University of Reading

Microsoft Excel 2013™
An Intermediate Guide (Level 2)

Contents

Introduction

This intermediate level guide deals with some of the more scientific facilities available in Excel. It also covers database facilities (sorting and selection) plus customisation of charts. The guide assumes that the user is familiar with the topics covered in *Microsoft Excel - An Essential Guide*. More advanced notes (*Advanced Spreadsheet Topics Using Microsoft Excel*) are also available.

Opening the Example File

Log into an IT Lab PC as usual and start up Excel 2013:

1. Click on the **Start** button, choose **All Programs** then **Microsoft Office 2013** and **Excel 2013**
2. Click on **Open Other Workbooks** (or you can use **<Ctrl o>**) then **Computer** and **[Browse]**
3. Click on **My Computer** then *double click* on **Data (D:)**
4. *Double click* again on the **Training** folder and choose **phoenix.xlsx**
5. Press **<Enter>** for **[Open]**

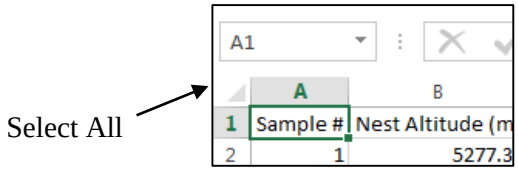
Note: For those using these notes on a computer not run by Information Technology, the example file can be downloaded from the link provided on the web page at step 4 above.

The set of data which appears is information on the size, weight and colour of 50 (mythological) birds eggs recorded from nests at a variety of altitudes. The initials of the collectors are also included.

Selecting Cells

Excel has various shortcuts for selecting a range of cells (besides the usual method of dragging through the required cells). These include:

- *entire rows/columns*: click on the row/column heading number/letter (or press **<Shift/Ctrl space>**)
- *a block of cells*: click in the top left corner of the block then, holding down **<Shift>**, press ***<arrow>*** keys to extend the selection in the directions of the arrows. Alternatively, select the top left cell then hold down **<Shift>** and click in the bottom right cell
- *a row/column range*: click on the starting row/column heading then either hold down **<Shift>** and use the ***<arrow>*** keys or **<Shift>** click on the end row/column heading
- *non-adjacent cells or blocks*: hold down **<Ctrl>** as you make your selection
- *part rows/columns*: click on the cell at the start of the selection then hold down both **<Ctrl>** and **<Shift>** and press the ***<arrow>*** key in the direction required. Alternatively, hold down **<Shift>** and *double click* on the active cell border in the direction required. Repeat this, using either method, to extend the new selection to a block of cells
- *the data set*: hold down **<Ctrl>** and press the **<a>** key. Note that **<Ctrl *>** can be used to select just part of the data - up to a blank column/row
- *the entire worksheet*: click on the *Select All* button (the grey blue rectangle in the top left corner of the worksheet, where the row and column headings meet) or you can press **<Ctrl a>** *twice* (if the current cell is within the data) or *once* if it is an empty cell



You can also select a range of cells using a command – on the far right of the **HOME** tab on the *Ribbon* choose **[Find & Select]** then **Go To...**. In the *Reference:* box, type in the cell or range of cells you wish to select. Note that when using this method, the selection is added to the *Go to:* list so that you can easily make the same selection again. Named ranges also appear in this list. **Go To...** is also activated by **<Ctrl g>** or **<F5>**.

Try using some of the above methods to select different areas of the worksheet.

Simple Data Manipulation

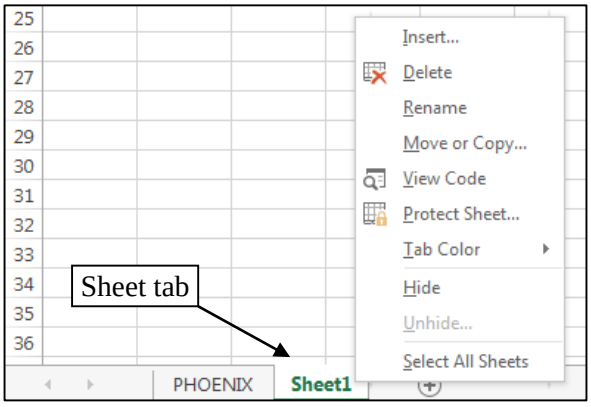
Using Multiple Sheets

In the *Essential Guide*, everything was done on a single worksheet, however a workbook can contain several sheets, each with different sets of data, charts etc. Indeed, charts are usually stored on separate *chart sheets*.

The *sheet tab* (at the foot of the screen) shows the worksheet name. New sheets can be created; old ones renamed, copied or deleted. In the exercise below, you will create a copy of the *phoenix* sheet (this is a good idea with any worksheet as it allows you to play around with the data while preserving a copy of the original).

To create a new worksheet:

1. Click on the **[New sheet]** button to the right of the *PHOENIX* tab (you can also use **<Shift F11>**)



To rename the worksheet:

2. *Right click* on the new *Sheet1* tab and select **Rename** from the shortcut menu (note that you can *Insert* new sheets here). Alternatively, *double click* on the tab name to select it - *Sheet1* is now highlighted
3. Type in the new name (call it **`Red-Brown`** - you'll be using this later) then press **<Enter>**

To make a copy of a worksheet:

4. Position the cursor over the *PHOENIX* tab, press the *right* mouse button then, from the shortcut menu, select **Move or Copy...**
5. In the *Move or Copy* window, click on the ***Create a copy*** check box in the bottom left corner and set *Before sheet:* to **(move to end)** - note that you can also copy or move a worksheet to an entirely new workbook or one already open under *To book:*
6. Press **<Enter>** for **[OK]** and a copy, *PHOENIX (2)*, will be created on the right

To delete a worksheet (eg the copy of the data):

7. *Right click* on the *PHOENIX (2)* tab then select **Delete** from the shortcut menu
8. You need all the sheets here, so press **<Esc>** or click on **[Cancel]** - normally you would press **<Enter>** for **[Delete]** to confirm the deletion

Note: No warning message appears if a sheet is empty.

