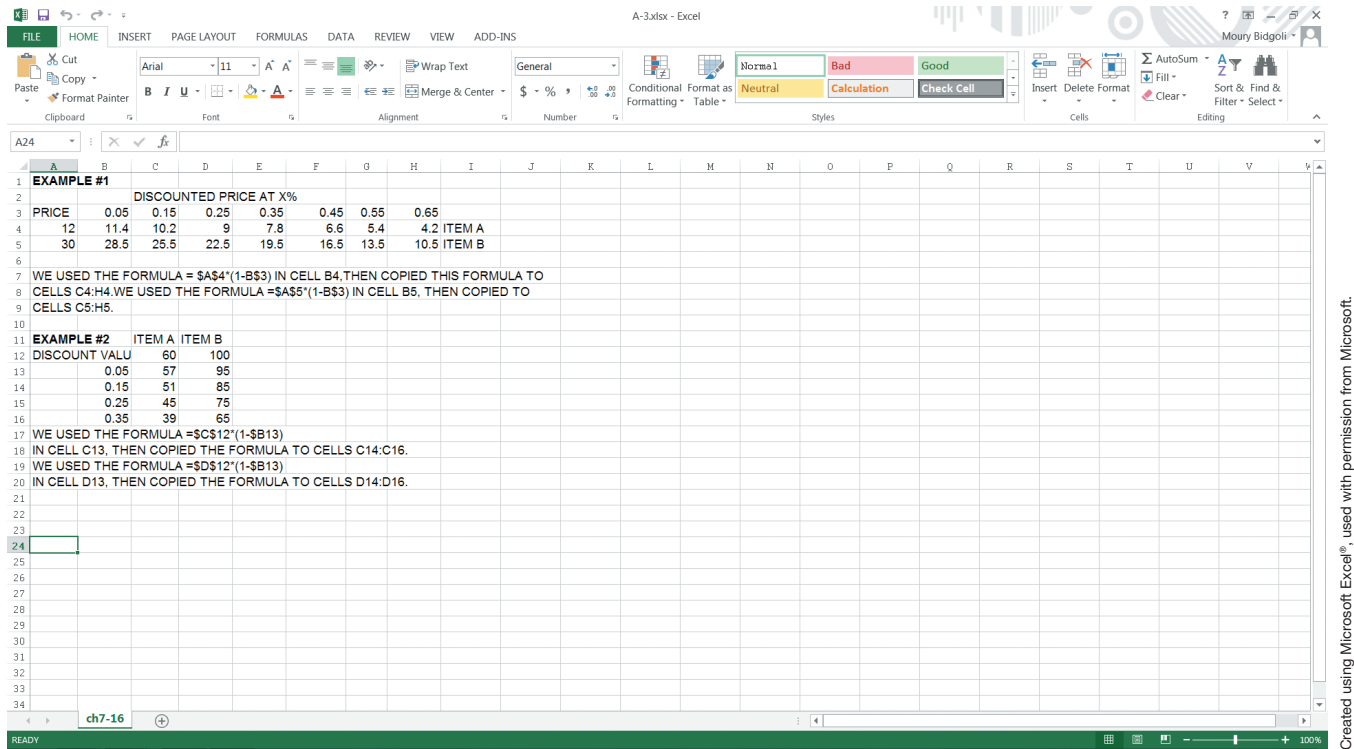
A-5 FINANCIAL FUNCTIONS

Financial functions are concerned with the time value of money. They also calculate different depreciation methods. In this section, we introduce FV, NPV, PMT, SLN, and SYD.

A-5-1 FV(Rate,Nper,Pmt,Pv,Type)

The Future Value function returns the future value of an investment based on periodic, constant payments, and a fixed interest rate. The parameters used in the function are explained below:

Rate is the yearly interest rate.

Nper is the total number of payment periods in an annuity.

Pmt is the payment made each period.

Pv is the present value or the lump-sum amount that a series of future payments is worth right now. If Pv is omitted, it is assumed to be 0.

Type is either 0 or 1 and indicates when payments are due. If Type is omitted, it is assumed to be 0. If payments are due at the end of the period, Type=0. If payments are due at the beginning of the period, Type=1.

You must always be consistent when using Nper and Rate. If you make monthly payments on a 6-year loan at 8% annual interest, use 8%/12 for Rate and 6*12 for Nper. If you make annual payments on the same loan, use 8% for Rate and 6 for Nper. Exhibit A.4 shows two examples of this function.

When working with Excel functions, you should always use cell addresses instead of actual values. By doing this, you will be able to perform what-if analyses by changing the contents of cell addresses without changing the formulas.

Exhibit A.4
The Future Value function

A-5-2 NPV(Rate,Value1,Value2,…)

The Net Present Value function calculates the net present value of an investment by using a discount rate and a series of future cash flows. Cash outflows are negative values, and cash inflows are positive values.

The cash inflows and outflows do not need to be equal. This function is very helpful for calculating the today worth of an investment that may generate different future cash inflows and outflows. Exhibit A.5 illustrates two examples of this function.

Exhibit A.5
The Net Present Value function

A-5-3 PMT(Rate,Nper,Pv,Fv,Type)

The Payment function calculates the payment for a loan based on constant payments and a fixed interest rate. The parameters used in the function are explained below:

Rate is the interest rate for the loan.

