Physics
Guide to Excel

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Physics

Guide to Excel

Support Materials

qsdv

Physics: Guide to Excel – Student material

INTRODUCTION

Microsoft Excel for PC and Apple Macintosh.

Microsoft Excel is part of the Microsoft Office software package (usually consisting of Microsoft Word, Microsoft Excel and Microsoft Power Point). The Microsoft Office software is available for PC and Apple Macintosh machines. This guide is written for the PC using Microsoft Excel 97 running in Microsoft Windows 98.

It is appreciated that some Physics departments work with Apple Macintosh machines. There are three minor differences between Microsoft Excel for PC and Microsoft Excel for Apple Macintosh.

1. The formatting windows displayed by Excel for PC vary slightly from those displayed by Excel for Apple Macintosh. Although each window is arranged slightly differently, it will display the same range of options.
2. When the Control key is used on the PC, the Apple key is used on the Apple Macintosh.
3. When formatting fonts on the PC version, the True Type symbol appears beside True Type fonts. This does not appear on the Apple Macintosh version.

Summary of the Guide to Excel

This Guide to Excel is divided into 5 sections.

1. Entering and analysing data
2. Plotting a chart
3. Editing a chart
4. Handling uncertainties
5. Constructing Formulae

The first three sections of this guide lead the user through the steps required to process a set of data from the Higher Physics experiment, Light intensity and distance. The user begins with a set of raw data and is taken through the processes of entering and analysing the data, plotting, and editing the chart, to produce a chart of I/lux against $(1/d^2)/cm^{-2}$ suitable for inclusion in an Outcome 3 report.

The fourth section uses a set of data from the Higher Physics experiment, Half-value thickness of lead for gamma radiation. The user is taken through the steps required to use Excel to calculate approximate random uncertainties, percentage uncertainties, absolute uncertainties and the plotting of error bars (aimed specifically at Advanced Higher students).

The fifth and final section takes the user through the most commonly used arithmetical operators and functions required to create formulae for inclusion within Excel spreadsheets. These operators and functions include trigonometric and logarithmic functions.

This guide has been written on the assumption that the user has a very basic knowledge of spreadsheets. The first three sections will take a novice approximately 30 minutes to complete. With a little practice the user should be able produce a chart suitable for inclusion in an Outcome 3 report in about 5 minutes.

Using Microsoft Excel within Outcome 3 reports.

At present, students are not required to submit typed Outcome 3 reports. Students may use Excel (or any other suitable data analysis software) when tackling Outcome 3 but there are two criteria to which they must adhere.

1. The student must not be given a spreadsheet with pre-prepared column headings nor formulae, as they are being assessed on their ability to enter quantities and units into a table.

2. The chart plotted must not have a best-fit line entered by the computer. As the student is being assessed on his or her ability to draw a best-fit line, any charts produced using Excel (or other suitable data analysis software) must have a best-fit line hand-drawn by the student.

At Advanced Higher Physics, Excel may be used to analyse large amounts of experimental data, and allows the student to plot error bars charts.