The order of the sheets can be altered simply by dragging and dropping the sheet tabs.

9. Position the mouse cursor over the *Red-Brown* sheet tab
10. Hold down the mouse button and drag the sheet to the right hand side
11. Release the mouse button to drop the sheet tab in the new position

You can also colour-code the sheet tabs. This aids sheet identification if you have a lot of sheets. Note that the active sheet tab name turns **green** when selected:

12. *Right click* on the *Red-Brown* sheet tab and choose **Tab Color**
13. From the selection of *Standard Colors* choose **Dark Red** on the far left
14. Click on the *PHOENIX* sheet tab to see its full colour (the active sheet tab is always coloured white)

Other options when you right click on a sheet tab include *Protect Sheet* (you can protect a sheet with a password), *Hide* (to hide a sheet) and *Select All Sheets* (if you have several sheets identically laid out and want to carry out the same calculations on each – any action on the one sheet is repeated on the others).

Cell References when Using Multiple Sheets

If you want to use a cell on another sheet in a formula, then you have to include the sheet name in the cell reference. The full reference is of the form *Sheet*!*Cell* (you may have already noticed such references, eg when you have used the *Chart Wizard*). Usually it's easiest to fill in the reference by moving to the sheet concerned and clicking on the required cell:

1. Move to the empty sheet by clicking on the *Red-Brown* tab
2. In cell *A1* type `=10*`
3. Click on the *PHOENIX* tab then on cell *D2* - note how the cell reference is added to the formula
4. Press **<Enter>** and cell *A1* on the *Red-Brown* sheet is filled in
5. Move up to *A1*, note the cell reference in the formula again, then press **<Delete>** to empty the cell contents (they are not needed here)

Sorting the Data

Sort & Filter: 

It's often useful to have data displayed in some order - alphabetical or increasing/decreasing numbers. To sort the data based on a particular column, the active cell must be in that column. Here, you are going to sort the data in order of increasing nest altitude:

1. Move to the original copy of the data by clicking on the *PHOENIX* tab
2. Move the active cell into column *B* - click on any cell containing data (**don't** select more than one cell)
3. Click on **[Sort & Filter]** on the far right of the **HOME** tab (or *right click on a cell* and choose **Sort**) then choose **Sort Smallest to Largest** - note: for more complex sorts use **Custom Sort...**

The eggs should now be ranked in order of nest altitude, with the lowest at the top. Note how the sample numbers in column A have changed.

4. Repeat step **3** but choose **Sort Largest to Smallest** – the highest mountains now appear at the top

Tip: Occasionally you may want to sort only part of the data, leaving the surrounding data exactly as it is. To do this you must first select the data before you click on a sort button. Try this out if you like, but make sure you reverse any sort before you continue the course - use the **[Undo]** button to undo any changes.

To learn more, see the *Microsoft Excel 2013: Sorting, Subtotals and Outlines* advanced notes.

Creating Data Subsets

Excel offers limited database facilities whereby you can extract a subset of the data to work on. As an example, let's store a copy of the red-brown eggs on the sheet created earlier.

1. Make sure that the active cell is somewhere within the data on the *PHOENIX* tab
2. Click on the **[Sort & Filter]** button and choose **Filter** - a *filter arrow* is added to each column heading
3. Click on the *filter arrow* in cell *F1* and turn off *Blue-Green* and press **<Enter>** for **[OK]** - only red-brown eggs are now shown (the row numbers turn blue and it tells you *29 of 50 records found* at bottom left)
4. Select all the *Red-Brown* records - press **<Ctrl a>**
5. Press **<Ctrl c>** or click on the **[Copy]** button (or *right click* and choose **Copy**)
6. Move to the *Red-Brown* worksheet by clicking on its tab
7. Make sure you are in cell *A1* then just press **<Enter>** for **[Paste]**
8. To resize (*autofit*) all the columns in one go, press **<Ctrl a>** to select all the cells then *double click* on any of the dividing lines separating one column heading from its neighbour
9. Click on the *PHOENIX* tab to move back to the original data and click on any cell to end the selection

You'll see later an easier way to make a copy of the blue-green eggs on a new *Blue-Green* sheet.

Excel allows you to set selection criteria on more than one column - for example, you might want eggs that are both red-brown and which have a diameter of more than 8.5cm. To do this:

10. Click on the *filter arrow* in cell *D1* and choose **Number Filters** then **Greater Than...**
11. In the *Custom AutoFilter* window which appears type a value of `8.5` in the right-hand box
12. Press **<Enter>** for **[OK]** - only red-brown eggs over 8.5cm in diameter are now displayed

Finally, turn off both selection criteria and redisplay all the original data as follows:

13. Click on the **[Sort & Filter]** button and choose **Clear**

Note: you can turn off the criteria one at a time by using the list arrow at the top of each column and choosing **Clear Filter From ...**

14. To remove the filter arrows, click on the **[Sort & Filter]** button and choose **Filter**

More complicated selections can be made using **[Advanced]** in the *Sort & Filter* section on the **Data** tab. To learn more about filters, see the *Microsoft Excel 2013: Filters* advanced notes.

Text Rotation and Wrapping

Orientation: 

One feature which you may find useful, especially if you have a column heading which is much wider than the data beneath, is text rotation. Using this you can display more columns on a screen (or print more on a page):

1. Select row *1* by clicking on the row number **1**
2. Click on the **[Orientation]** button in the *Alignment* group and choose **Rotate Text up**

Though the headings are now very narrow, you would have to turn your head sideways to read them. There's a better solution as you'll see in a minute.

