C7: Quantitative Techniques

Module 3

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Module 3

Spreadsheet modelling in management

Introduction

Now that you have laid the mathematical and statistical foundations, you can move into the area of modelling and decision making with electronic tools. In today's world, it is essential to know how to use computer-based modelling and quantitative methods. Through these methods, computations that are time-consuming and almost impossible to do by hand become quick and simple.

You can apply the techniques and ideas of the previous two modules in a very practical way by using spreadsheets. These can be found in computer software packages, and also as "freeware" on the Internet.

Different spreadsheet options operate in very similar ways and there can be different versions of the same software (for example, the popular Microsoft Excel 2003 and Excel 2007), but the basic features remain the same.

Do not worry if you have never used spreadsheets or Excel. Work slowly through all of the examples and remember that you learn by making mistakes. The aim of this module is not to turn you into a computer programmer, but to make you aware of the possibilities of electronic spreadsheets.

Outcomes

Upon completion of this module you will be able to:

- **master** basic spreadsheet techniques;
- **generate** graphs, charts and tables electronically to display data;
- **apply** sensitivity analysis to cash flow problems;
- **evaluate** projects and capital budgets;
- **use** ANOVA analysis on data;
- **apply** spreadsheet tools such as Data Analysis and Goal Seek; and
- **use** simple macros in VBA.

Unit 9

Introduction to spreadsheets

Introduction

The objective of this unit is to introduce you to the basics of electronic spread sheets. While the unit is intended for students who have little or no previous experience with spread sheets, we assume you have some previous experience using a computer.

The rest of the material (from Unit 10 onwards) covers more advanced features and shows you how to apply the techniques developed in Modules 1 and 2 to spread sheets.

There are two main spread sheet packages: Microsoft's Excel (versions 2003 or 2007) and OpenOffice.org's Calc (which can be downloaded free from www.openoffice.org).

Outcomes

Upon completion of this unit you will be able to:

- **understand** menu bars, toolbars and dropdown menus;
- **enter**, **change** and **delete** data in a cell;
- **use** formulas, references and functions;
- **save** and **retrieve** files;
- **format** the appearance of a cell's contents;
- **change** the width of a column;
- **insert** rows; and
- **move** data from one location to another.

What is a spreadsheet?

Open your spread sheet software. Click on the Excel icon (picture) or the OpenOffice.org Spread sheet icon on your desktop or menu bar. Although all of the concepts are explained using Excel version 2003, all spread sheet software applications work in a similar way, so you should be able to adapt the instructions to your needs.

If you don't have Excel, use the following instructions to download OpenOffice.org from the Internet free of charge:

OpenOffice.org is an open-source office software suite that can be downloaded and used free of charge. The suite includes programs for word processing (Writer), spread sheets (Calc), presentations (Impress), graphics (Draw) and databases (Base).

It is available for different languages and platforms. Files can be transferred between OpenOffice.org and many other office suites.

To download OpenOffice.org:

1. Access the OpenOffice.org website by typing this in your browser window:
   http://www.openoffice.org
2. Choose the second option ("I want to download OpenOffice.org") by clicking on it.
3. This will start downloading the OpenOffice software for the Windows platform in US English. (There is a link if you want to download it for a different platform and/or language.)

Note: The file is quite big (approximately 148 MB) and might take some time (45–60 minutes) to download, especially if you have a slow connection

4. Once downloaded, run the file (by double-clicking on the file name). This will load the installation files onto your computer. This is a short process and once the files have been loaded, installation is automatic.
5. You will be guided through the installation steps. Choose the Complete installation to install all the programs and features of OpenOffice.org. The installation process should only take a few minutes.

   Ensure you tick the box to make an OpenOffice.org icon on the desktop.

   If you want to install only part of the software (for example Calc, the spread sheet program), choose the Custom option. This will use less space (but only use this option if you are an advanced user).
6. To run OpenOffice.org, double-click on the icon that has been created on your desktop.

   The first time you run OpenOffice.org, you will be taken through a short registration process, after which the program will open.
7. To open a spread sheet, click on the Spread sheet icon.

In Excel, open a new workbook by clicking on the New Blank Document icon in the Standard Toolbar. Or click on <File> and then <New>.

On the screen is a spread sheet, which is a grid of rows and columns with row and column headings, as shown in Figure 1 (Excel) and Figure 2 (OpenOffice Calc).

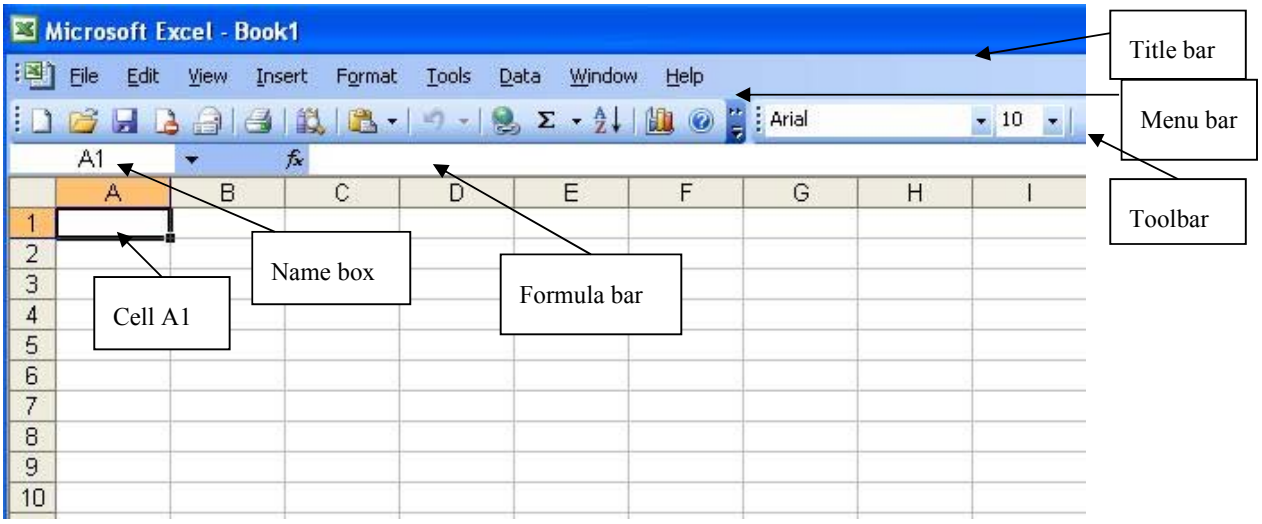


Figure 1 Spreadsheet for Excel

The empty blocks are called cells. The top line on your screen is called the title bar and should say something like "Microsoft Excel – Book 1".

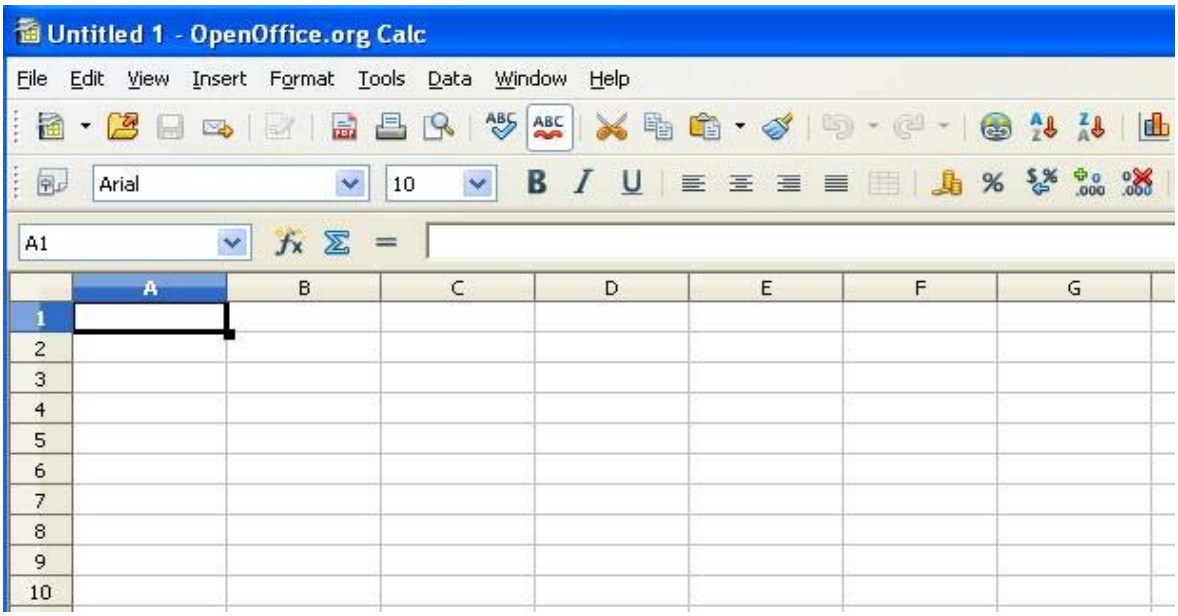


Figure 2 Spread sheet for OpenOffice Calc

Menus and toolbars

Below the title bar is a line with these names (for Excel 2003):
File Edit View Insert Format Tools Data Window Help

Or, for Excel 2007, the menus are labelled:
Home Insert Page Layout Formulas Data Review View Acrobat

These lines form the menu bar. Clicking on any of these words activates a dropdown menu with several options. For example, if you click on <View> the following dropdown menu will appear:

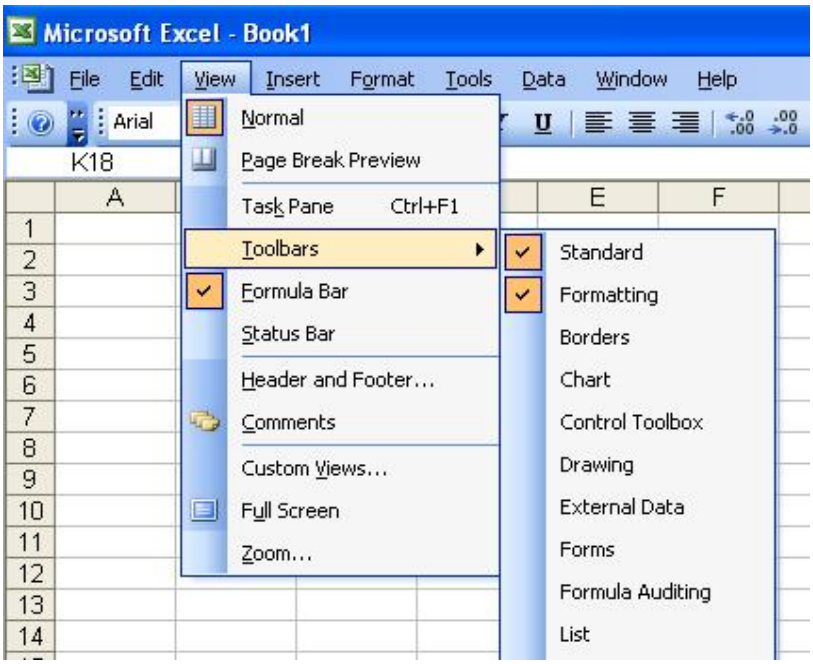


Figure 3

In the case of Excel 2007, a new row of icons will appear.

Below the menu bar are a few lines with icons (pictures). Investigate the menus and icons to see what features are available on your particular spread sheet. These features appear on toolbars as sets of icons. Moving the mouse over an icon makes a screen tip (description of the feature) appear. The ? icon is a Help facility and is very useful.

The rest of this module refers to Excel 2003. Practise using your particular spread sheet so that you become familiar with it – there is no substitute for spending time with your computer.

Follow these steps to ensure you have the toolbars showing on screen that you will use later on by:

- Click <View> on the menu bar.
- If there is a tick mark next to Formula Bar on the dropdown menu do nothing, otherwise click <Formula Bar> and <View> again.

- Click <Toolbars>. Another dropdown menu with the names of other available menu bars appears. If there are tick marks next to Standard and Formatting, do nothing, otherwise click <Standard> and <Formatting> so that tick marks appear.

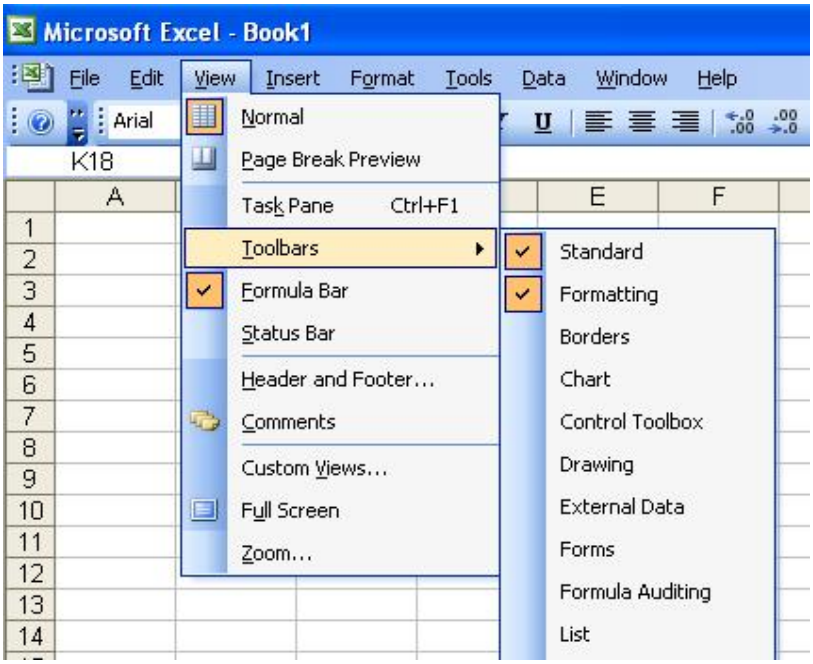


Figure 4

To make any dropdown menu disappear from the screen, click anywhere on the grid itself and the dropdown menu will disappear.