Nper is the total number of payments for the loan.

Pv is the present value or the total amount that a series of future payments is worth now.

Fv is the future value or a cash balance you want to attain after the last payment is made. If Fv is omitted, it is assumed to be 0.

Type is either 0 or 1 and indicates when payments are due. If type is omitted, it is assumed to be 0. If payments are due at the end of the period, Type=0. If payments are due at the beginning of the period, Type=1. Exhibit A.6 shows two examples of this function.

Exhibit A.6
The Payment function
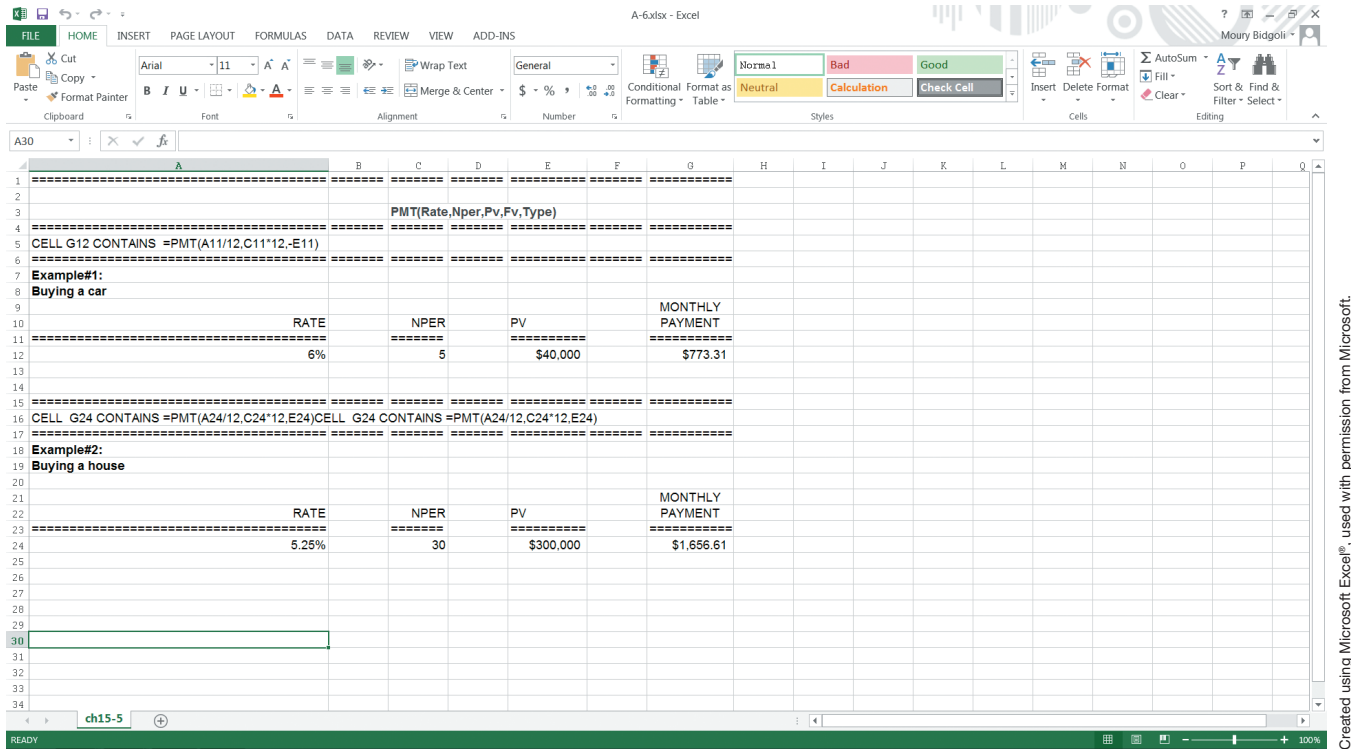
A-5-4 SLN(Cost,Salvage Value,Life)

The Straight-Line Depreciation function calculates the straight-line depreciation of a piece of equipment for one period. This method assumes the same amount of depreciation for every period. The parameters used in the function are explained below:

Cost is the initial cost of the equipment.

Salvage Value is the value of the equipment at the end of the depreciation period.

Life (**useful life**) is the number of periods over which the equipment is depreciated.

Exhibit A.7 shows two examples of this function.

Exhibit A.7
The Straight-Line Depreciation function

Created using Microsoft Excel®, used with permission from Microsoft.

A-5-5 SYD(Cost,Salvage Value,Life,Period)

The Sum-of-the-Years' Depreciation function calculates the sum of the years' depreciation for the selected period. The parameters used in the function are explained below:

Cost is the initial cost of the equipment.

Salvage Value is the value of the equipment at the end of the depreciation period.

Life (**useful life**) is the number of periods over which the equipment is depreciated.

Period is a given period in useful life.

This method of depreciation accelerates the rate of depreciation; therefore, more depreciation expenses occur in earlier periods than in later periods. Because maintenance costs are minimal in the first few years, this method balances out the total cost of a piece of equipment. In later years, there are fewer depreciation costs and more maintenance costs. Exhibit A.8 shows two examples of this function.