3. Press **<Ctrl z>** to **[Undo]** the orientation – you can try some of the other options, if you like
4. The final option, **Format Cell Alignment**, gives you even more options – try that next

Here, under *Orientation* on the right-hand side, note that you can rotate the text to any angle.

5. Press **<Esc>** for **[Cancel]** to close the dialog box
6. If necessary, press **<Ctrl z>** for **[Undo]** button to reset the text orientation to normal

An even more useful feature is *Wrap text*. This allows text to wrap onto more than one line within a cell:

7. With row *1* still selected, click on the **[Wrap Text]** button to the right of **[Orientation]**
8. Next, *right click* on the letter **B** at the top of the second column and choose **Column Width ...**
9. Set the *Column Width:* to **`8`** – press **<Enter>** for **[OK]** (only the first word of the heading appears)
10. Finally, *right click* on the number **1** at the left of the first row and choose **Row Height...**
11. Set the *Row Height:* to **`50`** – press **<Enter>** for **[OK]**

You can also force text onto a new line by holding down **<Alt>** and pressing **<Enter>**. This would allow you to store an address, for example, in a cell. Excel automatically adjusts the row height for you in this case.

12. Click on cell *D1* and press **<F2>** to enter edit mode

Tip: *Double clicking* on a cell also lets you edit its contents without having to use the *Formula Bar*.

13. Move the insertion point to immediately before *(cm)* then hold down **<Alt>** and press **<Enter>**
14. Repeat steps **12** and **13** on cell *E1* - you can then *autofit* the column widths, if you want
15. Finally, select row *1* then click on **[Middle Align]** (above **[Center]**) to display the headings perfectly

Further Graphics

Scatter (X-Y) Charts

A quick examination of the sorted data should show you that a clear relationship exists between nest altitude and the other variables - the eggs get smaller the lower the altitude. Try plotting this on a chart next. With scientific data, both the independent and dependent variables often vary over a *continuous* range. This contrasts with the business data used in the *Essential Guide*, where the dependent variables (income, costs, etc) applied to equal time periods (years). To activate the horizontal X-axis, a *Scatter* chart must be used.

1. Select the data needed for the chart (*B1* to *E51*) – drag through the range *B1* to *E1*, then hold down **<Ctrl>** and **<Shift>** and press **<*down_arrow*>** to select the whole columns
2. Click on the **[Quick Analysis]** button attached to the selected data (or press **<Ctrl q>**)
3. Click on **CHARTS** then choose **[More ...]**

Note the results shown as *Recommended Charts*. Both the *Line* and *Stacked Column* charts are rubbish. The middle *Scatter* plot is better (columns C to E are plotted against the Altitude) but the points have been joined by a jagged line, which is not required. To see more charts:

4. Click on the **All Charts** tab then on **X Y (Scatter)**
5. The selected chart is perfect - press **<Enter>** for **[OK]**

A chart now appears on the *Phoenix* sheet and extra *CHART TOOLS* tabs are added to the *Ribbon*. To move the chart to a new sheet and add labels:

6. Click on the **[Move Chart]** button on the far right of the **DESIGN** tab (or *right click* on the chart and choose **Move Chart...**)
7. Choose the *New Sheet* option and name the sheet **`EggPlot`** - press **<Enter>** for **[OK]**
8. Also on the **DESIGN** tab, click on **[Quick Layout]** and choose the first (**Layout 1**) – this automatically gives you placeholders for a title and the axis labels
9. Click in the *Chart Title* placeholder (there's no need to delete the existing text) and type **`Phoenix Eggs`** - press **<Enter>**
10. Click in the horizontal *Axis Title* placeholder and type **`Metres`** - press **<Enter>**
11. Finally, click in the vertical *Axis Title* placeholder and type **`Centimetres`** - press **<Enter>**

Note how *Diameter* and *Length* appear on 2 lines in the legend because you forced new lines in the cells.

Customising your Charts

Excel offers various facilities, including adding or changing text (titles, axis labels etc) or the legend; modifying the axes (range, tick marks etc); changing line and shading patterns; and adding trendlines and error bars. You can also select different font, foreground, background and infill colours.

Secondary Axes

Though all three measurements correlate positively with nest altitude, the length and diameter are on a much smaller scale than the mass and as such look a bit silly on the same chart. To overcome this, you can add a second y-axis.

1. *Right click* on any of the (blue) egg mass points and choose **Format Data Series...**
2. In the new *Format Data Series* pane, under *SERIES OPTIONS* choose *Plot Series On* **Secondary Axis**
3. To label the new axis, click on the **[Chart Element]** button (the green cross)
4. Move the mouse over **Axis Titles** and click on the arrow (►) which appears on the right
5. Check on **Secondary Vertical** then type `Grams` and press **<Enter>**
6. In the **Format Axis Title...** task pane, set the *Text Direction:* to **Rotate all text 90°**

The chart is now much clearer. Note that once a secondary Y-axis has been turned on, you can also have a secondary X-axis. This can be useful for comparing a single data series over two time periods, for example.

Trendlines

Excel gives you the opportunity of adding best-fit lines (lines which show the trend of your y values as the x values increase, calculated using regression analysis) to your plotted data. To do this:

1. *Right click* once on any of the blue egg mass data points and choose **Add Trendline...**

You can now choose from a variety of options

2. First, turn on the **Display Equation on chart** and **Display R-squared value on chart** check boxes at the foot of the pane

To get the best results, you need to maximize *R-squared* (this shows the proportion of the trend represented by the line). See what happens if you choose a different line:

3. Click on **Exponential** at the top of the lines and note how *R-squared* reduces from **0.9886** to **0.9066**
4. Try the other lines, if you like, but end by choosing **Linear**
5. Once you have found the best fit, turn off *Display R-squared* (unless you need it shown)

Knowing the Equation is also useful. If you have a mountain nearby, of altitude 12000 metres, you can plug that value (x) into the equation to calculate the likely mass (y) of an egg laid on its summit (this gives 120g). Similarly, you could plug a value for y (mass) into the equation and calculate x (the altitude).