Cells

Look at the grid (spread sheet) as shown in Figures 1 or 2. Above the cells you will find the toolbars, showing icons such as a clean page, an opened folder, a printer, scissors, and so on. When you move your mouse pointer to any of the icons on the toolbar and hold it still, a label appears with a description of that icon's function. For example, when you click on the blank page, a new worksheet will be opened.

The cells themselves are named for the row and column in which they appear. For example, the cell in the first row, second column from the left is identified as B1, while the cell in the fifth row and fifth column is E5. This name appears in a block, called a name box, which sits above column A.

Each cell may contain a number, some words or a formula. To enter a number or text into a cell, click the cell where you want to enter the data. Then type the data and press <Enter> or <Tab>. You can change the entry in a cell by clicking on the cell again and typing in a new value to replace the old one. To delete the entry in a cell, click on it and press <Delete> on the computer keyboard. Practise putting data into cells and deleting it.

A useful pair of icons is the Copy and Paste combination. The icon for Copy is double pages and Paste is shown by a clipboard with a page. To copy the contents of a cell (its numerical value or formula), click on the cell, click the Copy icon, click on the new cell and click the Paste icon.

Note: The contents of a cell you click on will appear in the blank line labelled *fx* above the grid. This line is where you can enter formulas or functions and is called the Formula Bar. In Excel 2003, you can click on the <Insert> menu and then on <Function>. A list of functions you can use will appear. In Excel 2007, you can click on the Formulas icon and new icons will appear with functions such as Financial and Math.

Saving a workbook

To save a workbook, click on <File> and <Save> or on the 🖫 icon. Give the workbook an appropriate title and then save it. In Excel 2007, click on the Microsoft icon at top left, then on <Save>.

As you work on a file, keep on saving this file by clicking the 🖫 icon. It will automatically be saved under the same name. You can save a copy of the file with a new name by clicking on <Save as> in the <File> menu. When you start a new Excel session and you wish to retrieve your model, you do the following:

Click <File> in the menu bar, then <Open> in the dropdown menu, then choose and click the name of the file you want in the <File name> box. Click <Open>.

Activity 3.1

Activity

Make a spreadsheet

What will you do?

1. Open a new workbook. Enter this table in cells A1 to B7.

Year	Sales
1	112
2	243
3	265
4	310
5	400
6	450

2. Save the workbook as **Annual Sales Figures**. Change all sales entries by adding 100 to each number. Save the workbook and close.
3. Open the workbook again. Enter the words "Total Sales" in Cell A9.
4. Create a new workbook. Enter this table in cells A1 to B5.

1	3
2	5
3	7
4	9
5	11

5. Copy the table to cells E8 to F12. Save the workbook as **Linear Function**.

Note: When you enter numbers greater than 1,000 in Excel, it is best to omit the comma.

Formulas and functions

Let's perform operations on the data in cells. Open a workbook, enter any numbers in cells A1 and A2 and save it as **Practice**.

Click on the cell where you want the answer to an operation to be displayed. Then click in the empty formula bar next to *fx* (just above column C in the grid) to enter the formula. A formula in Excel always begins with an equal sign (=), followed by what the formula calculates. Then press <Enter> on the keyboard. The result of the formula is displayed in the cell.

For simple mathematical operations, use these symbols in spread sheet calculations:

+	for addition	−	for subtraction
*	for multiplication	/	for division
^	for exponentiation		

Formulas and operations are usually applied to cells. If you want to calculate the ratio of the numbers appearing in cells A1 and A2 and display that answer in cell A3, follow these steps:

- Click on A3.
- Click in the *fx* box.
- Type in =(A1/A2).
- Press <Enter>.

The answer will appear in A3. If you change the values in A1 and A2 and click on cell A3, the new answer will appear. Practise the different operations (addition, multiplication, and so on).

If you want to copy a formula from one cell to another cell, click on the first cell, click on the Copy icon, click on the new cell and click the Paste icon.

Apart from the easy mathematical operations, spread sheets have built-in functions, as mentioned above.

To apply a formula to an entire column, row or block of cells, you need to reference the range of cells.

Here are some examples:

Reference	**Refers to**
A1:A5	the column consisting of cells A1, A2, A3, A4 and A5
A2:D2	the row consisting of cells A2, B2, C2 and D2
A1:B8	the block consisting of the 16 cells in rows 1 to 8 and columns A to B

Activity 3.2

Activity

Do calculations in spreadsheets

What will you do?

Open a workbook and enter this table in cells B2 to C6:

12	8
7	15
10	12
18	9
11	20

a) Enter the word "Sum" in A7. Calculate the sum of numbers in each column and display the answers in B7 and C7.

b) Enter "Product" in D1. Calculate the product of numbers for each pair Bi, Ci (i = 2, 3... 6) and display the answers in column D in cells D2 – D6.

c) Enter "All Sum" in A10. Calculate the sum of all numbers from B2 to C6 and display the answer in A11.
Check that A11 = B7+C7.

Here's our feedback

a) Method for calculations: Click on B7. Click in *fx* formula bar. Type in: =(B2+B3+B4+B5+B6). Press <Enter>. The answer "58" should appear.

You can repeat the process for C7 or do the following: Click on B7, click Copy, click on C7, click Paste. The answer "64" should appear. You will notice that when the formula is copied, Excel cleverly changes the cell references from B to C automatically.

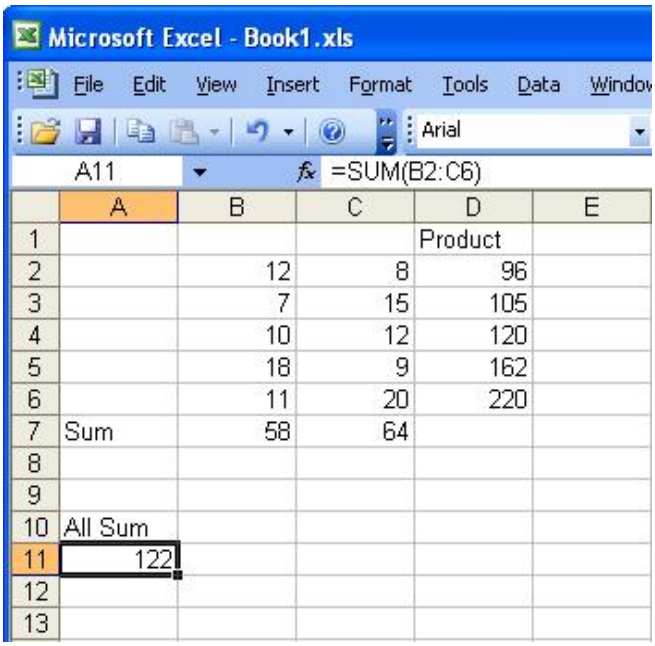
b) Click on D2. Click in the *fx* box. Type in: =(B2*C2). Press <Enter>. The answer "96" appears. Click on D2 again, click Copy, click on D3, click Paste. The content of D3 will have been adapted to = (B3*C3). Copy and paste for each cell down to D6. The cell references will automatically be changed.

If you do **not** want cell references to change when copying and pasting, you must give **absolute** references to such a cell. For example, if you want the formula in D3 to be = (B2*C3) — that is, the C-cells must change under copying but not the B-cells — then your original formula should read: = ($B$2*C2). The $ symbol fixes the cell reference.

c) Check that the answer is 122.

Note: The entry in cell A11 comes from the formula = SUM(B2:C6). This is an example of using range references and built-in functions. SUM is a function that sums everything in the range given in brackets. So instead of entering =(B2+B3+B4+B5+B6+C2+ C3+C4+C5+C6) in the function box after clicking on A11, you can enter =SUM(B2:C6

Your workbook for Activity 3.1 should look like this:



	A	B	C	D	E
1				Product	
2		12	8	96	
3		7	15	105	
4		10	12	120	
5		18	9	162	
6		11	20	220	
7	Sum	58	64		
8					
9					
10	All Sum				
11	122				
12					
13					

Figure 5

Some Excel functions

Excel has many built-in functions. They are always displayed in capital letters.

AVERAGE	calculates the average of a range of values.
MAX	finds the largest value in a specified range.
MIN	finds the smallest value in a specified range.
STDEVP	calculates the standard deviation of values.
VARP	calculates the variance of values.
FV	calculates the future value of a stream of periodic, equal payments.
PV	calculates the present value of a stream of periodic, equal payments.
NPV	calculates the net present value of a stream of periodic cash flows discounted at a fixed rate.

NPER	calculates the number of periods required for an annuity to reach a given future value.
PMT	calculates the annuity payment required to pay back a loan over a given period.
IRR	calculates the internal rate of return of a stream of periodic cash flows.
SKEW	calculates the skewness of a distribution.
KURT	calculates the kurtosis of a distribution.

Remember that a function must be preceded by "=" and followed by brackets containing the range of cells.

To find the whole range of available functions, click on an empty cell, then on <Insert> and then <Function>. Choose a category (if you're not sure which one, choose "All") and the specific function you want to use. Click on <OK> to enter that formula into the cell you have chosen. You can then enter the range of cells you want to apply the formula to.

To find out more about any of these functions and how to use them, you can use the Help function on the menu bar.

Activity 3.3

Activity

Calculate average and variance

What will you do?

1. For Activity 3.2, calculate the average of the numbers in each column.
2. Calculate the variance of these numbers:
   112, 114, 110, 116, 115, 118, 117.5, 113, 114.5.

Here's our feedback

1. In Cell A8, type the word "Average".

   Click on B8, click in Formula bar *fx* and type =AVERAGE(B2:B6). Press <Enter>. You can also click on <Insert> and <Function> then choose Average.

   Click on B8 again, click Copy, click on C8 and click Paste. Press <Enter>. You should see values 11.6 and 12.8, respectively, in cells B8 and C8.

2. Enter the numbers in a column in a workbook. Choose a cell to display the answer. Click on it and enter the function VARP and the correct range for the arguments in the formula bar *fx*. It should look like Figure 6.

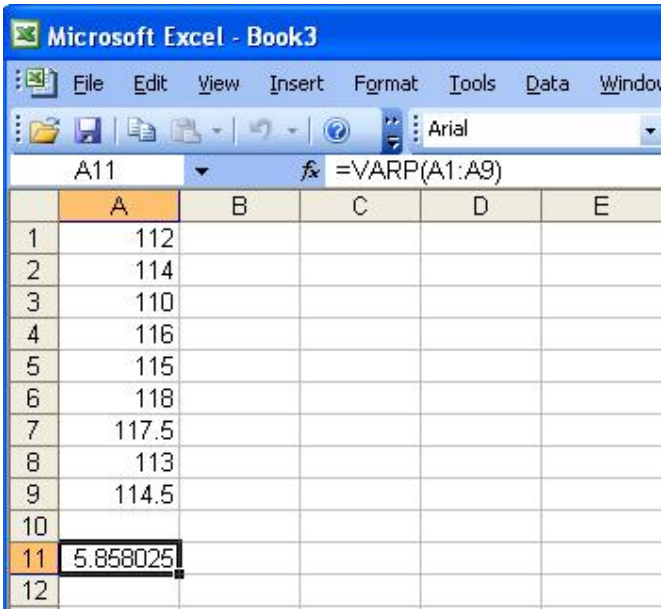


Figure 6

The variance is 5.858 (rounded off to three decimals).

Note: You will notice two functions that deal with variance:

VAR and VARP. VARP assumes the given values x_i form the total population of values and is based on the formula:

$$\text{variance } (x) = s^2 = \frac{\sum (x_i - \bar{x})^2}{N}$$

VAR assumes the given values form only a sample of a greater population of values, and is based on the formula:

$$s^2 = \frac{\sum (x_i - \bar{x})^2}{N - 1}$$

You can revise these concepts in Unit 6 of Module 2.

Changing the width of cells and aligning entries

You can change the width of columns. If, for example, you want to widen column A, move the mouse pointer onto the line (boundary) between the blocks for A and B in the row headings. When you're on the right line, a special symbol (a vertical line with two left-right arrows) appears. Drag to the left or right (by pressing and keeping the left mouse button down, then moving) until the column is the width you want.

Learn to align entries to improve the spread sheet's appearance. Follow these steps to align the heading in cell A1 to the right:

- Click on A1.
- Click <Format> on the menu bar and then click <Cells> on the dropdown menu. Click the Alignment tab.

In the Horizontal box, click on the arrow (▼) to reveal the available options and then click on Right. Click OK. Activity 3.2 Activity 3.2

Activity 3.4

Activity

Do more calculations

What will you do?

Create a new file in Excel and enter the data from the Module 2 section "Charts, graphs and histograms". The table gives the sales figures for the number of pairs of sunglasses sold in a shop in an island resort.

Month and sales figure		Month and sales figures	
January:	8	July:	32
February:	6	August:	44
March:	9	September:	36
April:	15	October:	21
May:	18	November:	12
June:	26	December:	10

Choose suitable headings and right-align them. Calculate the following in the workbook:

1. Average monthly sales figure.
2. Minimum sales figure.
3. Median and mode for sales.
4. Skewness of the distribution of sales.
5. Variance in sales over the year.

Applications: Project evaluation

This section returns to the "Applications" discussed in Unit 1 in Module 1, with the aim of evaluating a specific project by doing a sensitivity analysis and comparing different projects.

Sensitivity analysis means asking "What if?" questions for changes in the discount rate. You then make decisions based on the values of the criteria

Net Present Value (*NPV*), Profitability Index (*PI*) and internal rate of return (*IRR*). Electronic spread sheets make these analyses simple, whereas in Module 1 all calculations were done by hand and you did not consider the *IRR* there precisely because of computational difficulties.