Exhibit A.8
The Sum-of-the-Years' Depreciation function

A-6 STATISTICAL FUNCTIONS

Excel offers several statistical functions, including AVERAGE, MAX, MIN, and so forth. With the exception of COUNT, these functions accept numeric values and list values for arguments. The COUNT function accepts numeric as well as nonnumeric values as arguments. In all of these functions, an argument can be a single address or a group of addresses. The following are brief descriptions of Excel's most popular statistical functions:

AVERAGE calculates the average of all values included in a list or group.

COUNT counts the number of occupied (nonblank) cells in a list.

MAX returns the maximum value in a list.

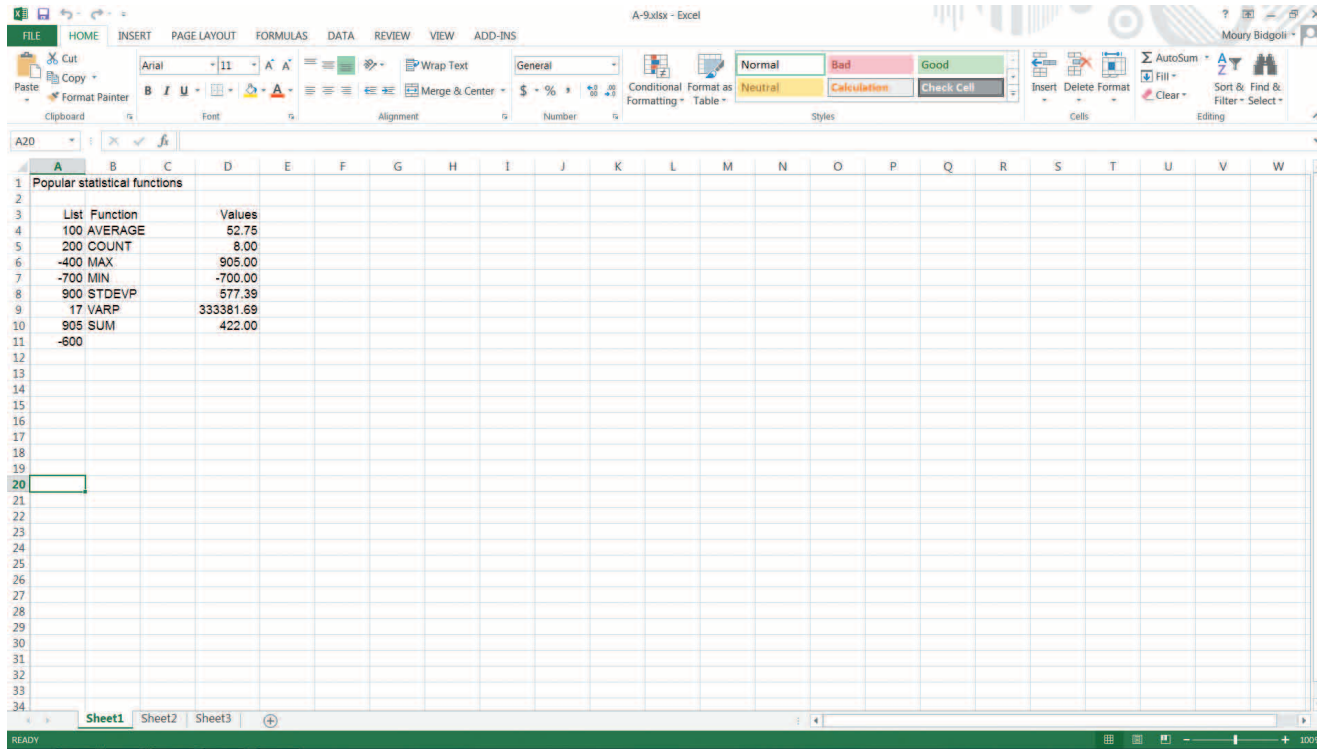**MIN** returns the minimum value in a list.

STDEVP calculates the standard deviation based on the entire population.

VARP calculates variance based on the entire population.

SUM calculates the sum of all values in a list.

Exhibit A.9 shows an example that uses these functions.

Exhibit A.9
Statistical functions

A-7 LOGICAL FUNCTIONS

These functions generate values based on the results of conditional statements. When you use logical functions, remember that a blank cell has the value of 0. If you use a list that represents a range of cells, Excel examines the upper-left cell.

A-7-1 AND

The AND function returns true if all of its arguments are true.

A-7-2 OR

The OR function returns true if any of its arguments is true.

A-7-3 NOT

The NOT function reverses the logic of its argument.