The final trendline option is forecasting forwards or backwards. This lets you extend the line back to the axis or on to higher values. This can be used, for example, to show what would happen to future house prices if the trend over the period covered by the data were to continue. To see this:

6. Next, set the *Forecast* to extend the line *Backward:* by `1158` units (to meet the Y-axis)
7. Press **<Enter>** or click on **[Close]**
8. Repeat the above steps for the other data series, if you want to fully annotate your chart

Changing the Legend

You may have spotted that a new entry (*Linear (Mass)*) has appeared in the legend, To remove this:

1. Click once on the *Legend* then click again on the new *Linear (Mass)* entry
2. Press **<Delete>** to remove this entry

To change the position of the *Legend*:

3. Click on the *Legend* to display *the Format Legend* task pane
4. Click on **Legend Options** – the third button showing a column chart

Modifying the Axes

To change the settings for an axis simply *click* on it to display the *Format Axis* task bar. Here:

1. Click on the left *vertical* axis (click on the numbers) to select that axis
2. In the *Format Axis* task pane, click on **Axis Options** – again, the button showing a column chart
3. Under *Bounds*, set the *Minimum* to `5.0` and the *Maximum* to `16.0`

You are now making full use of the plot area. Note what other options are available.

Changing Data Markers and Line Style

To change the point markers or line style:

1. Click on one of the points to be changed - the **Format Data Series** task pane appears
2. Click on **Fill & Line** – the first button showing a paint pot
3. No line is needed for this data, so click on **MARKER**
4. Click on **MARKER OPTIONS** to change the marker **Type** and/or **Size**
5. Click on **FILL** to change the **Color**

Note: Excel also allows you to format a single data point in a series. Select the data series, then select the required point – try this here, if you like. Better still, work through the next section.

Adding Data Labels

Sometimes, you may want to add labels to points on your chart. You can add labels to a whole series or just to specific points. Try this next:

1. With a data series already selected, click on the point in the series to which you want to add a label
2. Next, click on the **[Chart Elements]** (green cross) button and check on **Data Labels** - you can position it using the arrow (►) on the right of this

The numeric value of that data point is now shown. To change this to your own label:

3. Click on the label to select it then again to enter edit mode
4. *Double click* and you have a choice of which label to use
5. Here, ignore these (click the mouse button once) and type in your own label – eg `Point A`
6. Repeat the process for any other point you wish to label

Changing Chart and Plot Area

The Chart and Plot Areas form the background to the chart itself. By default, a white *Plot Area* is placed on a white *Chart Area*, but you may prefer to have these coloured. To do this:

1. Click on the chart background (outside the axes) - the *Format Chart Area* task pane
2. Click on **[Fill & Line]**, if necessary, then on **FILL** to change the **Color**

Note: you can also change the background colour from the shortcut menu by *right clicking* on the *Chart Area*.

To change the *Plot Area*:

3. Repeat steps **1** and **2** but, this time, begin by clicking inside the axes to display the *Format Plot Area* pane

Changing Text

To modify the main title, for example:

1. *Right click* on the words *Phoenix Eggs* on the chart to display the pop-up menu

Note that the *Format Chart Title* task pane also appears if you need to change more obscure settings.

2. Use **Font** to change the style, size or font itself or **Fill** to set a coloured background
3. Press **<Enter>** for **[OK]** to enforce your changes

Error Bars

Error bars are another feature which you may need on a chart. These show the range of values represented by each of your data points (ie if you had collected another egg from the same nest, its mass etc would be expected to lie within the error bar range). To show the error bars:

1. Select the (blue) egg mass series by clicking on any of the points on the chart
2. Next, click on the **[Chart Elements]** button then move the mouse over **Error Bars** and click on the arrow (►) which appears on the right
3. Choose **More Options...** to display the *Format Error Bars* task pane
4. Click on **Error Bar Options** – the third button showing a column chart

Here you can decide which sort of error bars you require (*Plus*, *Minus* or *Both* based on the *Standard error*, *Standard deviation*, *Percentage* or a *Fixed value*). If you have calculated the values yourself, choose **Custom** then click on **[Specify Value]** and type in or drag through the cells containing the values.

5. Leave the *Display* settings as the defaults but set the *Error Amount* to **Standard Error**
6. To end this section close the task pane by clicking on its **[Close]** button

Further Data Manipulation

Naming Ranges

In the *Essential Guide* you saw how to name a single cell; you can apply the same procedure to a cell range and then use this in your formulae. A range of cells is also known as an array.

1. Move to the *PHOENIX* sheet and select cells *C2* to *C51* - click on *C2* then hold down **<Ctrl>** and **<Shift>** and press **<*down_arrow*>**
2. Click on the active cell name (*C2*) in the *Name Box* (just above the heading to column A) - the name will be highlighted (or *right click* on the selection and choose **Define Name...**)
3. Type in the new name for the range, call it **`mass`**, and press **<Enter>** - note that cells *D2:D51* and *E2:E51* have already been named **diameter** and **length** for you.

The next section demonstrates the use of named ranges in formulae and functions.

Using Ranges in Formulae and Functions

A wide range of functions is available within Excel. These can either be typed in directly, or can be invoked by clicking on the **[Insert Function]** button (or use **<Shift F3>**). Examples include MAX and MIN (the largest and smallest values); SQRT; LOG/LN (logarithms); PI (ie 3.14159); RAND (a random number); and SIN/COS/TAN (the trigonometric functions). Note that all functions use brackets - PI and RAND need dummy brackets ().