Internal rate of return (*IRR)*

The internal rate of return gives the break-even rate of return for the project — that is, the rate r at which initial investment $C_0 = PV$ of cash inflows, or $NPV = 0$. This means solving for r from the equation:

$$\frac{C_1}{(1+r)} + \frac{C_2}{(1+r)^2} + \frac{C_3}{(1+r)^3} + \ldots + \frac{C_n}{(1+r)^n} = C_0$$

If the *IRR* is larger than the given required rate of return, the project is profitable.

Spreadsheet modelling for projects

Excel has functions for *PV*, *NPV*, *IRR*, and so on under the Financial category. Locate them and read the descriptions in the Functions box. Use the Excel *Help* function for assistance with how functions work in Excel.

Activity 3.5

Activity

Work with a cash flow stream

What will you do?

You are given a cash flow stream over 12 months. The initial investment (month 0) was 12,000 cedi. This is an outflow. The required rate of return is 1.14% per month.

1. Enter the data in an electronic spread sheet in cells A3:A15 (months 0–12) and B3:B15 (outflow and inflows). Remember that an outflow is negative, so B3 should be −12000.
2. Enter the words “Discount rate” in cell C3 and the rate into D3.
3. Enter appropriate headings in A1 and B1 for the data in the workbook.
4. Calculate these formulas:
   a) Average monthly cash inflow
   b) Maximum monthly cash inflow
   c) Standard deviation of cash inflows
   d) *NPV*
   e) *PI* (profitability index)
   f) *IRR*

Month	Cash flow	Month	Cash flow	Month	Cash flow
1	1,000	5	2,000	9	1,500
2	1,100	6	2,000	10	1,000
3	950	7	1,800	11	2,000
4	1,200	8	1,200	12	1,000

Remember to save your file regularly.

Here's our feedback

4.

a) Enter the word "Average" into cell A16.
Click on B16 and click in *fx* box.
Click <Insert> , <Function> and choose AVERAGE.
Enter range (B4:B15). The Formula bar should read:
=AVERAGE(B4:B15). Click <Enter>.
The value 1,395.83 should be displayed.

b) Enter the word "Maximum" into cell A17.
Click on B17 and click in *fx*.
Click <Insert> , <Function> and choose MAX.
Enter range (B4:B15).
Click <Enter>. The value 2,000 should be displayed.

c) Enter the word "Standard dev." into cell A18.
Click on B18, click in *fx*, <Insert> <Function> and choose STDEVP. Enter range (B4:B15).
Click <Enter>. The value 418.56 should be displayed.

d) Enter the word "NPV" into cell A20.
Click on B20, click in *fx*, <Insert> <Function> and choose NPV.
Enter arguments (D3,B4:B15) and add B3.
The Formula bar now reads: =NPV(D3,B4:B15)+B3.
Make sure that the value for the discount rate is entered as 1.14% or as 0.0144 into D3.
Click <Enter>. The value 3,531.78 should be displayed.

e) Enter the word "PI" into cell A21.
Click on B21, click in *fx* and enter =((B20/(−B3)+1).
Click <Enter>. The value 1.2943 should be displayed.

f) Enter the word "IRR" into cell A22.
Click on B22, click in *fx*, <Insert>, <Function> and choose IRR.
Enter argument (B3:B15, ***guess***).
In place of ***guess*** you can enter a value such as the discount rate – in this case, 1.14% – or omit the guess.
Click <Enter>. The value 5.3% should be displayed.

Activity 3.6

Activity

Determine profitability and analyse sensitivity

What will you do?

Refer to Activity 1.8 in Module 1.

A company in Papua New Guinea has 30,000 PGK (kina or K) to invest in either Project A or Project B. Each project runs over three years. The expected cash inflows at the end of each year are displayed in this table.

Project A	Project B
Year 1: K 10,000	Year 1: K 14,000
Year 2: K 12,000	Year 2: K 12,000
Year 3: K 14,000	Year 3: K 10,000

The required rate of return (discount rate) is 8 per cent p.a.

1. Set up a spread sheet to determine which project is most profitable at this point. Use *NPV* (net present value) as the criterion.
2. Perform a sensitivity ("what if?") analysis to take into account a change in discount rate of 2 per cent, either upwards or downwards.

Activity 3.7

Activity

Understand the terminology

What will you do?

Use this terminology table to record any terms or words you're uncertain about.

This activity is an opportunity to consolidate your understanding of new terminology and concepts you encountered in Unit 9. Fill in the terms you have learned and then write your own descriptions of them.

Terminology

Term		Description
	:	
	:	
	:	
	:	
	:	
	:	
	:	
	:	
	:	

Remember these key points

- Using spread sheets facilitates project analysis and sensitivity analysis.
- Practice, practice and more practice will make using spread sheets a pleasure.

Unit summary

Summary

You have successfully completed this unit if you can:

- **enter** data into the cells of a spreadsheet;
- **set up** headings and **align** them;
- **enter** formulas into the function box *fx*;
- **use** the Excel functions from the drop-down menu; and
- **assign** ranges as arguments for functions.

Unit 10

Tables, charts and graphs in Excel

Introduction

Tables and charts are a convenient way to display interpretations of data. The tables, charts and graphs you considered in Modules 1 and 2 are simple to produce in an electronic spread sheet.

Upon completion of this unit you will be able to:

Outcomes

- **set up** tables of data in spread sheets;
- **generate** frequency tables and histograms;
- **present** data and equations with charts and graphs; and
- **analyse** data with the Descriptive Statistics analysis tool.

Tables and column charts

To display data in a graph, select the data, then choose <Insert> from the menu bar and click on <Chart>. Alternatively, in the top toolbar of the worksheet you will find an icon called Chart Wizard. Click on it. You will see a list of Standard Type and Custom Type charts and graphs.

This table shows a certain country's annual growth rate as a function of interest rate over 5 years. Enter this into a worksheet in cells A1 to B6.

Annual interest rate (%)	Annual growth rate for country (%)
4	6.4
6	5.0
8	3.7
10	2.5
12	1.6

Excel presents the data contained in a worksheet as a chart or graph. The Chart Wizard provides a quick way to generate a chart or graph:

- Select the cells that represent the data you want to plot in the chart – for example, the growth rate values contained in cells B2 to B6. You select cells by highlighting them: click and hold on B2, then move the mouse down to drag across the column to B6.
- Click <Insert> on the menu bar and then click <Chart> on the dropdown menu. Otherwise, click directly on the Chart Wizard icon in the toolbar.

Step 1 offers a choice of standard or custom-type charts. We will discuss column charts.

A. Click on Column and then on Clustered column. Click on <Next>. A column chart will appear.

Step 2 makes sure the correct data is used for the chart. Since you have highlighted column B2:B6, this will appear as data range Sheet1!$B$2:$B$6. If you have not chosen the range earlier, you can now enter B2:B6 in the Data range box. Make sure Columns is ticked, since the data is in column form.

If you click on the Series tab, you can give Series1 the name "Growth Rate". Click on <Next>.

Step 3 allows you to:

- add titles
- remove or add gridlines
- remove or label the Legend box to the right of the graph, and so on.

For example, you can label the *x*-axis as "Year". (The only way to learn how to use the options is to try them out and see how the graph is affected.)

Step 4 allows you to place the chart on one of the sheets that make up the workbook. When you click on <Finish>, the final graph appears.

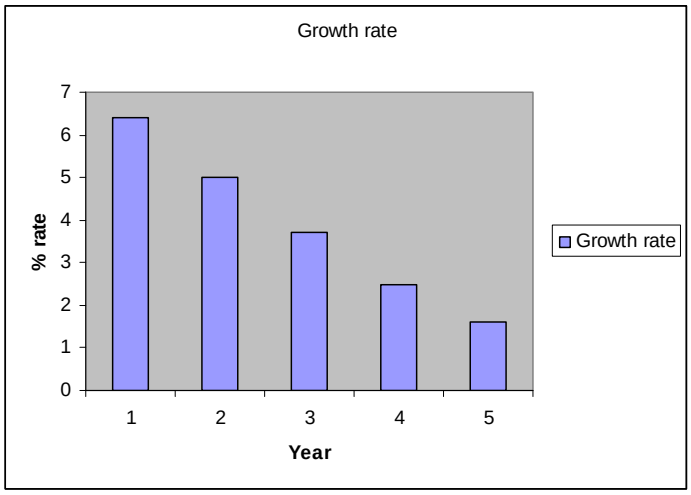


Figure 7

If you want to edit, right-click inside the frame of the graph and a list of options will appear. Click on Chart options and make the necessary changes. You can choose to display Interest rates by highlighting A2:A6 instead.

B. The clustered column chart in Figure 7 is not sufficient, as the interest rates are not displayed. Highlight the block A2:B6 to include both columns. Click on Column and again on Clustered

column. Both rates will appear as columns. Go through the steps to obtain the chart shown in Figure 8.

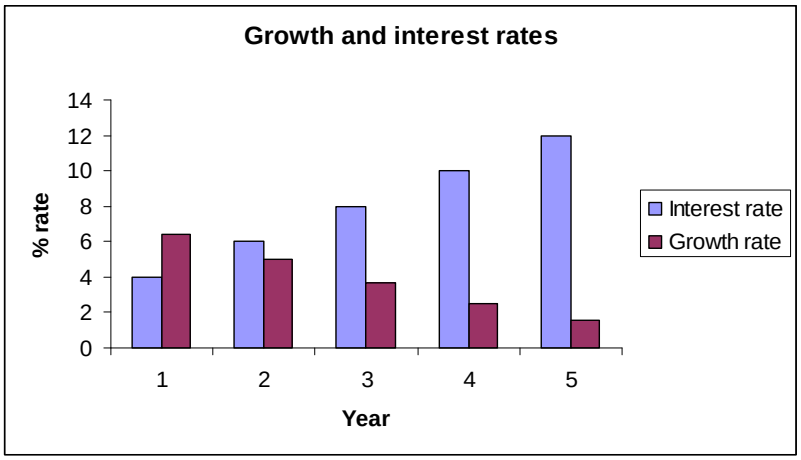


Figure 8

This enables you to see both quantities and how they change relative to each other.

C. Try a custom-type chart: Choose Line-Column. Go through the steps to obtain Figure 9.

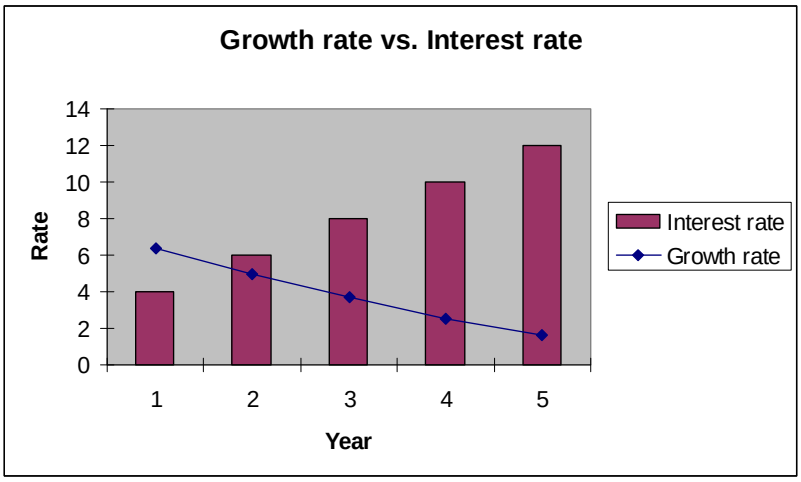


Figure 9

A disadvantage of column charts is that they are limited to category-type data – that is, the data is in groups (in this case, years) labelled 1, 2, 3... along the *x*-axis. We do not have growth rate as a function of interest rate.

Scatter graphs, lines and curves

The same data can be used to draw scatter graphs. Select A2:B6 by highlighting the block and then click on Chart Wizard.

Click on XY (Scatter) and choose the picture with the description "Scatter with data points connected by lines". Click <Next> and ensure

the data range is correct (both columns); also check that "Columns" is ticked, as the data has been entered column-wise.

Click <Next> and enter titles for your graph and the axes. Remove gridlines (if you wish) and the Series label under Legend (unless you want it). Click <Next> to choose a sheet and then <Finish>. If you want to remove the grey shading in the graph area, right-click inside the Plot area and click <Clear>.

Because you entered Interest rate in Column A, this will be interpreted as the independent variable *x* and displayed along the *x*-axis. Growth rate in the B-column will be displayed on the vertical (*y*) axis. Your graph will look like this:

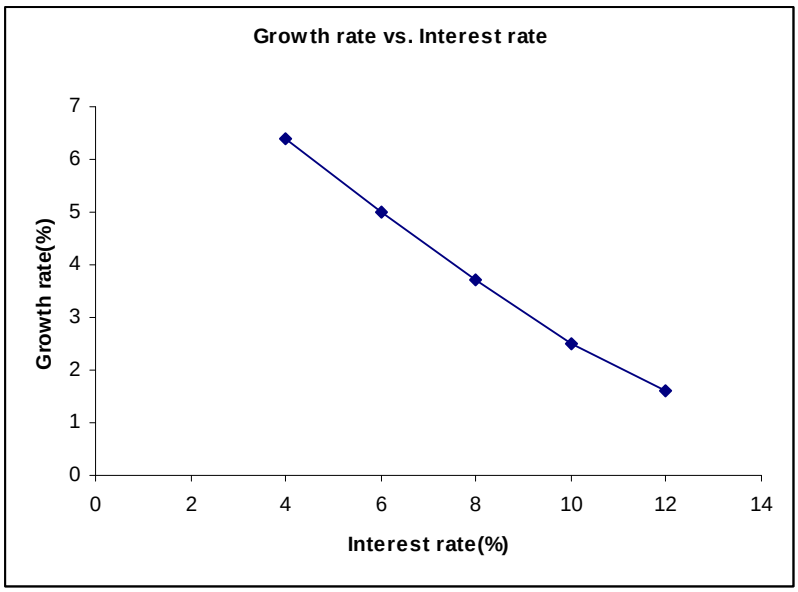


Figure 10

Remember: The final look of a graph is your choice, and the only way to get comfortable with Chart Wizard is to practise using it. Save workbooks with logical file names so you can easily find them again.