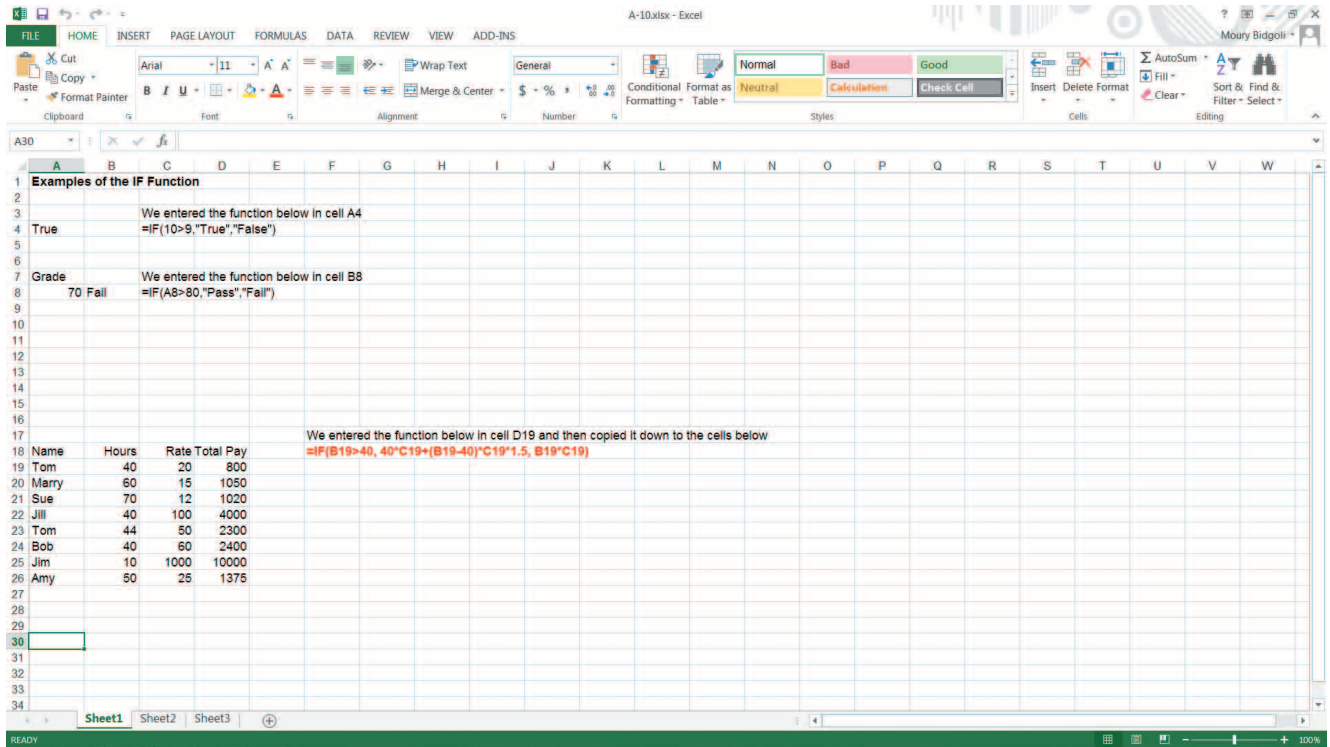### A-7-4 IF(Condition, A, B)

The IF function returns the value A if the condition is true and returns the value B if the condition is false. The condition must be either a numeric value or a calculation that results in a numeric value. For example:

Function	Returns
=IF(3<5, 10,-5)	10
=IF((10+5)/2<10,"T","F")	T

Exhibit A.10 shows a few examples of the IF function.

Exhibit A.10
The IF function

Another example of the IF function is calculating the total pay of an employee who has worked overtime. The formula is as follows:

=IF(H1>40,R1*40+(H1-40)*1.5*R1,H1*R1)

The total pay is rate (R1) multiplied by hours (H1). However, if the employee works more than 40 hours, overtime pay is calculated at the rate of 1.5 times regular pay. Overtime pay is only for the hours over 40 (see the lower part of Exhibit A.10).

There are many applications of the IF function. For example, you can use this function to check a customer's credit limit. If the customer's credit is good, you send one message; if it is bad, you send a different message. You can also use the IF function for inventory management; if the inventory on hand is below 500 units, you need to reorder. If it is not, you do not need to reorder.

Using the IF function with the logical operators NOT, AND, and OR adds a strong decision-making component to Excel. As introduced earlier, when you use AND, all the conditions must be true; using OR, only one of the conditions must be met; and NOT screens out everything that doesn't meet the condition.

Consider the information shown in Exhibit A.11. In Row 4, the student is accepted because she has met both conditions: Her GMAT is greater than 600, and her GPA is greater than 3.3. In Row 6, the student is accepted because her GMAT score is greater than 600, and the GPA condition does not matter. In Row 9, the student is rejected because both conditions must be true and, in this case, they are not. In the exhibit's column A, the actual formula is displayed instead of the results, so you can see exactly what was entered in cells D4 through D9.

Exhibit A.11
The IF function with logical AND, OR, and NOT

Created using Microsoft Excel®, used with permission from Microsoft.

Exhibit A.12 shows another example of the IF function. Northwest Lumber Company pays a commission to its employees based on the following conditions:

Under $15,000 total sales ($0–$14999)	No commission
$15,000 to $20,000 total sales ($15000–$20000)	$800
Over $20,000 total sales ($20,001+)	$800+15% of sales over $20,000

This example illustrates a Nested IF function. In column C, we show the actual formulas used in column D.

Exhibit A.12
A Nested IF function

A-8 LOOKUP FUNCTIONS

Lookup functions are used for searching a value in a table. The two commonly used ones are HLOOKUP and VLOOKUP, which are explained below.

A-8-1   HLOOKUP(Lookup_Value, Table_Array, Row_Index_Num)

The HLOOKUP function performs a horizontal table search (see Exhibit A.13). This function compares the value of Lookup_Value (test variable) to each cell in the top row of the specified table. The top row of the table used by the HLOOKUP function must be sorted in ascending order.

When Excel finds a number larger than the test variable, it stops and backs up one cell. Then, Excel moves down the specified number of rows (Row_Index_Num) and returns the content of that cell. If there is an exact match to the test variable, the search stops at this cell, and no backtracking takes place.