ENTERING AND ANALYSING DATA

Entering the independent variable

When Excel is opened this is what will be seen.
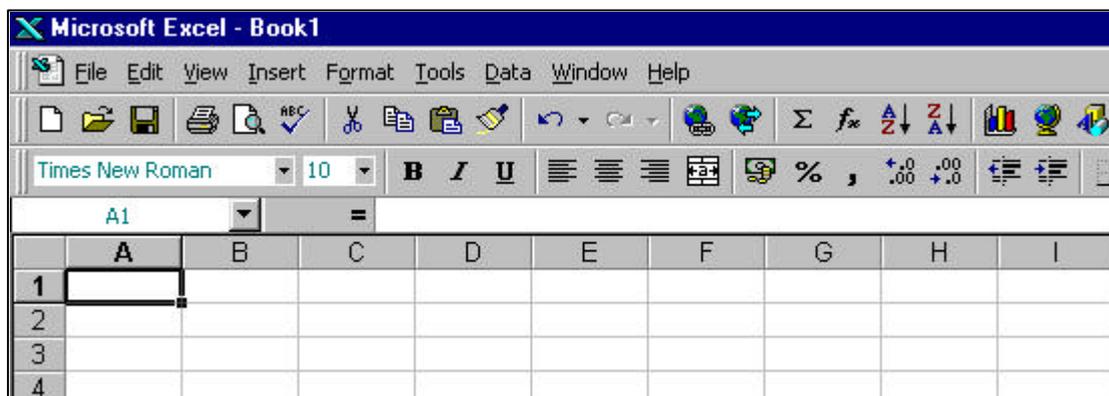
The independent variable (what was changed) should always be placed into the first column (column A). This ensures that the independent variable will be plotted on the x-axis. The dependent variable (what was measured) should always be placed into the second column (column B). This ensures that the dependant variable will be plotted on the y-axis.

Entering a column heading

The independent variable in this experiment was the distance of the light sensor from the lamp, measured in cm. The column heading is entered into the spreadsheet using the following steps.

1.   Use the mouse to click on cell A1 (shown in the above diagram). To check that the correct cell has been selected, look at the Name box (the white box above the grey A cell) and it should read A1.
2.   Type in Distance from lamp/cm. The text will appear in the Formula Bar (to the right-hand side of the equal sign).
3.   Press the Return key when this is done.

Entering data

1.   Click the mouse on cell A2. Type in the first number i.e. 25.
2.   Press the Return key. The cursor will move down to cell A3, into which the number 30 is typed.
3.   Continue with this until all of the data for distance has been input.

The spreadsheet will now look like this.

	A	B	C	D
1	Distance from lamp/cm			
2	25			
3	30			
4	40			
5	50			
6	60			
7	70			
8				
9				

Changing the column heading style.

The column heading is too large for the column. There are two ways to solve this problem.

1. Change the column width to fit the text width – useful for spreadsheets with few columns.
2. Change the text width to fit the column width - useful for spreadsheets with many columns.

Changing the column width to fit the text width.

1. Move the mouse cursor to the boundary between the grey A cell and the grey B cell. The cursor will change from a white cross to a black cross with arrowheads on the horizontal bar.
2. Double click the mouse and the column width will automatically change to fit the width of the text.

The spreadsheet will now look like this.

	A	B	C	D
1	Distance from lamp/cm			
2	25			
3	30			
4	40			
5	50			
6	60			
7	70			
8				

3. Go to Edit on the Menu bar.
4. Click on Undo and the screen will go back to the way it was.

Should the finished spreadsheet contain a large number of columns, this type of formatting will result in a very wide spreadsheet that does not easily fit onto an A4 page. It should only be used in spreadsheets with a small number of columns.

Changing the text width to fit the column width.