Activity 3.8

Activity

Practise graphs

What will you do?

Use the data in the various examples and exercises in Module 2 to generate column charts and scatter graphs.

Lines and planes

The Chart Wizard can generate lines from formulas in two-dimensional space and planes in three-dimensional space.

Activity 3.9

Activity

Price/Quantity relations and Break-even point with Excel

What will you do?

1. The relation between quantity Q of bags ordered by a buyer from a retail outlet and price P charged per bag is given by:
   $P(Q) = 250 - 0.14\,Q$, for $Q > 0$

   The units for P will be in the currency of the country. Represent the relation as a straight-line graph in a spread sheet.

   Interpret and discuss the result.

2. Total production cost TC = fixed cost + variable cost
   $= 12{,}000 + 50N$
   where N is the number of items produced.

   Total revenue $R = PN$ where P is the selling price per item.

   a) For $P = 80$, use Chart Wizard to determine the break-even point. (All numbers here are in Jamaican dollars, JMD).

   b) For $P = 100$, use Chart Wizard to determine the break-even point.

Here's our feedback

1. First, draw a table in Excel. Open a new workbook and write the titles "Quantity Q" in cell A1 and "Price P" in cell B1. Put the independent (Q) variable in the first column. Enter a number of suitable values for Q in the A column. Click on B2. Click in the Function bar. Enter the equation: =(250 – 0.14*A2). After pressing <Enter> the answer should appear in cell B2.

   Now click on B2 again and Copy. Click on B3 and drag down to highlight the B-column up to the last Q value. Click Paste. The equation will have been adapted to all the values for Q and the answers for P should appear.

A	B
Quantity Q	Price P
0	250
50	243
100	236
150	229
200	222
400	194

Now highlight the block with both columns, click Chart Wizard, choose Scatter (XY) and an appropriate sub-type (such as smoothed lines without markers) and continue the steps. A graph such as Figure 11 should appear.

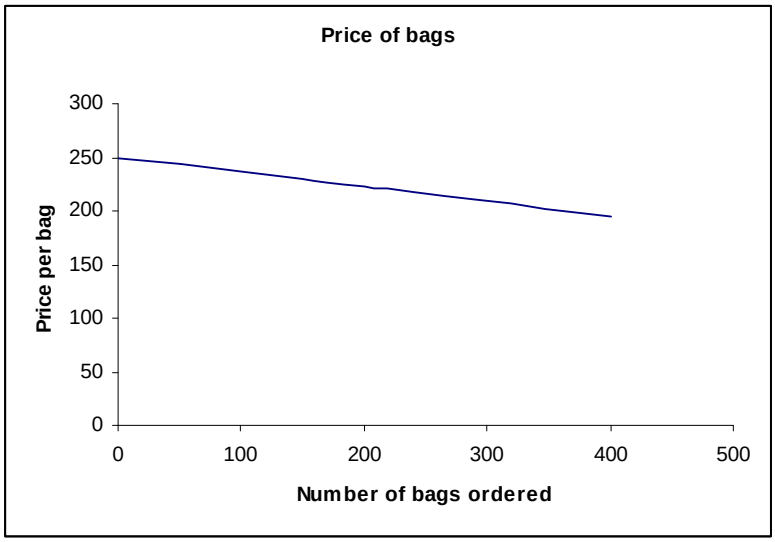


Figure 11

Clearly, the unit price of bags decreases with increasing quantities. The price of one bag is 249.86 and the price per bag for 100 bags is 236.00. This is a 5.5 per cent saving per bag.

2.

a) Draw the two lines $R = 80N$ and $TC = 12{,}000 + 50N$ on the same set of axes, with N on the x-axis.

First set up a table in block A2:C7.
Put headings *N*, *R* and *TC* in Cells A1, B1 and C1.
Set $N = 100, 200, 300, 400, 500, 600$ in the first column.
Enter the formula: =(80*A2) in B2; copy and paste into B3:B7.
Enter the formula: =(12000+50*A2) into C2.
Copy and paste into C3:C7.
Highlight A2:C7 and click on Chart Wizard. Choose Scatter(XY) and Line.

Go through the steps to obtain a graph like the one below. Now, if you move the mouse pointer to the point of intersection in the chart area, the coordinates (400, 32,000) will appear. This is the break-even point: 400 items should be manufactured to break even, and more to make a profit.

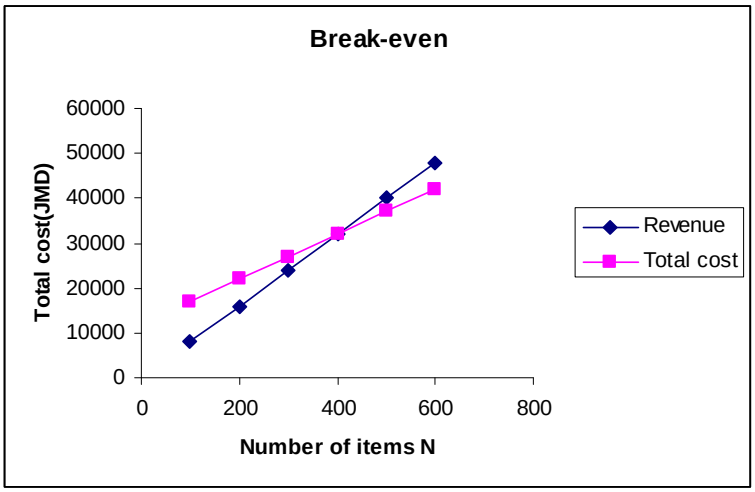


Figure 12

b) Repeat the exercise for P = 100. Choose more data points to draw the graph. The intersection is at N = 240, where TC = 24,000. In this case, the coordinates of the point of intersection will not appear under the mouse pointer, unless you chose 240 as a data point to draw the graph.

You will have to estimate the intersection co-ordinates from the graph.

Representation of parabolas

Parabolas can be represented in Excel.

Here's an example:

Consider the supply-demand case study from Module 1, Unit 3, "Applications of non-linear functions". The supply and demand for a particular product are described by these functions:
$P_S = Q_S^2 + 2Q_S + 16$ and $P_D = Q_D^2 - 2Q_D + 20$

(P_S is the price per item the supplier will accept, and P_D is the price the buyer is willing to pay. Q_S is the number of products supplied and Q_D is the number of products demanded.)

You want to find the equilibrium point where $P_S = P_D$. This is the intersection point for the two parabolas.

Follow the steps in Activity 3.9, question 2, to obtain the graph in Module 1, Figure 28.

Column A should contain these values for Q (thousands): −6, −4, −2, 0, 2, 4, 6. Column B should contain the corresponding values for P_S and Column C should contain values for P_D.

The formula to be entered in B2 is:
=(A2^2 + 2*A2 + 16).

Then copy and paste into B3:B8.
The formula to be entered in C2 is: =(A2^2 − 2*A2 + 20).
Then copy and paste into C3:C8.
Highlight A2:C8 and choose Scatter(XY) with smoothed line without markers.

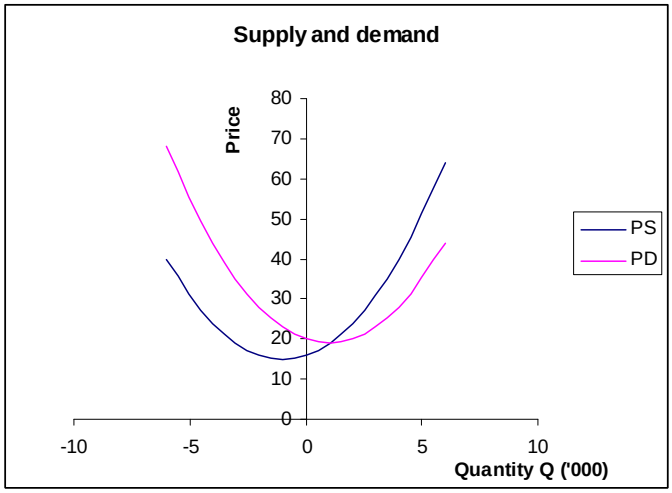


Figure 13

You can move the titles of axes by clicking and holding on them, then dragging the title box to the new location.

The intersection is at $Q = 1{,}000$ and $P = 19$. These values can be found, approximately, from the graph. Remember that 1 on the Q-axis means 1,000.

Activity 3.10

Activity

Get the graphs right

What will you do?

1. The budget for a small farm consists of expenses and income. Total expenses $TE = 10{,}000 + 235N$, where N is the number of units of land planted. Total income $I = 1{,}400N$.

   Determine the approximate budget-balancing (break-even) point with Excel's Chart Wizard. (All numbers are in Ghanaian naira.)

2. The supply and demand for a particular product is described by these functions:
   $P_S = 2Q_S^2 - 6Q_S + 2$ and $P_D = Q_D^2 + 2Q_D + 6$

   (P_S is the price per item the producer will accept and P_D is the price the buyer is willing to pay. Q_S is the number of products supplied and Q_D is the number of products demanded.)

   Use Excel to find the equilibrium point graphically.

Frequency distributions, histograms and data analysis

Excel has the capability to generate a frequency distribution for a large set of data. (Revisit Module 2: A frequency distribution presents the distribution of values in a data set. The range of the data values is divided into appropriate intervals, and the number of values occurring in each interval is counted.)

Consider this data set for a company's revenue, which you will enter into a worksheet:

Figure 14

To set up a frequency distribution for this set of values, you first find the range of the data values:

- Find the smallest data value in the set by entering in any open cell (for example, H4) the function: = MIN(B4:F15).
- Find the largest data value in the set by entering in any open cell, (for example, H5) the function: = MAX(B4:F15).

This gives the range of data values as 120 to 258. You must now select a set of intervals that will cover this range – use five intervals:

0 to 120, 120.1 to 160, 160.1 to 200, 200.1 to 240, 240.1 to 280.

Now that you have determined the interval boundaries, enter their **end points** onto the worksheet. Enter these in cells B20 to B24.

Excel always considers the first interval as an open interval, including all values less than or equal to the end point, in this case ≤ 120. Also, Excel always considers an extra interval after the last end point entered – that is, the open interval including all values greater than the last end point, in this case > 280.

Excel refers to the range of cells B4:F15 containing the source data as the data array, and to the cells B20:B24 containing the interval end points as the bin array.

Here's how the frequency distribution is calculated:

- Select (highlight) a range of adjacent cells into which Excel will enter the distribution – in this case, the six cells C20 to C25.

Figure 15

Notice that an extra cell, C25, is included in the selection, to provide for the extra interval considered by Excel.

- Type in the formula box: =FREQUENCY(B4:F15,B20:B24).

  Notice that the first argument (B4:F15) represents the data array, while the second argument (B20:B24) represents the bin array. You can also click on <Insert>, <Function> and choose Frequency.

- The FREQUENCY function is a so-called array function, which results in a range of values rather than a single value.
  Now hold down <Ctrl> and <Shift> and press<Enter>.

The results are in Figure 15.

Another way to generate the frequency distribution is to make use of the Data Analysis tool, which you will find on the Tools dropdown menu:

- Click <Tools> on the menu bar and then <Data Analysis>.

If Data Analysis did not appear:

- Click <Tools> on the menu bar.
- Click <Add-Ins> on the dropdown menu.
- Click <Analysis ToolPak>.]

If Analysis ToolPak is not listed in the Add-Ins dialog box, click <Browse> and locate the drive, folder name and file name for the Analysis ToolPak add-in, Analysis32.xll (usually located in the Library\Analysis folder), or run the Setup program if it isn't installed.

- Click <Histogram> in the Analysis Tools box.
- Click <OK>.
- Enter B4:F15 in the Input Range box.
- Enter B20:B24 in the Bin Range box.
- Enter B27 in the Output Range box.
- Click <OK>.

The result is shown here:

	A	B	C	D
26				
27		*Bin*	*Frequency*	
28		120	1	
29		160	11	
30		200	33	
31		240	12	
32		280	3	
33		More	0	
34				

Figure 16

Note: When using OpenOffice, you have to download a set of three macros to perform statistical analysis: Basic Statistics, Multivariate Statistics and Applications. This provides you with the functionality of Excel's Analysis ToolPak. These macros can be downloaded from http://www.ooomacros.org/user.php, which is linked to http://documentation.openoffice.org/thirdparty.html.

On the webpage for ooomacros, scroll down the list of macros to OOoStatistics and click on <Download>.

As you know, a frequency distribution may be presented graphically as a histogram, a frequency polygon or an ogive. You can use the Chart Wizard or the Data Analysis Tool:

- Click <Tools>, <Data Analysis>, <Histogram> and <OK>.
- Then enter the input range, bin range and output range as before.

- Click <Chart Output> and then <OK>.
- When the warning that the output range will overwrite existing data is displayed, click <OK>.

The same frequency distribution as before is displayed, with a histogram to the right of it.