1. Move to cell *H2* and type in the formula **`=mass/length`** (as you type, a list of ranges/functions appears – ignore them) then press **<Ctrl Enter>** (pressing **<Ctrl Enter>** keeps you in the same cell)
2. Check you are in cell *H2* – if not, move to it

3. Copy the formula a few rows using *autofill* (ie dragging the cell *handle* - the mouse cursor changes shape to a + when over the handle)
4. To fill down the whole column, *double click* on the range/cell's *handle* – this automatically fills down until Excel finds an empty cell in the column to the left

If you didn't know this trick already, it's a very useful one. You wouldn't want to drag down hundreds or even thousands of rows! It's also one reason why you should avoid empty rows in your data. If the autofill stops at an empty cell, simply *double click* on the handle again to jump across the row and continue downwards.

Note how, for each row, the value for the mass is divided by that of the length. As an example of using named ranges in a function, work out average values for egg mass, diameter and length at the base of each column:

5. Move down to cell *A53*
6. Enter the label **`Average`** then press **<*right_arrow*>** *twice* to move to cell *C53*
7. In *C53* type **`=AVERAGE(mass)`** and press **<*right_arrow*>** (the result should be 51.79)
8. In cells *D53* and *E53*, type **`=AVERAGE(diameter)`** and **`=AVERAGE(length)`** respectively (the values should be 7.84 and 11.21)

When using ranges in complex formulae, it is sometimes necessary to enter the formula as an *array formula*. You do this by holding down **<Shift>** and **<Ctrl>** as you press **<Enter>** to end typing. To illustrate this:

9. Move to cell *H53*
10. Type the formula **`=AVERAGE(mass/length)`**
11. Press **<Enter>** and you will find Excel cannot do the calculation - a *#VALUE!* error message appears showing you that you haven't entered the formula as an array
12. Move back to cell *H53*, press **<F2>** to enter *edit mode* then hold down **<Ctrl>** and **<Shift>** then press **<Enter>** again

The resultant value of 4.41 represents the average of (C2/D2) + (C3/D3) +... + (C51/D51). Note how Excel has surrounded the formula by { and } on the command line – sadly, you *cannot* type these in directly yourself.

Although using named ranges seems a user-friendly way of typing in formulae, they do not change when a formula is copied. Whenever you need a formula to change according to its position, the range should be specified explicitly (eg as *C2:C51*). To demonstrate this, carry out the following:

13. Move to cell *C54* and type in the formula **`=AVERAGE(C2:C51)`** – press **<Ctrl Enter>**
14. Copy the formula into *D54* and *E54* simply by dragging C54's cell *handle* across the cells

When you release the mouse button, the formula will be copied across (giving the same values as in row 53). Move between the cells and note how the formula has been modified for each column; compare these formulae with those in row 53. You could even copy the formula to cell H54.

Tracing Errors

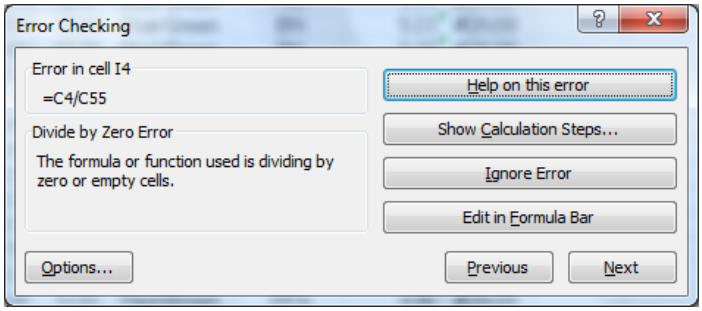
As a speadsheet is developed, it becomes more and more difficult to see how the values are built up. Excel provides a very useful facility that clearly shows which cells are dependent on which and the source of an error.

First, *standardise* some of the data. Standardisation is a statistical technique that involves dividing each value by the average for that set of data. It is often used to compare data which varies widely in scale - here, for example, mass ranges up to over 100, while the maximum length is just over 15. Dividing by the respective averages (51.79 and 7.84), produces values between 0 and around 2 for both series. These could then be plotted on a chart using a single vertical y-axis.

1. Move to cell *I2*
2. Enter the formula **`=C2/C53`** then press **<Ctrl Enter>** to stay in *I2*
3. *Double click* on the *cell handle* to fill down the column

You will find that an error **(#DIV/0!)** occurs in all but the top two cells. To trace the error:

4. Move to any cell reporting the error (eg *I4*)
5. Move to the **FORMULAS** tab on the *Ribbon* and click on **[Error Checking]** in the *Formula Auditing* section – the following window appears:



6. To get further information, click on **[Show Calculation Steps...]** – this isn't much help here!
7. Press **<Esc>** twice to close the *Error Checking* windows

To see the source of the problem more clearly:

8. Click on the arrow attached to the **[Error Checking]** button and choose **Trace Error**

The arrows show that *I4* is calculated from the values in *C4* and *C55* (which is empty - hence the *division by zero* error). Each of the values should have been divided by the average (in *C53* … or *C54*). You will see how to fix a value in a formula in a minute.

9. End by turning off the tracing by clicking on **[Remove Arrows]**

Other error messages which might appear include **#NAME?** (unrecognised text in a formula), **#NUM!** (invalid numeric values in a formula or function), **#REF!** (an invalid cell reference) and **#VALUE!** (the wrong type of argument or operand has been used).

Fixing a Row/Column in a Formula (*Absolute References*)

As has just been seen, when entering a formula it is sometimes necessary to fix either the row or the column or both. In Excel, this is achieved either by using a named cell or by using a *$ notation*.