1. Click on the grey A cell.
2. Go to Format on the Menu bar.
3. Click on Cells.
4. Click on Alignment and the Format Cells window will appear.
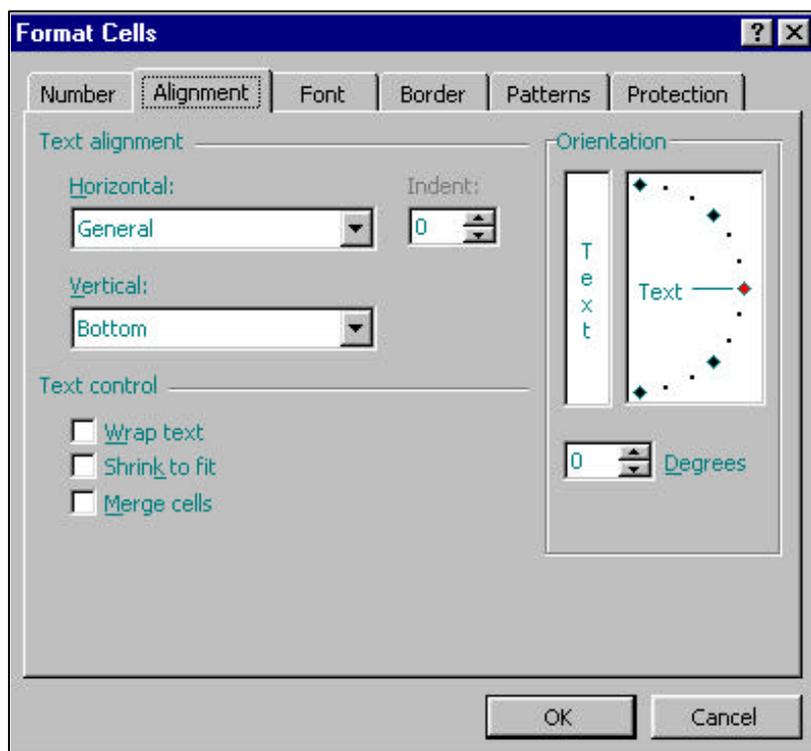
5. In the Horizontal cell, pull down the menu and select Centre.
6. In the Vertical cell, pull down the menu and select Top.
7. In the Text control options, click on Wrap text, and a small tick will appear in the box.
8. Click on OK and the spreadsheet will look like this.

	A	B	C	D
1	Distance from lamp/cm			
2	25			
3	30			
4	40			
5	50			
6	60			
7	70			
8				
9				

This style of column heading is very useful where the spreadsheet has a large number of columns and may have to be imported into a word document, such as an Outcome 3 report.

Entering the dependent variable.

The dependent variable in this experiment was the Intensity of light measured in lux.

1.　　　Use the mouse to select cell B1.
2.　　　Type in the heading, Intensity of light/lux.
3.　　　Adjust the text width to fit the column width, using the previous method.
4.　　　Select cell B2.
5.　　　Type in the first column of light intensities, beginning with 554.
6.　　　Select cell C1 and enter the column heading Intensity of light/lux.
7.　　　Adjust the text width to fit the column width.
8.　　　Enter the second column of data beginning at cell C2 with 556.

The spreadsheet will now look like this.

	A	B	C
	Distance from lamp/cm	Intensity of light/lux	Intensity of light/lux
1			
2	25	554	556
3	30	381	385
4	40	232	234
5	50	152	154
6	60	110	114
7	70	81	79
8			
9			

Entering an Excel function.

The Average Function.

In order to calculate the average Intensity of light, the average function may be used. An equal sign must be used before every function and formula to tell Excel that it must perform a calculation.

1.　　　Select cell D1, and enter the heading Average intensity of light/lux.
2.　　　Adjust the text width to fit the column width.
3.　　　Select cell D2.
4.　　　Type =average(
5.　　　Click onto cell B2, hold down the mouse, and drag the mouse over to cell C2.
6.　　　B2 and C2 will now have a moving dotted border, and the formula will now read =average(B2:C2
7.　　　Close the bracket to give =average(B2:C2) and the moving border will disappear.
8.　　　Press the Return key and the answer 555 will appear in cell D2. Whenever cell D2 is selected, the function will be shown in the Formula bar (to the right-hand side of the equal sign).

Copying a cell.

There are two ways to copy cells, depending on where the information is to be placed.

Copying a cell to a non-adjacent cell.

To copy the average function in cell D2 to cell D7, follow these instructions.

1. Select cell D2.
2. Go to Edit on the Menu bar.
3. Choose Copy. The cell will now have a moving dotted border.
4. Select the cell where the information is to be placed i.e. cell D7. The cell now has a grey border.
5. Go to Edit on the Menu bar.
6. Choose Paste.
7. The information from cell D2 will be pasted into cell D7 and the answer 80 will appear.

Copying a cell to adjacent cells.

To copy the average function in cell D2 to cells D3 to D7, follow these instructions.