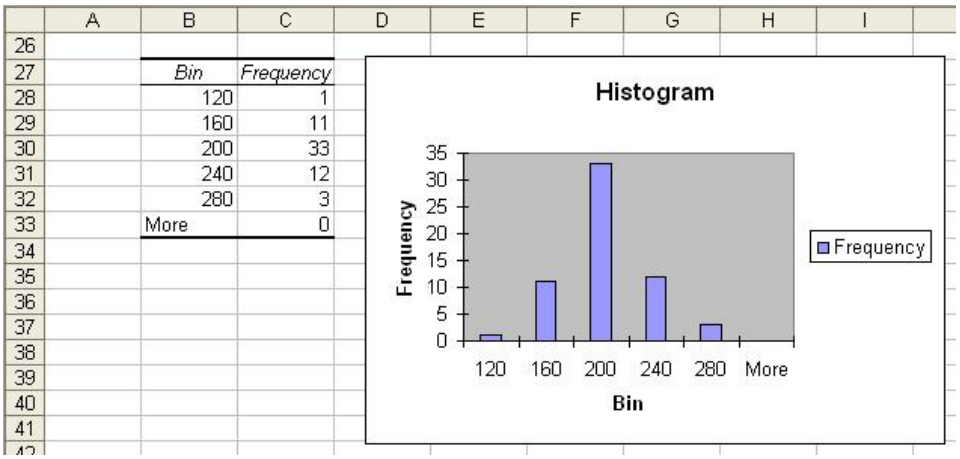


Figure 17

Descriptive statistics analysis

Excel has an option in its Data Analysis Tools to generate a set of descriptive statistics. This requires the data to be in a single column. To apply the Descriptive Statistics Tool to the data in column F for year 2000:

- Click <Tools>, <Data Analysis>, <Descriptive Statistics> and <OK>.
- Enter in the Input Range box: F3:F15.
- In the Grouped by options list, select Columns.
- Click <Labels in First Row> so that a tick mark appears next to it.
- Enter in the Output Range box: A30.
- Click <Summary Statistics> and <OK>.

This table should appear:

	2000
Mean	184.6667
Standard Error	5.986517
Median	184
Mode	#N/A
Standard Deviation	20.7379
Sample Variance	430.0606
Kurtosis	-0.96465
Skewness	0.169377
Range	66
Minimum	154
Maximum	220
Sum	2216
Count	12

Figure 18

The positive skewness means that more than half the values lie to the left of the mean. The negative kurtosis means that tails of the distribution are thinner than for a normal distribution. Therefore the probability of extreme values is smaller than for the normal distribution.

The other values are self-explanatory, but you should take some time to analyse and interpret them.

Activity 3.11

Activity

Analyse data

What will you do?

1. Do a Descriptive Statistics data analysis for revenue for the year 1996 in the data for Figure 15.
2. Interpret and discuss each of the values in the Descriptive Statistics box.

Activity 3.12

Activity

Understand the terminology

What will you do?

Use this terminology table to record any terms or words you're uncertain about.

This activity is an opportunity to consolidate your understanding of new terminology and concepts you encountered in Unit 10. Fill in the terms you have learned and then write your own descriptions of them.

Terminology

Term		Description
	:	
	:	
	:	
	:	
	:	
	:	
	:	
	:	
	:	
	:	

Unit summary

Summary

You have successfully completed this unit if you can:

- **set up** tables of data in spread sheets and draw charts and graphs;
- **generate** frequency tables and histograms; and
- **analyse** data with the Descriptive Statistics analysis tool.

Unit 11

ANOVA and Goal Seek

Introduction

Statistical and decision analysis can be complex if done by hand. Spreadsheets have tools and functions that make a manager's work easier. Performing analysis of variance (ANOVA) for large data sets becomes very simple and Excel's Goal Seek feature can be used to find unknown quantities from complicated equations (such as internal rates of return or *IRR*).

Upon completion of this unit you will be able to:

Outcomes

- **interpret** ANOVA statistics; and
- **find** implicit solutions of equations using Goal Seek.

Tip

Remember: In OpenOffice you have to download macros to perform statistical analysis. These macros can be downloaded from http://www.ooomacros.org/user.php, which is linked to http://documentation.openoffice.org/thirdparty.html.

On the webpage for ooomacros, scroll down the list of macros to OOoStatistics and click on <Download>.

Comparing data sets with ANOVA

ANOVA stands for **An**alysis **O**f **Va**riance. It was invented by Sir Ronald Aylmer Fisher in 1920 as a way of determining whether an event was most likely due to chance (natural variation). Conversely, it allows one to say with 95 per cent confidence whether the event was actually caused by some factor. The statistics you consult to make a decision are the *F* ratio and *F* critical value, named for Sir ***F***isher, which determine whether a result is statistically significant.

ANOVA is actually a method of comparing data sets. When you compare data sets with respect to a certain property, ANOVA looks at the variance within a data set and also the variance between sets. It allows us to decide whether the difference *between* data sets is statistically significant, or whether the differences are as large *within* the sets themselves. In the latter case, the difference is due to natural variation and not statistically significant.

Let us assume you have entered two or more sets of data in columns in a worksheet. Each data set is labelled by its name at the top of the column.

The cells containing the labels and data form a block called the Input Range. This is how the ANOVA method is then applied:

- Click <Tools> and <Data Analysis>.
- Click <Anova:Single Factor> and <OK>.
- Fill in the Input Range of the data, tick the box "Labels in First Row", then click <Output Range>.
- Enter any empty cell as output range and click <OK> to get the statistics.

Activity 3.13

Activity

Do an ANOVA analysis

What will you do?

This table gives the rating scores for the performance of three employees over five months. You have to determine whether there is a best employee and whether the difference between the employees' performance is statistically significant.

Owami	Chris	Aasia
140	138	155
160	148	162
158	158	148
145	165	160
150	160	158

1. Do an ANOVA analysis to find the employee with the highest average score.
2. Interpret the output.

Here's our feedback

1. Enter the table into cells A1:C6. This is the input range. The names Owami, Chris, Aasia appear as the first row. Follow the steps given above for comparing data sets with ANOVA. Choose A8 as the output range, for example, and click <OK>. The output is shown in Figure 19.

   It clearly appears that Aasia has performed best, with the largest total score and average, and the smallest variance in scores.

ANOVA: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Owami	5	753	150.6	71.8
Chris	5	769	153.8	116.2
Aasia	5	783	156.6	29.8

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	90.13333	2	45.06667	0.620753	0.553941	3.885294
Within Groups	871.2	12	72.6			
Total	961.3333	14				

Figure 19

2. The question is whether the results are statistically significant. Can you say with 95 per cent certainty that the differences in the three employees' scores are significant? Do the scores really signify that "Aasia is best"?

   Consult the F ratio (*F*) and F critical value *F crit*.

   If F > F crit, then there is a statistically significant difference.

   If F < F crit, then the score differences are best seen as chance differences or due to natural variation.

   In this case, $F = 0.620753$ and $F\ crit = 3.885294$. Clearly $F < F\ crit$ and therefore the differences in scores are not statistically significant. We cannot say with certainty (95 per cent) that the scores of these performances show Aasia to be the best employee.

Discussion

Statistical significance versus natural variation

In Question 2 of Activity 3.13, we concluded that the differences in scores for Owami, Chris and Aasia are not statistically significant. We can see this from the variation in scores between employees (measured as 90.13) being much smaller than the variation within scores of a single employee (871.2). Each employee's own performance varied more within the five months than the other employees' performances varied in comparison. So although Aasia's average score was the best, it is too simplistic to say that her performance over five months was the best.

The mean square or MS value between the employees' scores is 45.0667, and the MS value within an employee's score is 72.6. The *F* ratio is calculated as $F = \dfrac{45.0667}{72.6} = 0.62075$.

F crit gives the 95 per cent significant *F* value calculated from the data.

This is another example where it is unwise to make decisions based on simple calculations of averages or sums. When choosing between groups of people by comparing averages of characteristics, you should make sure that natural variation within any single group is not bigger than the significant variation between the groups.

Discuss some instances where conclusions about the superiority of one group over another, based on averages alone, could lead to negative consequences.

Activity 3.14

Activity

Analyse and interpret

What will you do?

The body mass of groups of people from four different countries is measured in kilograms.

Which group has the largest average mass? Can you make a statistically significant judgement?

Use ANOVA analysis and interpret the output.

Group A	Group B	Group C	Group D
67	62	72	58
72	94	65	62
55	110	96	53
58	81	98	57
71	90	118	66

Goal Seek

Consider this situation:

You want to find the interest rate if the present value *PV* of two cash inflows C_1 and C_2 at the end of years 1 and 2 is known.

Let $PV = 3{,}000$, $C_1 = 1{,}500$ and $C_2 = 2{,}000$.
The unknown interest rate is *R*. You must find *R* from the equation:

$$3{,}000 = \frac{1{,}500}{(1+R)} + \frac{2{,}000}{(1+R)^2}$$

Instead of trying to solve the problem algebraically (try it!), you open a spreadsheet.

- Write the names *PV*, C_1 and C_2 and *R* in column A, cells A1–A4.
- Enter the formula for *PV* in B1: =(B2/(1+B4)+B3/(1+B4)^2) and the values for C_1 and C_2 in cells B2 and B3. (Discard the comma when you enter values into the spreadsheet.)
- Enter a "seed" value for *R* in B4 (say, $R = 0$). A "seed value" means "starter value", i.e., a value that sets the process going.

With this *R* (=0), the value 3500 will appear for *PV* in the cell B1.

But you **seek** *R* so as to reach **goal** PV = 3,000.

- Click on B1.
- Click <Tools> and then on <Goal Seek> from the drop-down menu.

This Goal Seek box appears:

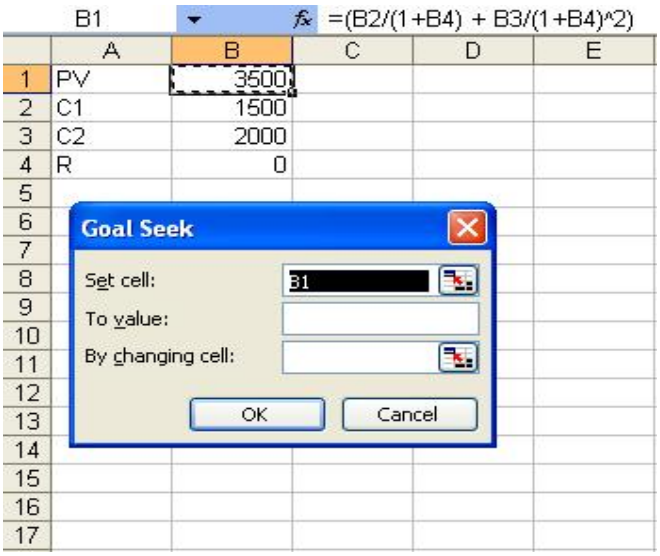


Figure 20

The box for "Set cell:" should read B1.

In the box for "To value:" enter 3000, and in the box "By changing cell:" enter B4. Click <OK>.

The value for *R* in B4 should change from 0 to 0.10391.

Therefore the interest rate R was about 10.39 per cent for the given cash inflows C_1 = 1,500 and C_2 = 2,000, and with PV = 3,000.

Activity 3.15

Activity

Use Goal Seek

What will you do?

1. The relation between quantities P and Q is given by:
   $P^2 = 2Q^3 + Q^2 - 15.46$
   Use Goal Seek to determine the value of Q when P = 13.5.
2. The future value of an ordinary annuity is 24,000 kina.
   There are annual payments of 1,500 kina every year for 10 years.
   What was the annual rate of return over the period?
   (See Module 1, Unit 1, "Annuities" and use Goal Seek.)
3. Find the monthly interest rate R if the PV of four cash inflows C_1, C_2 , C_3 and C_4 at the end of each of 4 months is given as:
   PV = 600, C_1 = 150, C_2 = 200, C_3 = 250, C_4 = 280

Activity 3.16

Activity

Understand the terminology

What will you do?

Use this terminology table to record any terms or words you're uncertain about.

This activity is an opportunity to consolidate your understanding of new terminology and concepts you encountered in Unit 11. Fill in the terms you have learned and then write your own descriptions of them.

Terminology

Term		Description
	:	
	:	
	:	
	:	
	:	
	:	
	:	

Remember these key points

Spreadsheets contain powerful tools for analysing data and making decisions based on the statistics generated by the software. Once again, we emphasise that the interpretation of statistics is a process that demands responsibility and sensitivity. In turn, these depend on knowing the models and their limits. One example is the question of the statistical significance of differences between groups, as opposed to the natural or chance variation within groups of data.

Unit summary

Summary

You have successfully completed this unit if you can:

- **implement** different data analysis and statistics analysis tools in a spread sheet;
- **generate** and **interpret** ANOVA statistics; and
- **find** implicit solutions of equations using Goal Seek.

Unit 12

Other spreadsheet facilities for model building

Introduction

As you progress in building spread sheet models, you will need to use more of the functions and objects available in Excel or OpenOffice. Building simulation models, for example, requires you to generate random numbers. But consulting tables of values to compute probabilities for random variables can be cumbersome unless you are using Excel.

You may also find it useful to record or write your own macros. A macro is a set of instructions to perform a sequence of operations, which automates the process. Therefore, macros are small programs written, in this case, in the Visual Basic (VB) programming language. (Visual Basic for Applications (VBA) is the language that manipulates the objects in Excel, and VB is the computer language that forms the backbone of VBA).

Upon completion of this unit you will be able to:

Outcomes

- **apply** a range of Excel functions in building management and business models;
- **implement** simple VBA; and
- **understand** the use of macros.

More Excel functions

Six additional functions that can be used in model building are discussed below. Some of these will be applied in the next modules.

BINOMDIST

This calculates the probabilities for outcomes or events of **binomially distributed** random variables. The binomial random variable counts the number of successes *a* in a fixed number *N* of independent runs of the experiment. The formula in Module 2, Unit 8 ("Discrete random variables") is not always easy to apply.