1. Move to cell *I2* and press **<F2>** to enter *edit mode*
2. Correct the formula to read `=C2/C$53` and press **<Ctrl Enter>**

The $ notation fixes row 53 - had you also wanted to fix column C you would have used *C53*. When both the row and column are fixed, this is known as a *fully absolute reference*.

Tip: You can also fix a cell reference by pressing **<F4>** immediately after typing the reference when entering a formula. This circles round the possible notations each time the key is pressed.

3. *Double click* on the *cell handle* to copy the amended formula down the column - the error messages should disappear

For practice, you could drag the formula in cell *I2* across to *J2* and *K2* then complete the standardized data by *double clicking* on the *cell handles* in *J2* and *K2*

Move around the new cells and note how the formulae have automatically been adjusted for their relative position - the column reference varies while the row reference remains fixed. To show how these relate:

4. Move to any cell in column *C* then click on the **[Trace Dependents]** button on the **FORMULAS** tab
5. Do this again then to show all the cells which would be affected if the cell in column C were to change
6. End this section by clicking on the **[Remove Arrows]** button

Note that you can also use **[Trace Precedents]** to work your way back through a spreadsheet, to see exactly how a value has been calculated at each stage.

Freezing the Column Headings

When you have data which stretches down more than one screen, you lose the column headings as you scroll down. You can permanently display these headings by freezing them:

1. Move to the **VIEW** tab on the *Ribbon* and choose **Freeze Panes** then **Freeze Top Row**
2. Try using the scroll bars to move down the data - the column headings do not disappear
3. Press **<Ctrl Home>** - this now moves you to cell *A2* (not *A1*)

See the *Microsoft Excel 2013: Splitting Windows and Fixing Panes* advanced notes for more details.

Data Analysis

Although Excel is not a comprehensive statistical package, it does provide some rudimentary analysis tools - including Anova, Fourier Analysis, Regression and T-tests. For more thorough analyses of your data, a statistical package such as SAS, SPSS, Genstat or Minitab should be used. Consult the Statistical Advisory Service for help with this. They can advise you on the suitability and limitations of Excel for your work.

Many of the data analysis tools are not installed by default. They can, however, easily be added in:

1. Move to the **FILE** tab, choose **Options** then **Add-Ins** on the left
2. At the bottom of the screen under *Manage*, click on **[Go...]**, then check on **Analysis ToolPak**

Note: *Analysis ToolPak – VBA* is a very advanced feature offering you the opportunity to make functions available to your own programming (with *Visual Basic*) . The *Euro Currency Tools* give you the exchange rates when each currency joined the Euro and are useful for converting historical data. The *Solver Add-in*

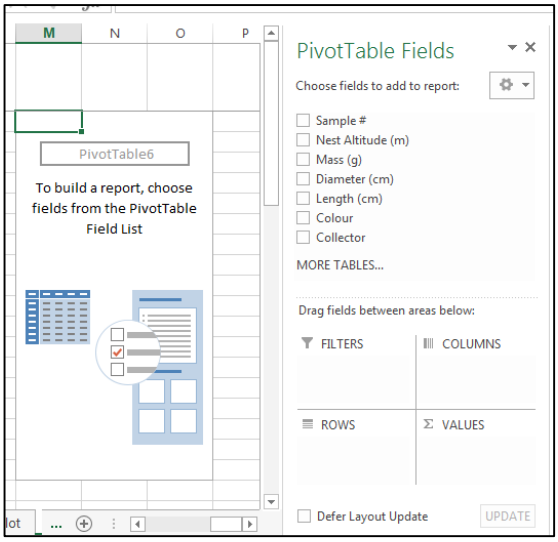
3. Click **[OK]** to add in the *Analysis ToolPak*

Pivot Tables

Pivot tables allow you to create interactive summary tables of your data. Here is a simple example:

1. Check you are using the *PHOENIX* data and the current cell is inside the data (eg in *A1*)
2. Move to the **INSERT** tab on the *Ribbon* and click on the **[PivotTable]** button on the far left
3. In the *Create PivotTable* window turn on the **Existing Worksheet** option and set the *Location* to **`M2`** then press **<Enter>** for **[OK]**

A skeleton Pivot Table appears, starting in *M2* (scroll right and up to see it), while two extra PivotTable Tools tabs appear on the *Ribbon*. A *Pivot Table Fields List* task pane also appears on the right:



You now have to select which data series you are summarizing by dragging the field buttons from the *Field List* pane and dropping them into the areas below the field list. For this particular set of data, it's easy to summarize by collector and egg colour.

4. Drag and drop the **Colour** field button down into the area marked *Columns*
5. Drag and drop the **Collector** field button into the area marked *Rows*
6. Drag and drop the **Collector** field button again, this time into the ∑ *Values*

The end result should look like this:

Count of Collector	Column Labels		
Row Labels	Blue-Green	Red-Brown	Grand Total
BN	1	8	9
BRV	6	3	9
CDS	9	1	10
FLC	1	9	10
RFA	4	8	12
Grand Total	**21**	**29**	**50**

Because you used a text field (the initials of the collectors) for the summary data, the default is to count the number of cells for each collector. Had you used a numeric field, the default would have been to sum the values. Various other measures are available, including average, maximum and minimum. You can have several of these showing by dragging further field buttons into the data area.