1. Select cell D2.
2. Move the cursor to the bottom right hand corner of the cell and the cursor will change from a white cross to a black cross.
3. Once the cursor has changed, hold down the mouse button and drag down the screen until cells D3 to D7 are edged in grey.
4. Release the mouse button. The answers will appear in each of the cells, and the cursor will change back to a white cross.

The spreadsheet will now look like this.

	A	B	C	D
1	Distance from lamp/cm	Intensity of light/lux	Intensity of light/lux	Average intensity of light/lux
2	25	554	556	555
3	30	381	385	383
4	40	232	234	233
5	50	152	154	153
6	60	110	114	112
7	70	81	79	80
8				
9				

Inserting a column.

The relationship between light intensity and distance is an inverse square relationship.

$$\text{Intensity of light} \propto \frac{1}{\text{distance}^{\,2}}$$

$1/d^2$ is calculated from the independent variable. When plotting a graph (known as a Chart in Excel), the independent variable (or any data resulting from its use) should always be placed to the left-hand side of the data for the dependant variable. It will be necessary to insert a column between columns A and B.

1. Click on the grey B cell. The whole of column B will now be highlighted.
2. Go to Insert on the Menu bar.
3. Click on Columns.
4. An empty column will have been inserted between the former columns A and B. The new column will have become column B and the former columns B, C, and D will have been shifted one letter to the right.

The spreadsheet will now look like this.

	A	B	C	D	E
1	Distance from lamp/cm		Intensity of light/lux	Intensity of light/lux	Average intensity of light/lux
2	25		554	556	555
3	30		381	385	383
4	40		232	234	233
5	50		152	154	153
6	60		110	114	112
7	70		81	79	80
8					
9					

Entering a formula in the column heading.

The formula $1/d^2$ and unit cm^{-2} are to be used as the column B heading. The column heading will be input as $(1/d^2)/cm^{-2}$. The brackets around the term $1/d^2$ are there to make the heading more legible, as $1/d^2/cm^{-2}$ is not very clear.

1. Select cell B1.
2. Type in (1/d2)/cm-2
3. In the Formula bar, highlight the first number 2 using the cursor. The screen will look like this.

	A	B	C	D	E
1	Distance from lamp/cm	l2)/cm-2	Intensity of light/lux	Intensity of light/lux	Average intensity of light/lux
2	25		554	556	555
3	30		381	385	383
4	40		232	234	233
5	50		152	154	153
6	60		110	114	112
7	70		81	79	80
8					
9					

4.   Go to Format on the Menu bar.

5.   Choose Cells and the Format Cells window will appear.
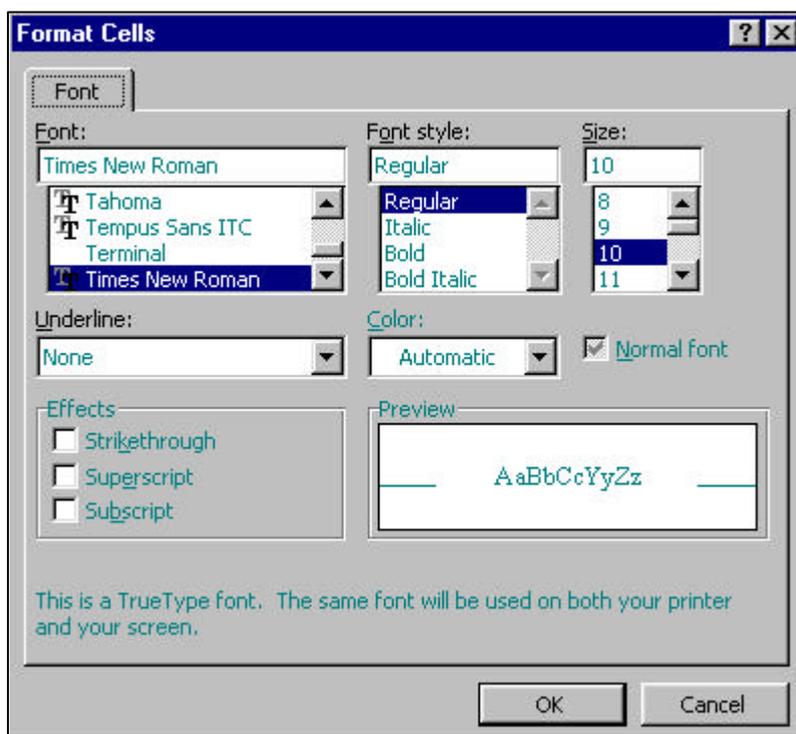
6.   Click on Superscript and a small tick will appear beside the word.