In Excel we use: =BINOMDIST (number, trials, probability, cumulative) where number = *a*, trials = *N*, probability = *p*, and cumulative is set to TRUE if cumulative probabilities are desired and to FALSE if individual probabilities are desired.

Here's an example:

Look at Activity 2.12, Question 2 again: Laptop components are packed into boxes at a factory. Each box contains 25 items. It is said that 15 per cent of all items produced are defective. What is the probability of there being no defective items in each box?

In the appropriate cell in an Excel workbook, click <Insert>, <Function > and then choose BINOMDIST.
In the *fx* line you will see: =BINOMDIST().
Fill in the values of arguments in the pop-up box:
(0, 25, 0.15, FALSE).
Click <OK>.
The answer 0.017198 appears.

NORMDIST

This calculates the probabilities for outcomes or events of **normally distributed** random variables. You need the mean and standard deviation of the random variable as inputs. Only cumulative values are given (because these are continuous random variables).

Here's an example:

Look at Question 2 in Activity 2.13 of Module 2:
If random variable X has the normal distribution with $\mu = 10$ and $\sigma = 5$, determine the probability $P(X > 18)$.

In terms of the cumulative probability distribution, you have to find $1 - P(X \leq 18)$. Using Excel, you don't have to construct the standardised normal variable Z.

In a cell in an Excel workbook, click <Insert>, <Function> and then choose NORMDIST.
In the *fx* line, you will see: =NORMDIST().
Fill in the values of arguments in the pop-up box, so that the *fx* line reads: =1−NORMDIST(18,10,5,TRUE). Click <OK>.
The answer 0.054799 appears.

IF

The "IF" function is a logical function that gives an output value corresponding to true or false, depending on whether the logical test (condition) is satisfied or not. This function is useful in decision-making and categorising.

It has the form: =IF(Logical test, Value if true, Value if false).

Here's an example:

You have the daily closing price for Share A in cell B1 and want to know when the share price drops below the critical value of 10. In that case, you want "SELL" to appear in cell B3; otherwise you want "KEEP" to appear.

Enter any value for the share price in B1. Click on B3.
Insert the IF function. Enter the arguments in the pop-up box so that the *fx* line reads: =IF(B1<10,"SELL","KEEP").

Press<Enter>. Either SELL or KEEP will appear in B3.
In Figure 21, B1=9.9 and so B3 =SELL.
Change the value in B1 to 12.56 and press <Enter>. B3 should read KEEP.

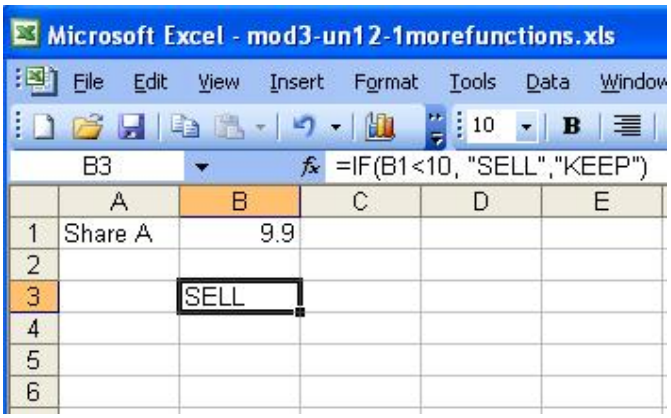


Figure 21

RAND

This generates **random numbers** from the uniform distribution. These numbers will lie in the interval [0, 1]. The function has the form =RAND() and no arguments are entered. To generate numbers between 0 and 20, enter =RAND()*20.

Here's an example:

You want to generate 10 random numbers (uniformly distributed) between 0 and 50 in the cell range A1:A10 to simulate 10 values of a certain quantity.

Click in cell A1, enter =RAND()*50 in the *fx* line and click <Enter>.
A number will appear in A1.
Click A1, click Copy, then highlight A2 to A10 and Paste.
You will have a column of 10 random numbers.

RNG (random number generator)

This generates random numbers from a selection of different distributions, including the normal distribution.

Go to <Tools>, Data Analysis, Random Number Generation and click <OK>. Choose the distribution you want, fill in the pop-up box and click <OK>.

VLOOKUP

This function searches the left-most column in a table for a table value that you have specified. It then finds the **value** corresponding to that in another column specified by you as Column no (column number).

The form is:
=VLOOKUP(Table value, Lookup table, Column no, Nearest).

This function is very useful when searching through large tables of data. If you want the nearest (approximate) match, enter TRUE for Nearest. If you want an exact match, enter FALSE.

Here's an example:

You employ 1,999 people. Each has a staff number. There is a big data (Lookup) table with range A1:D2000 showing job level, salary in Jamaican dollars and age, entered against each staff member's number. Staff numbers are not in sequence and not consecutive. You want to find the salary (in column 3) of staff member number 17634. A small section of the table in columns A to D looks like this:

Staff number	Job level	Salary (JMD)	Age
16437	2	92,000	58
32772	1	165,000	62
17634	10	16,000	23
5258	4	58,000	37
65471	3	68,000	46

Figure 22

Click on a chosen output cell (say, E2), then <Insert>, Function, VLOOKUP.
Enter arguments to read: =VLOOKUP(17634,A1:D2000,3,FALSE).
Enter FALSE because you want the staff number to be an exact match.
The output is then: 16000.

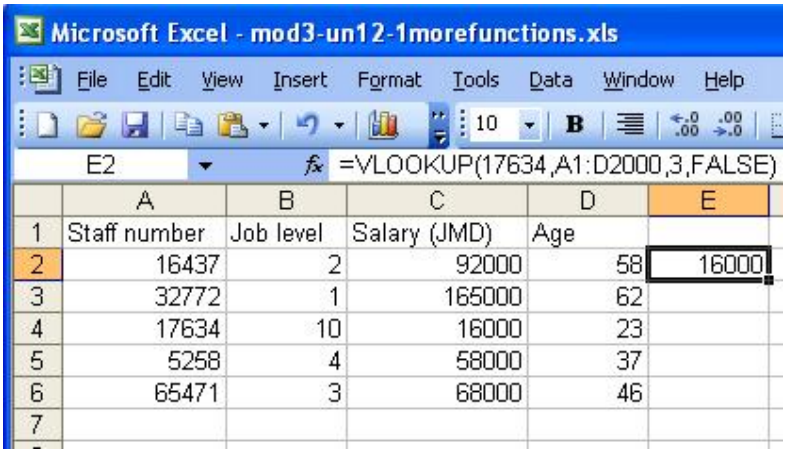


Figure 23

Activity 3.17

Activity

Practice these functions

What will you do?

Figure 24 shows an extract from a data set of daily share price returns (%) for five shares over the first 132 trading days in 2008. The total data set is in a spreadsheet. The extract shows days 123–127.

Daily return (%)

Trading day no.	Share A	Share B	Share C	Share D	Share E
123	2.0	3.55	−4.5	3.4	1.48
124	−1.2	2.1	0.0	1.2	0.0
125	0.0	−2.4	−0.8	1.05	0.0
126	1.4	−3.0	0.6	0.0	−2.8
127	3.6	1.0	1.0	1.18	−1.73

Figure 24 Extract from data set

All share price returns are normally distributed.

Copy the extract into a spread sheet in the range A1:F6.

1. It has been estimated that for 2008 the average daily return for Share B is 1.75 per cent and the daily volatility is 2.52 per cent.

   What is the probability that the daily return for Share B will be less than −1 per cent? (Use NORMDIST. Also solve this manually using the Appendix at the end of Module 2.)

2. You want to know if the daily return for Share D was higher than 1% on day 124. If that was the case, let “GOOD” appear in cell G3; otherwise let “BAD” appear. (Use the “IF” function).

3. Find the return for Share C for day 126 using the VLOOKUP function.

4. Generate random percentage returns for 20 days for Share B. (You must use the normal distribution from the RNG function.)

Visual Basic for Applications (VBA)

For the purposes of this course, we provide only an introduction to VBA. If you have programming experience, you will have few problems in implementing it. Practising with VBA in the workplace and in your spare time is the only way to really get comfortable with it. Even if you will not be using VBA yourself, someone may present you with a VBA model and you would at least want to know what it is!

Introduction

VBA in Excel is a tool for expanding the power of spread sheet modelling. It is a programming language that you receive with Excel, so you don't need any extra software. OpenOffice does not have this facility, although you can download and record some macros.

VBA enables you to take an Excel spread sheet model and turn it into an application that can be used by others who know little about spread sheets or programming. Such users will be presented with an easy-to-use "input side" where they enter data, and an "output side" where they receive a report or answer.

For example, the end-users want to enter an interest rate and receive a report on the value of the *NPV* and *PI* and the suitability of the financial investment. The users do not have to understand how you modelled the problem; they merely want to see the answers and use the answers to help them make decisions. VBA does exactly that.

The Visual Basic Editor (VBE)

Make sure you have VBA installed.

Note: In Excel 2003, click on <Tools>, <Add-Ins>, and then check that Analysis Toolpak-VBA has been ticked.

In Excel 2007, you should see these tabs at the top:
Home, Insert, Page Layout, Formulas, Data, Review, View, Developer.
The Insert tab contains charts; the Data tab contains Data Analysis and Solver; and the Developer tab contains Visual Basic.

If you cannot see the Developer tab, click again on the Microsoft button at top left. Click <Excel Options> at the bottom, then click <Popular> and select Show Developer Tab in the Ribbon. The Developer Tab should now show at the top in the list of tabs

You find the VBA Editor by opening Excel. You should have spread sheet Book 1 open.

Click on <Tools>→ Macro →Visual Basic Editor. Or just press Alt-F11.

Now you will see a large grey code window on the right.

There may be a Project Explorer window and a Properties window on the left. If they are not there, click on <View> in the VBA toolbar and then on <Project Explorer> and <Properties Window> to open these windows.

You can open and close these windows. (Click on <X> to close a window.) Keep the Project window open.

This is what the screen looks like:

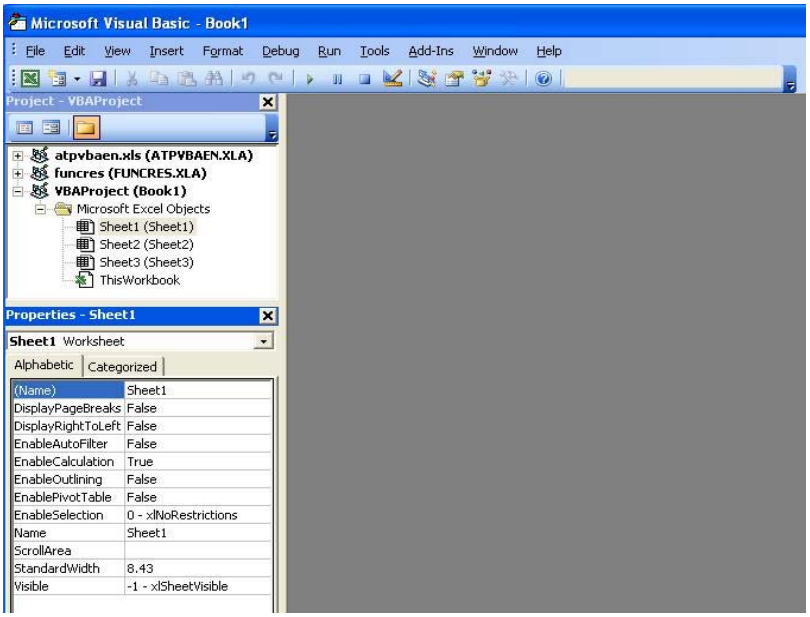


Figure 25

Note: There are two other useful windows: Immediate and Watch.

Immediate can be used for one-line VBA commands that you want to execute immediately.

The Watch window is for debugging (getting rid of programming errors). We will not use them now, but they can be found under the View option on the VBA menu bar.

Next, you will have to open a project and a module to work on. To insert a module, click on <Insert>→Module on the menu bar. You will see Module 1, Book 1. The white space is the window where you will type your VBA code (see Figure 27). You can enlarge the code window by clicking on the icon □ , next to the box with × in it, on the right of Module 1 (Code).

Click on <View>→Toolbars to make sure you have the Standard, Edit and Debug toolbars open. (You open and close toolbars by clicking to the left of whichever toolbar you want to open or close.) Click on the icons to see what features are available. The Object Browser on the standard toolbar is a good help tool.

Click on <Tools>→Options. Check ✓ the Require Variable Declarations box and uncheck the Auto Syntax Check box.

You may also have to set your security in Excel to Medium instead of High. Microsoft sets security on High by default, but this can mean your VBA code will not run. You reset the security by going back into Excel. To get back to Excel, click on the Microsoft Excel tab at the bottom of your screen. In Excel, go to <Tools>→Macro→Security, as shown in

Figure 26. Click on <Security> and select Medium. This is very important!