Exhibit A.13
The Hlookup function

If the test variable is smaller than the first value, the function returns an error. If the test variable is larger than all of the values, the search stops at the last cell in the top row of the table, then Excel moves down the specified number of rows and returns the contents of that cell.

Using the information shown in Exhibit A.13, the following HLOOKUP functions return the values shown:

=HLOOKUP(25000,B4:H9,2)	2500
=HLOOKUP(40000,B4:H9,3)	2900
=HLOOKUP(24000,B4:H9,5)	1900
=HLOOKUP(22500,B4:H9,2)	2300
=HLOOKUP(15000,B4:H9,3)	#N/A

A-8-2 VLOOKUP(Lookup_Value,Table_Array,Col_Index_Num)

The VLOOKUP function performs a vertical search much like the HLOOKUP function's horizontal search. VLOOKUP compares the value of the test variable to each cell in the first column of a specified table (see Exhibit A.14). Again, in order to work correctly, the contents of these cells must be sorted in ascending order.

Exhibit A.14
The Vlookup function

When Excel finds the first number that is either not greater than the test variable or an exact match, it moves across the search table in the specified number of columns and returns the contents of that cell.

If the test variable is smaller than the first value in the search column, the function returns an error. Using the information shown in Exhibit A.14, the following VLOOKUP function returns the values shown:

EXAMPLES OF VLOOKUP:

=VLOOKUP(26500,A4:G10,2)   3000

=VLOOKUP(45000,A4:G10,3)   7100

=VLOOKUP(37300,A4:G10,4)   5200

=VLOOKUP(41000,A4:G10,5)   6300

=VLOOKUP(47000,A4:G10,6)   7400

=VLOOKUP(50000,A4:G10,7)   8500

=VLOOKUP(19000,A4:G10,1)   #VALUE!

Exhibit A.15 shows an interesting application of the VLOOKUP function. In this example, Professor Smith uses the function to assign letter grades to his students based on the results of three test scores. We've entered a LOOKUP table in cells H10:I14. Excel assigns letter grades to the average of these tests using the LOOKUP table. Exhibit A.15 shows the actual formulas. We selected **Formulas** (from the menu bar), then clicked **Show Formulas**. Exhibit A.16 shows the results without using the Formulas option.

Exhibit A.15
The Lookup table with Show Formulas option

Exhibit A.16
The Lookup table with actual values

A-9 USING EXCEL FOR WHAT-IF ANALYSIS

What-if analysis calculates the effects of a change in one variable on other variables or an entire worksheet. A simple example is break-even analysis. The break-even point is the number of units generated in which total cost is equal to total revenue. For example, if the fixed cost of an operation is $500, the variable cost of a unit is $10, and the selling price is $15, the break-even point would be 100 units. At this point, the company will neither lose nor gain anything. Above this point, the company will gain, and below this point the company will lose. Excel can help you discover what will happen to the break-even point if, say, the selling price is increased to $17 or the variable costs are decreased by $3.

This feature can be used in a much more complex environment. Let's say you have projected the budgets of your company for the next 5 years. Suddenly, you learn that the projected income for 2018 will be reduced by 5%. What is the impact of this income reduction on the entire budget? Thousands of accurate calculations must be done in order to answer this question. But if the budget is on an Excel spreadsheet, the software can perform all of the calculations almost instantly, and with no errors. Just change the old value to the new value and press Enter.

What-if analysis can be done with charts as well (see Appendix B). Change any data item, and Excel generates a new chart instantly. The next section presents a couple of Excel's what-if analysis features that use the Data Table command.

A-9-1 WHAT-IF ANALYSIS USING DATA TABLE: ONE VARIABLE

The Data Table (with one variable) command can be used to determine the effect of one variable on a formula or an entire worksheet. There are many areas where this command can be useful—for example, the effect of different interest rates on an IRA plan, the effect of different interest rates on a loan, or the effect of different commission percentages on the total commission generated by a salesperson.

To use the Data Table command with one variable, you must first establish a table range. In Exhibit A.17, C4:E15 is the table range. The table range can be anywhere in the worksheet.

Exhibit A.17
The Data Table command with one variable

Next, you must choose an empty cell outside the table range as the input cell. The address of this cell will be used to change values in a formula; it is also used in Excel internal calculations. Do not be concerned about its role. In this example, the input cell is A5.

Next, fill in the changing values in a column—in this case, cells C5:C15. Above and to the right of these values, in cell D4, is the formula, in this case the future value: =FV(2000,A5,20). This function calculates the future value of an IRA plan to which you contribute $2000 each year for 20 years with a variable interest rate.

We copied the =FV(2000,A5,20) to cell E4, but we changed the number of years to 30. The intersection of these values (interest rates and formulas) is empty; this empty cell will be used by the Data Table (with two variables) command introduced in the next section.