7.   Click on OK and the column heading will now reads $(1/d^2)$/cm-2, although it will <u>not</u> have changed in the Formula bar.

8.   In the Formula bar, highlight the –2 using the cursor.

9.   Go to Format on the Menu bar.

10.   Choose Cells and the Format Cells window will appear.

11.   Click on Superscript and a small tick will appear beside the word.

12.   Click on OK and the column heading will now read $(1/d^2)$/cm^{-2}, although it will <u>not</u> have changed in the Formula bar.

The spreadsheet will now look like this.

	A	B	C	D	E
1	Distance from lamp/cm	$(1/d^2)/cm^{-2}$	Intensity of light/lux	Intensity of light/lux	Average intensity of light/lux
2	25		554	556	555
3	30		381	385	383
4	40		232	234	233
5	50		152	154	153
6	60		110	114	112
7	70		81	79	80
8					
9					

Entering a formula.

Column B is to be used to calculate the value of $1/d^2$ for each of the values of distance in column A. In order to do this a formula must be entered into the column B cells. For information on creating a formula see the section entitled Constructing formulae.

1. Select cell B2.
2. Type in =1/(A2^2). The hat symbol (^) is entered by pressing the Shift key and the number 6 key together. It means " to the power of".
3. Press the Return key and the answer of 0.0016 will appear in cell B2.
4. Copy the formula to cells B3 to B7 using the given method for copying a cell to adjacent cells.

The spreadsheet will now look like this.

	A	B	C	D	E
1	Distance from lamp/cm	$(1/d^2)/cm^{-2}$	Intensity of light/lux	Intensity of light/lux	Average intensity of light/lux
2	25	0.0016	554	556	555
3	30	0.0011111	381	385	383
4	40	0.000625	232	234	233
5	50	0.0004	152	154	153
6	60	0.0002778	110	114	112
7	70	0.0002041	81	79	80
8					
9					

Formatting numbers.

The numbers in column B have a range of decimal places. They may be expressed in scientific notation by carrying out the following instructions.

1. Click on the grey B cell to highlight the whole of column B.
2. Go to Format on the Menu bar.
3. Choose Cells. The Format Cells window will appear.
4. Click on the Number tab at the top of the window. The window will look like this.
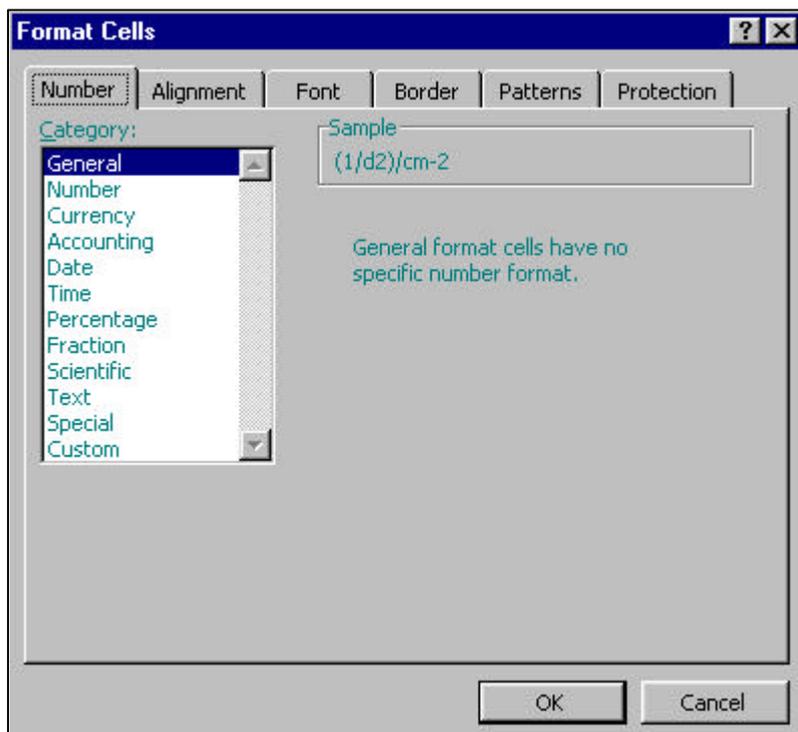
5. Go to the Category options and click on Scientific. Click the down arrow once to change the number of decimal places to 1.
6. Click on OK and the Spreadsheet will now look like this.