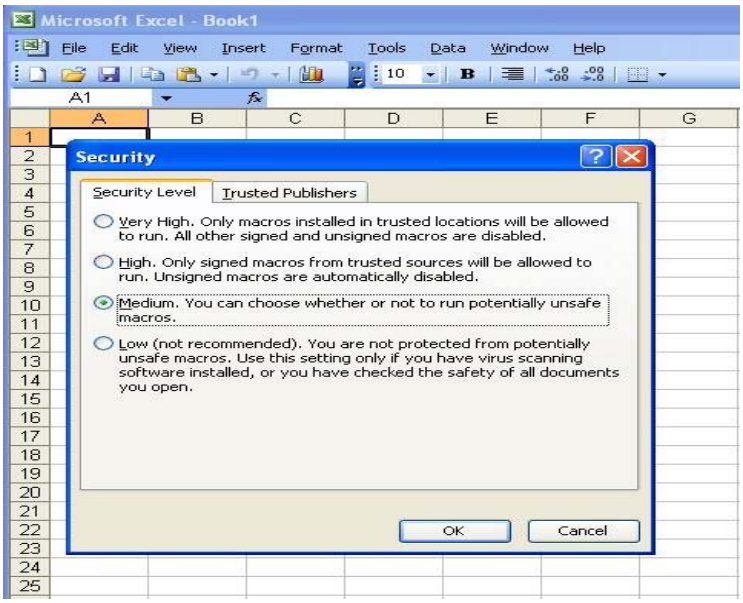


Figure 26

To go back to VBA, just click on <Microsoft Visual Basic> at the bottom of the screen.

Don't feel overwhelmed by all the unfamiliar words, toolbars and windows. It takes practise to get used to everything.

Now close the VBA Book 1 from the File menu on the toolbar. Close Excel. Start all over again by opening Excel, going to VBA Editor and opening a module.

The line Option Explicit will appear in the code window (Figure 27). This is to remind you that you had previously chosen ✓ Require Variable Declarations from Tools→Options.

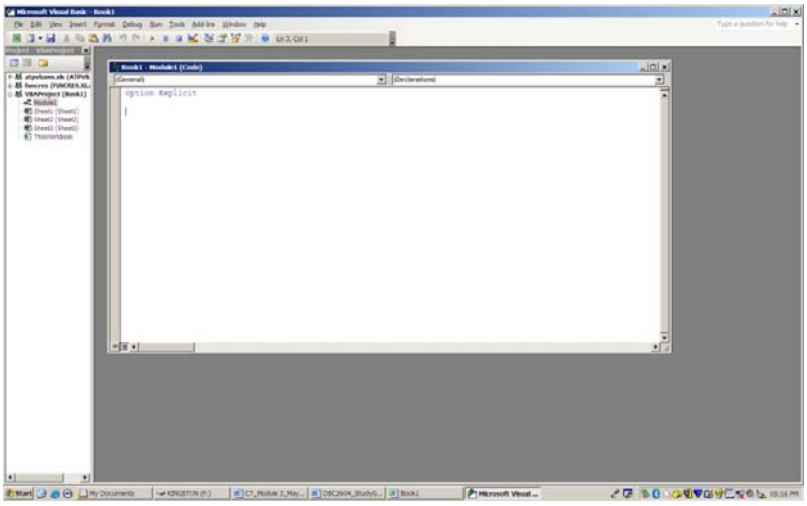


Figure 27

Why did we choose Require Variable Declarations? Because VBA will then remind you that you have to declare the variables in a program. In Example 2 from Sample VBA Programs (coming next), you will see how variables are declared.

Variables such as i, j, numberHigh, totalCost, or whatever names you choose in a program, take on numerical values during the execution of the VBA program. Variables i and j will typically take on values 1, 2, 3, and so on; variable total Cost will typically be a monetary value.

Variables i and j have to be declared as integers so that VBA knows how to handle them and the computer knows how to store the values in its memory. This is done with the statement:
Dim i As Integer, j As Integer

Variable totalCost will be declared as Currency with the statement:
Dim total Cost As Currency

Integer values must lie between −32768 and 32767. Integers outside this range must be declared as Long. Decimals are declared as Single or Double.

Variables can also take on non-numerical values such as names, or True or False. If variable first Name can take on values such as John, Mary, and so on, it is declared as:
Dim first Name As String

If variable isThere can take on the values True or False, it is declared as:
Dim isThere As Boolean

Each type of variable requires a certain amount of memory and VBA handles it in a certain way. Declaring variables helps the program to run smoothly. It is customary to give the Dim statements after the opening line of your program.

Note: In programming languages, there are often statements such as:
total Cost = total Cost + 100

This means that whichever value the variable total Cost had in the memory, this old value (on the left-hand side of the = sign) will now be replaced by a new value, namely the old value + 100, as specified by the right-hand side of the = sign.

Sample VBA programs

Example 1:

Follow these steps for a friendly first macro (VBA program).

1. Open the VBA Editor by pressing Alt-F11 or click on <Tools>→ Macro→Visual Basic Editor.
2. Open a module (<Insert>→Module). This module (named “Module 1”) will contain the VBA code that you write for the “friendly program”. The Code window is the open blank space on the right.

3. Start a sub-routine (sub). This is a piece of code that performs a specific task. You start a sub by clicking in the Code window and typing Sub followed by the name of the sub-routine. In this case, you can type: Sub show Message()

4. Press Enter. You will see End Sub appear in the code window. VBA adds it automatically because every sub-routine must end with this line. You will also see the name showMessage at top right.

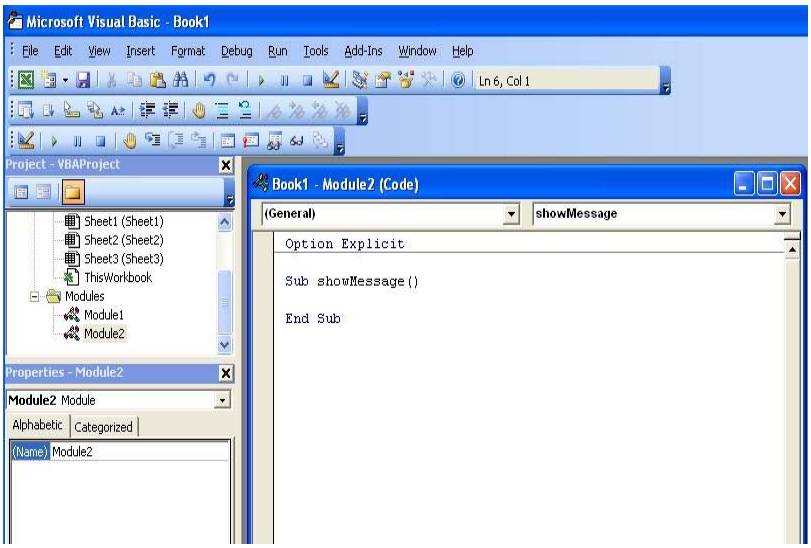


Figure 28

Save the program by clicking on <File> on the toolbar and then on <Save Book1>. Save it in the My Documents folder and give it any name (for example, FriendlyVBA.xls) by typing the name in the File Name box to replace Book1.xls and clicking on <Save>.

5. Now press the Tab key – this causes lines of the code to be indented so that the code's structure is clear. Then enter the next line of code, exactly as shown, between the Sub and End Sub lines:
Msg Box "Hello Everybody!"

6. Place the cursor at the end of End Sub. Run the program by clicking on the <Run> button on the top menu and then <Run Sub>. Or just press F5.

7. A message box will pop up in Excel with the message:
Hello Everybody!

8. Click on <OK> to return to the VBA program.

9. Click on <File> in the toolbar and then <Close> and return to Microsoft Excel. Or just click on <X> at the top right of the VBA program. You have written your first VBA macro. Save and close the file Friendly.xls. If Excel warns you that you haven't saved your changes, make sure you save before you close the program.

Example 2:

A company has three branches and monitors sales over 12 months. The data is:

Month	Branch 1	Branch 2	Branch 3
Jan	150000	123500	160000
Feb	110120	98450	154000
March	108050	96300	150674
April	112300	92150	146866
May	111000	98500	145000
June	120500	89600	138800
July	116335	96300	131200
Aug	115700	98521	141750
Sept	129645	116560	145600
Oct	135000	121000	152900
Nov	141890	126000	159500
Dec	155668	132900	172100

Figure 29

The numbers represent sales figures in dollars.

You are asked to write a spread sheet application that will show how many months of the year the sales in each branch were above a certain value. A user of this program does not want to see any programming code, but wants to be able to simply type in an amount such as 110000 and immediately see, for each branch, how many months of the year the sales were above USD 110,000.

1. Open a file in Excel, type in the data and save the data as Salesdata.xls. The numbers (amounts) must lie in the range B2:D13. Remember to make sure that you have set your security in Excel to Medium so that your VBA code will run.

   (Go to <Tools>→Macro→Security and select Medium.)

2. Activate VBA by pressing Alt-F11. Make sure the Project Explorer window is open (<View>→Project Explorer). In the Project Explorer window, make sure VBA Project Salesdata.xls is highlighted. (Click on it if necessary.)

3. Open a module (<Insert>→Module). This module (named “Module 1”) will contain the VBA code that you write for the sales data. The Code window is the open blank space under Salesdata.xls - Module 1(Code).

4. Start a sub-routine (sub). This is the piece of code that performs the specific task of monitoring sales. You start the sub by clicking in the Code window and typing: Sub CountHighSales()

   Press Enter. You will see CountHighSales appear at the top right of the window. This is the name of the program you are writing. The aim of the program is to count the number of high sales in each branch. You will also see End Sub in the window. VBA adds it automatically, because every sub-routine must end with this line.

5. Type the code between Sub CountHighSales() and End Sub:

   First, press the Tab key – this causes lines of the code to be indented so the code's structure of the code is clear. Then enter the lines exactly as shown and press Enter after each line. Press Tab for every indent that you want to make. Press Backspace to remove an indent. Other words and comments will appear as you type, but don't worry about them now. Be very careful to type exactly as shown: the syntax of computer code must be perfect!

   There is a space before the underscores _. The underscore is used when a line of code runs over to the next line. Otherwise you must fit in each line of code on a line. The character "&" must also have a space before and after it. Afterwards, save the code.

```
Sub CountHighSales()
    Dim i As Integer
    Dim j As Integer
    Dim numberHigh As Integer
    Dim salesCutoff As Currency

    salesCutoff = InputBox("What sales value do you want to check
    for?")
    For j = 1 To 3
        numberHigh = 0
        For i = 1 To 12
            If Range("B2:D13").Cells(i, j) >= salesCutoff
            Then _  numberHigh = numberHigh + 1
    Next i
    MsgBox "For Branch " & j & ", sales were above " & _
        Format(salesCutoff, "0 000") _
        & " on " & numberHigh & " of the 12 months."
    Next j
End Sub
```

Remember: The underscore _ is used when a line of code runs over to the next line because you cannot fit it in one line. You may use this wherever you need to. You should now see the same as shown in Figure 30.

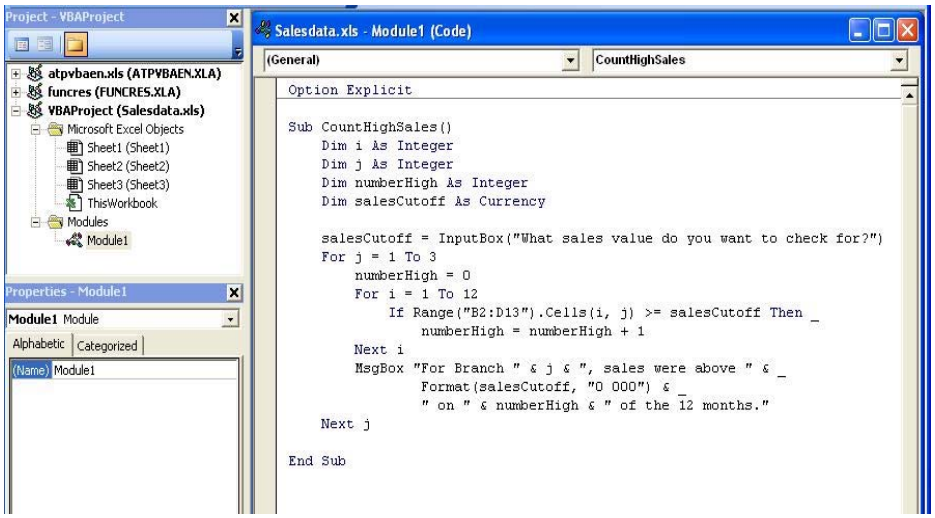


Figure 30

6. Now run the program. Place the cursor anywhere in the sub-routine and click: <Run> → Run Sub/User Form, or press F5. You should see a box like Figure 31 pop up in the workbook:

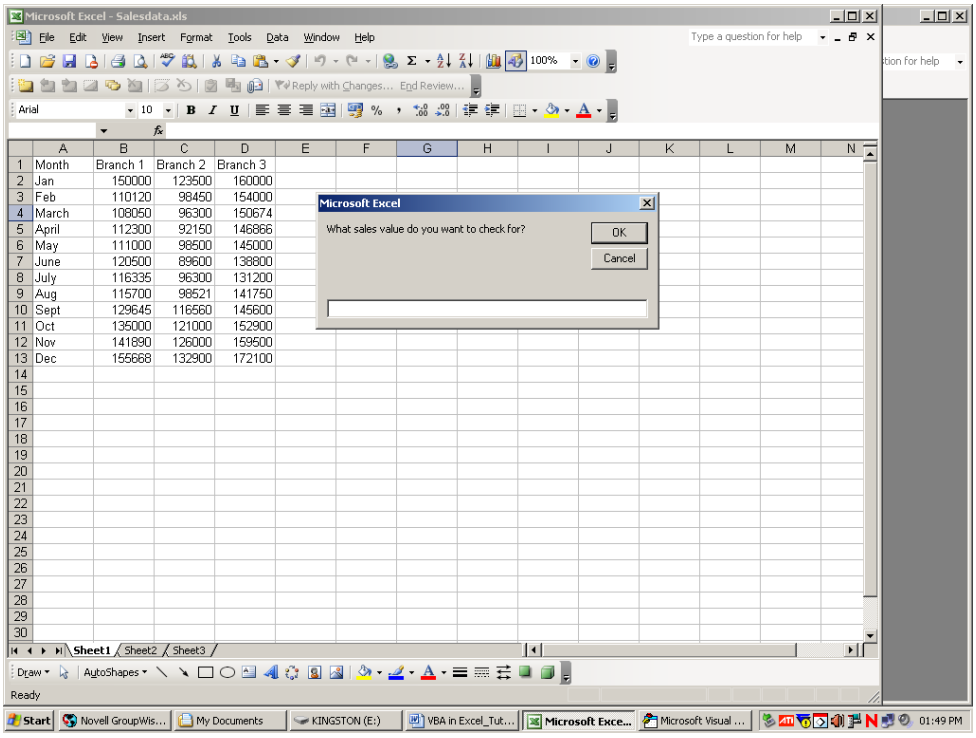


Figure 31

Enter any value (for example, 110000). Click on <OK>. A box will pop up with the answer:
For Branch 1, sales were above 110000 on 11 of the 12 months.