7. *Right click* on **Count of Collector** in cell *M2* and choose **Value Field Settings**

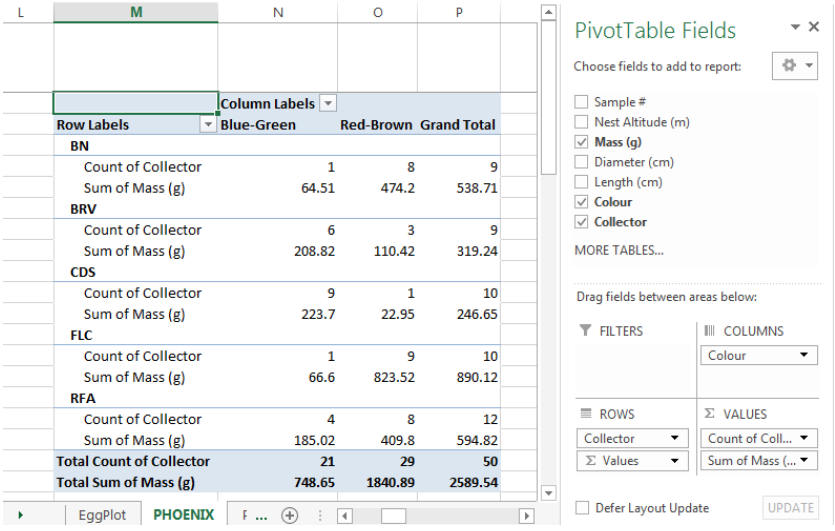
Explore (but don't change) the list of measures on the *Summarize Values by:* tab. Further options are available on the *Show Values as:* tab.

8. Press **<Esc>** or click on **[Cancel]** to leave **Count** as the chosen option
9. Next turn on the check box for **Mass (g)** in the *Pivot Table Field List* – the data is automatically added to the table

You now have both a count of the eggs for each collector and the sum of their mass. The results might look clearer if the two sets of figures are separated out:

10. Drag the ∑ **Values** from the **Columns** to below *Collector* in the **Rows**

Your Pivot Table should now look like this:



If you change any of your data values, the Pivot Table is not updated automatically. Instead, you have to use the **[Refresh]** button:

11. Move to cell *G11* and change the collector from FLC to **`BN`** and press **<Enter>**
12. Click on the pivot table (to activate it) then *right click* on it and choose **Refresh** - note how the values are updated (collector BN now has two blue-green eggs)
13. Reset the value in *G11* to **`FLC`** and update the pivot table again

Pivot Tables have one other very useful feature. If you *double click* on any of the calculated cells in a table, a copy of that data is pasted onto a new sheet. To see this:

14. *Double click* on the number **21** (the *Grand Total* of *Blue-Green* eggs) – the data is copied to a new sheet
15. *Right click* on the new sheet tab and **Rename** it then choose an appropriate **Tab Color**
16. End by moving back to the *Phoenix* tab

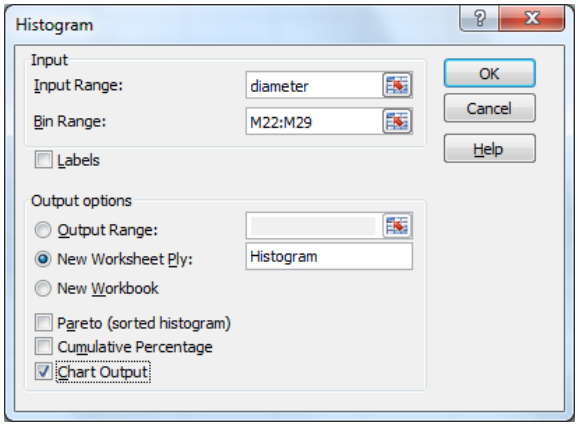
For more about pivot tables, see the *Microsoft Excel 2013: Pivot Tables* advanced notes.

Histograms

Before running the histogram tool, you should first set up *bin values* (to define the divisions for each histogram range). As you will see, Excel can also draw a chart for you, if requested.

1. Starting in *M22*, type the number `5` - press **<Ctrl Enter>**
2. Drag the *cell handle* down to cell *M29* then click on the **[Auto Fill Options]** button which appears next to the bottom of the selection and choose **Fill Series**
3. Check you have the rest of the bin numbers: `6`, `7`, `8`, `9`, `10`, `11` and `12` in *M22:M29*
4. Click on the **DATA** tab on the *Ribbon* and then on **[Data Analysis]** on the far right
5. From the list of analysis tools, choose **Histogram** - press **<Enter>** or click on **[OK]**
6. In the *Histogram* window, set the *Input Range:* to `diameter` and *Bin Range:* to `M22:M29`
7. Under *Output options*, keep the default of output to a **New Worksheet Ply:** but name the sheet `Histogram`
8. Click on the **Chart Output** check box for a chart

The *Histogram* window should look as follows:



9. Press **<Enter>** or click on **[OK]** and watch what happens
10. Enlarge the chart - click on it (to activate it) then drag the bottom handle downwards

The Histogram tool works very well but it can be annoying to have a *More* category. To remove this from the chart (and frequency table):

11. Select cells *A10* and *B10*
12. *Right click* on the selection and choose **Delete...**
13. Leave *Delete* as **Shift cells left** - just press **<Enter>** or click on **[OK]**

The labelling on the X-axis could be improved further by editing the bin values in cells *A2* to *A9*:

14. Move to cell *A2* and type `<5` then press **<Enter>**
15. In cell *A3* type `'5-6` (the quote is vital - without it you get a date) and press **<Enter>**
16. Continue typing `'6-7, '7-8 ... '10-11, >11` into cells *A4* to *A9*