When you have defined the parameters, the future value of the IRA plan will be calculated for different interest rates and numbers of years. Exhibit A.17 shows an application of this command. After building the table, the following keystrokes were used to fill in the table:

1. Select cells **C4:E15.**
2. Click **Data.**
3. Click **What-If Analysis.**
4. Click **Data Table.**
5. Click **column input cell.**
6. In the dialog box, enter **A5**, then click **OK.**

A-9-2 WHAT-IF ANALYSIS USING DATA TABLE: TWO VARIABLES

You can use the Data Table command with two variables to calculate the effects of two variables over the entire worksheet or a specified range. Suppose Sunrise Electronics has designed a formula for calculating the total salary of each employee. The total salary is calculated based on the years of education and years of experience. In every case, $2000 is the base salary. The formula is as follows:

=2000+100*A1+175*B1, where A1 is the number of years of experience and B1 is the number of years of education (these are the input cells).

In Exhibit A.18, we've used the Data Table command to calculate the entire table for Sunrise Electronics. The table range is D3:H18, the row input cell is A5, and the column input cell is B5. The formula =2000+100*A5+175*B5 was copied in cell D3, which is the intersection of row 3 (years of education) and column D (years of experience). We entered the numbers 1 to 15 in cells D4:D18 and numbers 12, 16, 18, and 21 in cells E3:H3. After the table was built, the following keystrokes were used to fill the table:

1. Select cells **D3:H18.**
2. Click **Data.**
3. Click **What-If Analysis.**
4. Click **Data Table.**
5. Click **Row input cell.**
6. Enter **B5.**
7. Click **Column input cell.**
8. In the dialog box, enter **A5.**
9. Click **OK.**

Exhibit A.18
The Data Table command with two variables

A-10 USING EXCEL FOR GOAL-SEEKING ANALYSIS

Goal-seeking analysis is the reverse of what-if analysis. Here, you ask a question such as the following: "To generate $5,000,000 in total sales, how much money should I spend on advertising?" If you build an advertising model (Excel provides you with the tools to do this), performing this kind of analysis is easy. When performing a goal-seeking analysis, you manipulate one variable in order to achieve a goal. Excel's Goal Seek feature assists you with these kinds of analyses.

As an example of using goal-seeking analysis, recall that earlier in this appendix you were shown how to use the PMT function to calculate a loan payment amount. In that case, the amount of the loan, the interest rate, and the payback period were known in advance. Suppose instead that you want to buy a house worth $200,000, you want to pay the loan off in 15 years, and you are only able to pay $1500 a month. Therefore, you want to know the interest rate at which you should secure the loan in order to be able to buy this house. Excel's Goal Seek feature can answer this question for you. Follow the steps below:

1. Start a blank worksheet.

2. In cell A1, enter **Loan amount**.

3. In cell A2, enter **Payment period**.

4. In cell A3, enter **Yearly interest rate**.

5. In cell A4, enter **PMT formula**.

6. In cell B1, enter **200,000**.

7. In cell B2, enter **15**.

8. In cell B4, enter **=PMT(B3/12,B2*12,B1)**. We left cell B3 empty for the interest rate that will be calculated by the Goal Seek feature. Please notice that we divided B3 by 12 and multiplied B2 by 12 in order to make them consistent; payments are monthly, and the interest rate is also monthly now.

This is all the input data you need. As soon as you enter the PMT formula in cell B4, Excel displays (1,111.11) (see Exhibit A.19). That is because, at this point, the interest rate is 0. Also, it is displayed as a negative number because this is a cash outflow.

Exhibit A.19
A sample worksheet for the Goal Seek feature
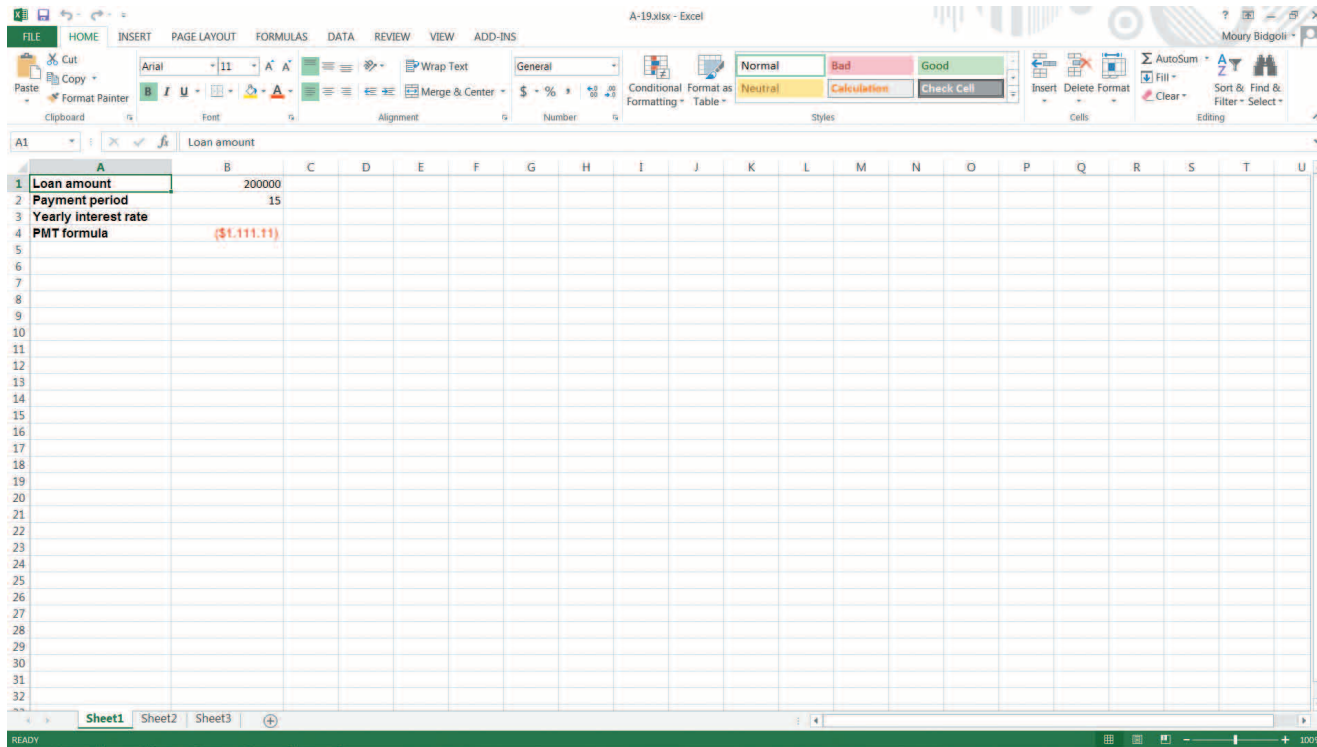
Follow the steps below to calculate the interest rate using the Goal Seek feature:

1. Click cell **H1** (or any other cell outside the worksheet data).

2. Click **Data, What-If Analysis,** and **Goal Seek.** The Goal Seek dialog box opens (see Exhibit A.20).

3. In Set cell, enter **B4**.

4. In To value, enter -**1500**.

5. In By changing cell, enter **B3**. As soon as you click **OK,** 4.2% is displayed in cell B3. We formatted the B3 cell with the **Percentage** option to one decimal (see Exhibit A.21).

Exhibit A.20
The Goal Seek dialog box
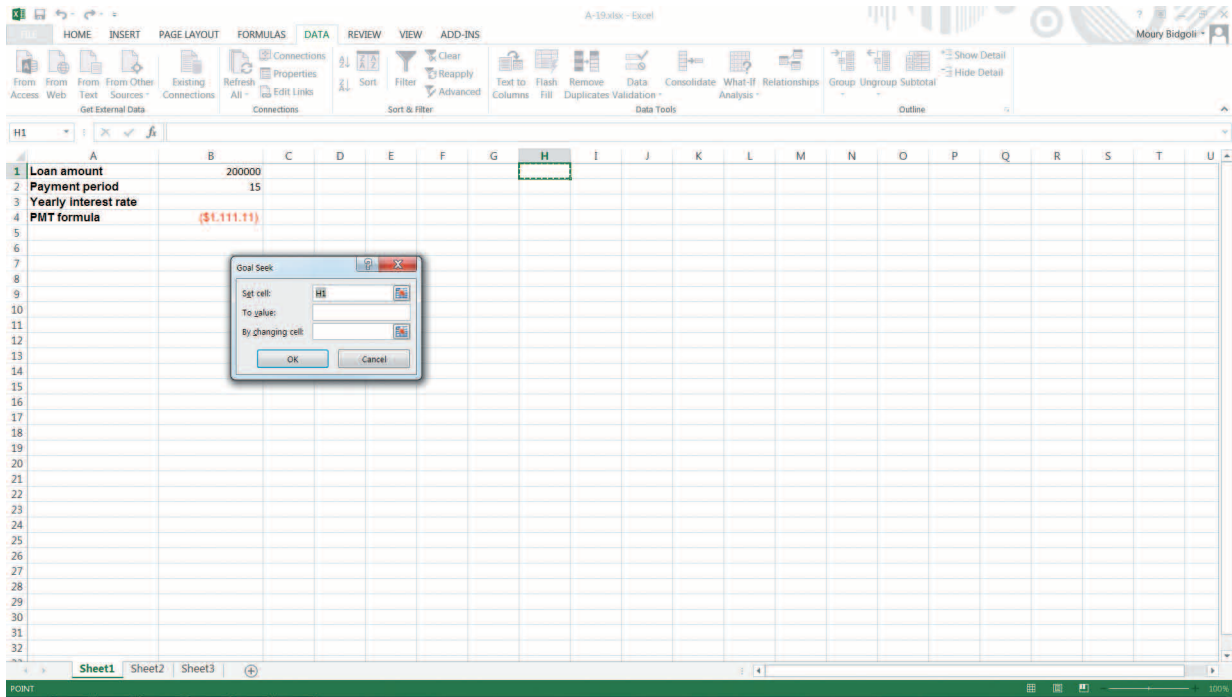
Exhibit A.21
The interest rate calculated by the Goal Seek feature