Click <OK> again, and another box will pop up with the answer:
For Branch 2, sales were above 110000 on five of the 12 months.

Click <OK> again, and another box will pop up with the answer:
For Branch 3, sales were above 110000 on 12 of the 12 months.

Click <OK> again, and you can enter fresh values (for example, 120000).

7. Study the code to see if you can follow the logic and get a feel for VBA.
8. Save and close all files. To open the workbook again, open Excel, open Salesdata.xls, press Alt-F11 and your code will appear as "Module 1". (You will have to click on <Enable Macros> first.) If there are any problems, make sure you have set your security in Excel to Medium instead of High.
9. **Optional exercise:** To make the macro more user-friendly, go to Excel and into the file Salesdata.xls.
   Right-click on the top toolbar to see a list of toolbars.
   Click on <Forms>. A little toolbar will appear, which you can move to where you want it.
   Click on the icon (at right, second from top in the small Forms (Fo) toolbar) that reads "Button" when you hold your cursor over it. Then click on a spot next to the sales data.
   A box with names will appear.
   Click on <CountHighSales> to make sure you go to the right VBA file (in case you have saved other VBA files).
10. Click on <OK>. A box labelled "Button 1" will appear. Enlarge this box by holding the cursor over the right-hand side so that ↔ appears. Left-click on the mouse, hold down and drag the mouse to the right. You will see how the box enlarges.
11. You can remove the Forms toolbar by clicking on <X> at the top right of the Fo toolbar.
12. Place the cursor inside the button box in front of the letter B, delete the words "Button 1" and type in your own name for the button, such as: "Months with high sales".
13. Click outside the button box. There will now be a grey button labelled "Months with high sales". When you place the cursor over the grey button, a hand symbol will appear. Click it and the question "What sales value do you want to check for?" will appear.

    Values can now be filled in, as before. With each click on <OK>, the answers will appear.
14. Users now only have to open the Excel file called Salesdata.xls, click on <Enable Macros>, click on the "Months with high sales" button and proceed. They will not see the actual VBA macro.

Error messages

You may get an error message when you try to run a program. If a line is coloured red, you have typed it incorrectly. If you get a run-time error, click on <End> and try to find and fix errors. If you click on <Debug>, a line will be indicated in yellow. This means the error is in, or close to, that line.

Intellisense

This is a feature of the VBA Editor. You will notice that when you type in code, comments will appear or words will be completed for you. This is to help you make fewer mistakes.

There is not time for a more detailed analysis, but you should now at least have an idea of how VBA macros are structured.

Recording macros

The operations and commands that you use in Excel files to build spreadsheet models can automatically be changed into VBA code, stored and applied to other data. The recorded program is called a macro. Using macros makes you a sophisticated user of Excel.

Recording macros is also another means of learning about programming in VBA. The recorded program is usually not very elegant, but it provides a way for you to see how to create VBA code.

To record actions in Excel, open a new file in Excel and click: <Tools>→Macro→Record New Macro.

Give the macro a name and store it, preferably in Personal Macro Workbook. If you store it in This Workbook, you can only use it in that particular workbook.

After you have clicked <OK> on the Record Macro box, a Stop Recording box will pop up. This allows you to click to stop recording. If the Stop box does not appear, right-click on a toolbar and then click on the Stop Recording item.

Here's an example:

We enter a set of data, name the range of values, and sum the values in Excel. This process is recorded.

1. Open a new Excel file and name it SumCosts.
2. Enter this table in cells A1:B13.

Month	Cost
Jan	5000
Feb	1120
March	8050
April	2300
May	1000
June	500
July	6335
Aug	5700
Sept	9645
Oct	5000
Nov	1890
Dec	3668

Figure 32

3. In cell A14, type “Total cost”.
4. Turn the recorder on with <Tools>→Macro→Record New Macro, and name it “SumFormula”. Store it in the Personal Macro Workbook. Click <OK>.
5. In cell B14, enter = SUM(B2:B13). This will be recorded.
6. Click the Stop recording button on the Stop box. The process of finding the sum of numbers in a column has been recorded.
7. To see what the code looks like, press Alt-F11. Click on the + next to VBAProject (Personal.xls) in the VBA Project Explorer. Click on the + of the Modules.
8. Double-click on the “Module 2” folder (or whichever module contains the macro) to see the recorded macro, as shown in Figure 33.

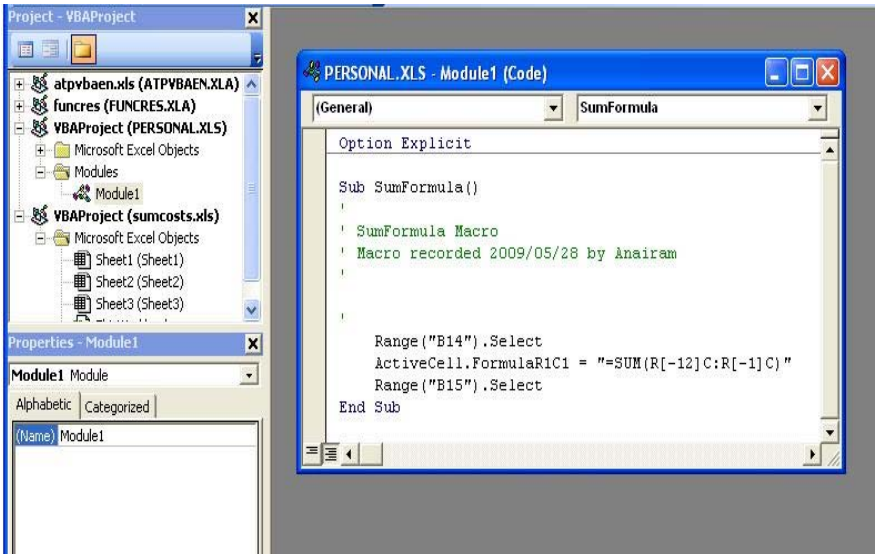


Figure 33

9. You can now create a new Excel file and enter new data for 12 months in cells B2:B13. Click on <Tools>→Macro→Macros. The name of all your macros, including the recorded macro SumFormula, will appear. Choose SumFormula.
10. Click on <Run>, and the values in the range of cells will be added, with the sum appearing in cell B14.

Case study:
Group research project

This case study involves accountability ratings for companies. Accountability is defined as "a company's ability to explain and justify its actions, and to take responsibility for the consequences of those actions" (Accountability Rating™).

Accountability Rating™ evaluates companies in four key areas (see www.accountabilityrating.com):

1. Strategic intent: Does the company seek to address important social, environmental and broader economic issues in its core business strategy?
2. Governance and management: Are senior executives and the board accountable to stakeholders when setting strategy and formulating policy on extra-financial issues?
3. Engagement: Does the company engage in dialogue with the people and groups who have an interest in its business, may be affected by it or have an effect on it? Does the company publicly report its social and environmental performance?
4. Operational performance: How effective has the company been in implementing its management systems and engagement mechanisms?

The four areas are equally weighted and companies are scored. Accountability Rating™ publishes the scores for the world's largest 100 companies in *Fortune* magazine every year. It also ranks countries and regions.

A study was done in South Africa using Accountability Rating™ measures ("Correlates of corporate accountability among South Africa's largest listed companies by Eccles, Pillay & de Jongh, *Southern African Business Review*, 2009). The authors reported statistically significant relationships between accountability and company size and industry sector. On this basis, they suggest that a company's size and its industry sector motivate socially responsible corporate behaviour.

Group assignment: Your group should do at least one of these:

1. Register on www.accountabilityrating.com and study the methodology of the rating model.

   Study the findings. Write a paper discussing and/or critiquing the methodology and findings.

2. Read the paper "Correlates of corporate accountability among South Africa's largest listed companies". You can access the paper from the journal's website: http://www.unisa.ac.za/sabusinessreview.

   Do a data analysis on the authors' data to see whether you agree with their findings. Write a report.

This is a more challenging and long-term project and can be tackled at the end of Module 5: set up a questionnaire along the lines of Accountability Rating™ and send it to companies in your own country. Collect and organise the data and perform a data analysis like the one undertaken by the *Southern African Business Review*. Write a short paper discussing your results and see whether you can have it published in a local journal or magazine.

Activity 3.18

Activity

Understand the terminology

What will you do?

Use this terminology table to record any terms or words you're uncertain about.

This activity is an opportunity to consolidate your understanding of new terminology and concepts you encountered in Unit 12. Fill in the terms you have learned and then write your own descriptions of them.

Terminology

Term		Description
	:	
	:	
	:	
	:	
	:	
	:	
	:	
	:	
	:	
	:	
	:	

Remember these key points

This unit introduced additional Excel functions. It also showed you the basic ideas behind VBA and how you can use it to enhance the modelling of management processes and the presentation of your final model.

Unit summary

Summary

You have successfully completed this unit if you can:

- **implement** some additional functions in spreadsheet modelling;
- **generate** random numbers;
- **write** simple programs using VBA; and
- **record** macros.

Assessment

Assessment — Module 3

1.

a) Do a Descriptive Statistics Analysis for the data in Figure 34. Discuss all results.

Year	Pension fund return %
2000	10.00
2001	11.50
2002	13.80
2003	14.43
2004	10.50
2005	15.00
2006	12.28
2007	17.45
2008	−1.06
2009	−2.00

Figure 34

b) Present the data in a column chart and record a macro in VBA as you draw the chart.

2. You need a frequency distribution for the table of data. It describes the consumption of electricity (in kilowatt hours) of 40 households over the period of a month. Present the outcome as a histogram.

122	88	145	150	79
143	145	134	157	145
210	163	234	85	156
88	110	162	99	154
122	156	210	245	160
145	184	215	141	183
163	215	163	107	145
143	163	145	200	156

Figure 35

3.

a) Find the value of the internal rate of return *IRR* from the relation:

$$\frac{C_1}{(1+IRR)} + \frac{C_2}{(1+IRR)^2} + \frac{C_3}{(1+IRR)^3} + \ldots + \frac{C_n}{(1+IRR)^n} = C_0$$

The annual cash flows are:

$C_0 = 12{,}000$, $C_1 = 5{,}000$, $C_2 = 6{,}000$, $C_3 = 6{,}500$, $C_4 = 5{,}000$, $C_5 = 6{,}000$

b) Use both Goal Seek and the *IRR* function to find and compare answers.

c) Investigate the changes in *IRR* as you vary the initial investment C_0.

4. The "intelligence quotients" (IQ) of three groups of students are tested. Groups A, B and C correspond to highest-income families to lowest-income families. The researchers claim that students in Group A are the most intelligent because their average IQ is above 120 (namely 123.75). They also claim the students in Group C will not finish college because their average IQ is below 120, and the lowest at 117.88.

a) On a purely statistical basis, analyse the results (using ANOVA) and report your findings.

b) Critique the study on grounds such as sample size, ethics and the validity of using a measure such as IQ.

The data collected by the researchers is displayed in Figure 36:

Group A	Group B	Group C
135	120	120
130	125	118
100	110	125
140	130	128
100	90	125
95	140	120
145	100	130
105	118	120

Figure 36

5. Write a VBA program for the data in Question 4 that enables a user to find out how many students had IQ scores above a certain value in each group.

6. Figure 37 gives an extract from a data set of daily share price returns (%) for four shares during 2007.

Daily return (%)

Trading day no.	Share 1	Share 2	Share 3	Share 4
101	1.0	1.5	−4.5	2.4
102	−1.2	2.1	0.1	−1.2
103	0.5	−1.4	1.8	1.05
104	2.4	−0.4	0.6	0.0
105	1.6	−1.0	1.2	−1.18
106	0.4	0.2	1.0	−2.2

Figure 37

All share price returns are normally distributed.

Copy the extract into a spread sheet in the range A1:E7.

a) It has been estimated that, for 2007, the average daily return for Share 1 is 2.1 per cent and the daily volatility is 3.52 per cent. What is the probability that the daily return for Share 1 will be more than 2.5 per cent? (Use NORMDIST. Also solve this by hand, using the table at the end of Module 2).

b) You want to know if the daily return for Share 2 was higher than 2 per cent on day 102. If that was the case, let “HIGH” appear in cell F3; otherwise let “LOW” appear.

c) Find the return for Share 3 for day 105 using the VLOOKUP function.

d) Generate random percentage returns for 20 days for Share 4. (Use the normal distribution from RNG as random number generator.)

References

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XL Modeling. (2005). Excel VBA simulation basic tutorial [webpage]. Retrieved from http://www.anthony-vba.kefra.com/vba/vbabasic1.htm

Further reading

Reading

Where else can I look?

These texts and websites can be consulted for additional information:

Albright, S. C. (2000). *VBA for modelers*. Belmont, CA: Thomson Higher Education.

Anderson, D. R., Sweeney, D. J. & Williams, T.A. (2007). *Statistics for business and economics.* Dundee, Scotland: Thomson Publishers.

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