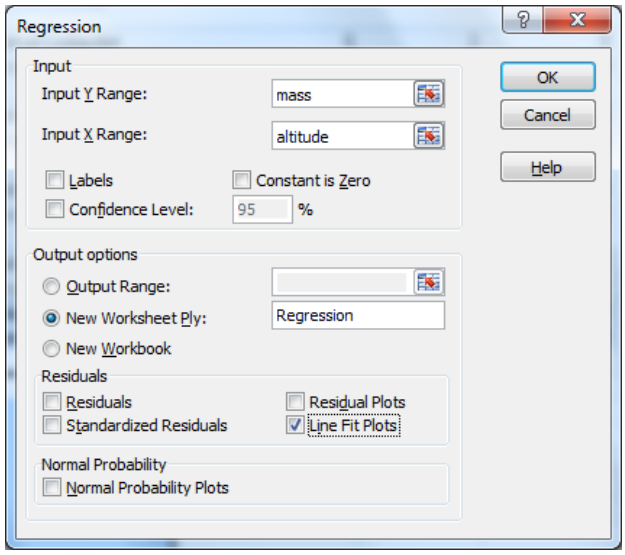
17. Move the chart onto its own sheet – *right click* towards the edge then choose **Move Chart...**
18. Select *New sheet:* and name it **`Histogram Plot`** - press **<Enter>** for **[OK]**
19. Change the *Title* to **`Histogram Showing Egg Diameters`** and *Bin* to **`Centimetres`**
20. Finally, remove the *Legend* – click on it to select it then press **<Delete>**

Regression Analysis

Regression is a commonly-used statistical tool in the scientific world. If you are not familiar with this statistical technique, ignore this next exercise. The hypothesis you'll be testing out is that egg mass is dependent on the nest altitude.

1. Click on the *PHOENIX* tab to return to your data
2. Move to the **DATA** tab on the *Ribbon* and select **[Data Analysis]**
3. Select **Regression** from the list of *Analysis Tools* - press **<Enter>** or click on **[OK]**
4. In the *Regression* window, set **Input Y Range:** to **`mass`** (or type **`C2:C51`**)
5. Press **<Tab>** then in **Input X Range:** type **`altitude`** (or type **`B2:B51`**)
6. Name the new sheet **`Regression`** against **New Worksheet Ply:** in *Output options*
7. To get a chart of the results, turn on **Line Fit Plots** under *Residuals*

The *Regression* window should look as follows:



8. Press **<Enter>** or click on **[OK]** and watch what happens

The regression results are displayed on a new worksheet, with a chart plotted at the side.

9. Move the chart onto its own sheet - *right click* on it then select **Move Chart...**
10. Choose *New sheet:* and name it **`Regression Plot`** - press **<Enter>** for **[OK]**

To add a best-fit line to your chart:

11. *Right click* on one of the (red) *Predicted Y* values and choose **Format Data Series**
12. In the *Format Data Series* pane, click on **[Fill and Line]** (the paint bucket)
13. Set **Line** to **Solid line** then click on **Marker** then **Marker Options**
14. Set this to **None** then **[Close]** the *Format Data Series* pane

Note that Excel does allow rudimentary multiple regression - set up the *Input X Range* to a block covering more than one adjacent column. However, your data may not be suitable for this so always seek guidance from the Statistical Advisory Service.

Pasting Worksheets and Charts into other Documents

If you want to incorporate information from Excel into Microsoft Word (or other software), the procedure is as follows:

a) *Worksheets* can be copied across simply by using **[Copy]** and **[Paste]** - in Excel, select and copy the cells you require then switch to Word and paste in the data. In Word, this is displayed as a table (without borders), with any formatting preserved. Such tables can be edited as normal text. Note, however, that with certain packages some Excel formats cause problems and have to be cleared before the copy/paste is carried out.

If **Paste Special** is used instead of **Paste**, then the data can be moved as *Unformatted Text*. This does not appear as a table but is instead *tab separated*. Using **Paste Special** you can also copy a worksheet as a *Picture*. This can then be rotated, if required, to appear landscape (sideways) on a portrait (upright) page. Note that the data in a picture cannot be edited.

Note: If you **Paste** by *right clicking* then these options can be selected by choosing the matching icon from the *Paste Options*. Help tips appear as you place the cursor over an icon to explain which button is which.

If you want to preserve a link between the Excel worksheet and other document (such that changes made in the source file are passed to the other) then turn on **Paste link** in the *Paste Special* window. Note: the files need to be kept in the same relative position – take care not to rename or move one into a different folder.

Worksheets can also be saved in various formats readable by many other applications including space/tab/ comma separated values. The format type can be set in the *Save As* window.

b) *Charts* can also be copied to a Word document (or other software, such as PowerPoint or Access) by using **[Copy]** and **[Paste]**. When pasting into Word, it is advisable to use **Paste Special** via the **[Paste]** button, as this gives you the options of pasting the chart as a picture and/or as a linked object (see above).

The default is to paste the chart as a *Microsoft Office Graphic Object*. This allows you to make changes to the chart in the normal way (*right click* and choose **Format**) but can cause problems if you change its size. Another option is to paste it as a *Microsoft Excel Chart Object*. When you *double click* on this, to edit it, it loads up Excel where you can not only make changes to the chart but to the data on the other sheet tabs. Again, however, if you change the size of the chart in your Word document, the text (chart/axes titles, legend etc) doesn't change causing the chart itself to shrink.

The best way to preserve how the chart looks is to paste it as a *Picture* (eg JPEG). Not only can you change the size with the layout intact but you can easily rotate it should you want it appearing sideways on an A4 page. The disadvantage of this is that any changes to the chart must be made in Excel – you would then have to copy it back into your Word document.

For details about copying Excel charts to Word see the document *Microsoft Word 2013: Graphics*.

Leaving Excel

To quit from Excel:

1. Press **<Alt F4>** or click on the **[Close]** button in the top right corner

Tip: <Alt F4> can be used to close any program – you can even use it to log out of Windows.

2. Click on **[Don't Save]** when you are asked whether you want to save the changes to *phoenix.xls* - there's no need to keep the changes

Last Revised: January 2016