This simple analysis tells you that if you secure a loan with a 4.2% interest rate, you will be able to buy a house worth $200,000 and your monthly payment will be $1500. Above this rate, you will not be able to afford the house. If you find a loan with an interest rate below 4.2%, your monthly payment will be less than $1500.
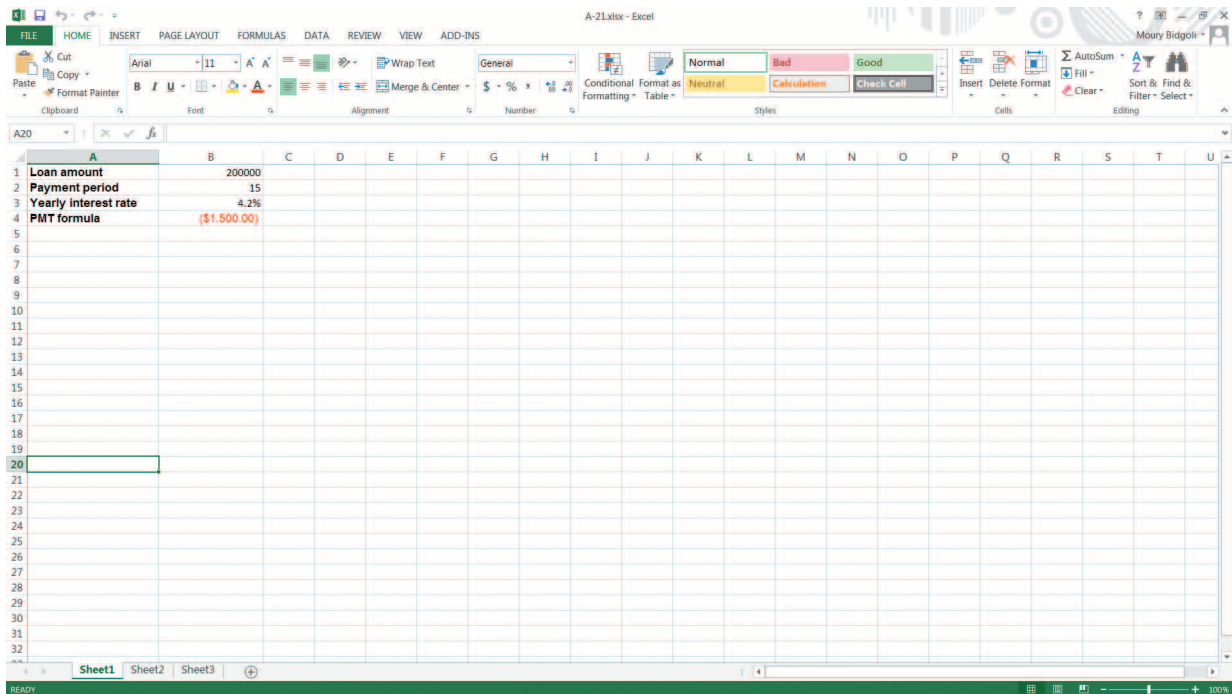
Problems, Activities, and Discussions

1. How many different addresses could a given cell have in Excel?

2. What are two examples of financial functions? Mention one business application of each.

3. What are two applications of the IF function?

4. What are two what-if features of Excel?

5. If the price of a car is $31,000, the interest rate is 4.9%, and the payment period is 5 years, how much is the monthly payment? If the interest rate goes down to 3.5%, how much is the new monthly payment?

6. A new Web-based order entry system for the ABC Company has the following estimated cash flows for the next 7 years. How much is the NPV of this project at 6% interest rate? Will the NPV go up or down if the interest rate goes up to 8%?

   –5000, –3000, –2000, 2900, 4400, 5900, 4800

7. The ABC Company pays a commission to its employees based on the following conditions:

   Under $10,000 total sales ($0–$9999): No commission

   $10,000 to $20,000 total sales ($10000–$20000): $1000

   Over $20,000 total sales ($20,001+): $1000+12% of sales over $20,000

   Using the Nested IF function, calculate the total commission for the following 10 employees:

Employee Name	Total Sales	Total Commission
Bob	$12,000	
Alan	$22,000	
Moury	$17,000	
Mary	$32,000	
Ron	$8000	
Dave	$14,000	
Brian	$25,000	
Jean	$29,000	
Lori	$9,800	
Jasmine	$31,800	

8. Modify the Lookup table in Exhibit A.15 as follows:

   LOOKUP TABLE

   50 F

   60 D–

   65 D

   68 D+

   70 C–

   75 C

   78 C+

   80 B–

   85 B

   88 B+

   90 A–

   95 A

   98 A+

   Now generate the new grade for each student. You may add additional students to the list with their test scores and see how accurately Excel assigns a letter grade to each student.

9. Modify the interest rates in Exhibit A.17 as follows:

   2.00%

   2.50%

   3.00%

   3.50%

   4.00%

   4.50%

   5.00%

   5.50%

   6.00%

   6.50%

   7.00%

In cell G4, enter the function =FV(A5,40,–2000). Now, using Data Table command with one variable, recalculate this new table.

10. In Exhibit A.18, enter the new formula listed below in cell D3 and calculate the salary of each employee:

=2100+A5*150+B5*225

How much is the salary of an employee with 10 years of experience and 18 years of education?

11. Using the Goal Seek feature of Excel, calculate the interest rate of a house worth $300,000 if you want to pay the loan off in 30 years and you are only able to pay $2000 a month.

12. The COUNT function accepts numeric as well as nonnumeric values as arguments. True or False?

13. Any cell in Excel has two absolute addresses and two mixed addresses. True or False?

14. All of the following are examples of valid Excel cell addresses except:
    a. A1
    b. 1A
    c. A1
    d. A$1

15. All of the following are examples of financial functions except:
    a. FV(Rate,Nper,Pmt,Pv,Type)
    b. NPV(Rate,Value1,Value2,…)
    c. IF(Condition, A, B)
    d. PMT(Rate,Nper,Pv,Fv,Type)