	A	B	C	D	E
	Distance from lamp/cm	$(1/d^2)/cm^{-2}$	Intensity of light/lux	Intensity of light/lux	Average intensity of light/lux
1					
2	25	1.6E-03	554	556	555
3	30	1.1E-03	381	385	383
4	40	6.3E-04	232	234	233
5	50	4.0E-04	152	154	153
6	60	2.8E-04	110	114	112
7	70	2.0E-04	81	79	80
8					
9					

The E stands for "times 10 to the power of". If any of the data were very small it would be possible to enter them into the spreadsheet using this notation for example, a wavelength of 720 nm, would be input as 720E-09.

When Scientific Notation is used in the spreadsheet, it becomes difficult to see any trends in the data. In the example being used, the trend becomes easier to spot if the cells are formatted to show four decimal places. The cells are formatted using the following instructions.

1.   Click on the grey B cell to highlight the whole of column B.
2.   Go to Format on the Menu bar.
3.   Choose Cells and the Format Cells window will appear.
4.   Click on the Number tab at the top of the window.
5.   Click on Number from the Category options.
6.   Click the upwards arrow three times to change the number of decimal places to 4.
7.   Click on OK and the spreadsheet will look like this.

	A	B	C	D	E
	Distance from lamp/cm	$(1/d^2)/cm^{-2}$	Intensity of light/lux	Intensity of light/lux	Average intensity of light/lux
1					
2	25	0.0016	554	556	555
3	30	0.0011	381	385	383
4	40	0.0006	232	234	233
5	50	0.0004	152	154	153
6	60	0.0003	110	114	112
7	70	0.0002	81	79	80
8					
9					

It is now clear to see that as $(1/d^2)/cm^{-2}$ is doubled the Average intensity of light/lux approximately doubles suggesting a linear relationship.

PLOTTING A CHART

Selecting data in non-adjacent columns

A chart of Average light intensity/lux against $(1/d^2)/cm^{-2}$ is to be plotted. The data for the chart are in Column B and Column E.

1.   Click on the grey B cell.
2.   Hold down the Control key (Ctrl) and use the mouse to click on the grey E cell.
         Apple Macintosh users should hold down the Apple key instead of the Control key.

The spreadsheet will now look like this.

	A	B	C	D	E
1	Distance from lamp/cm	$(1/d^2)/cm^{-2}$	Intensity of light/lux	Intensity of light/lux	Average intensity of light/lux
2	25	0.0016	554	556	555
3	30	0.0011	381	385	383
4	40	0.0006	232	234	233
5	50	0.0004	152	154	153
6	60	0.0003	110	114	112
7	70	0.0002	81	79	80
8					
9					

Selecting the Chart Wizard.

The Chart Wizard must now be selected. There are two ways to do this.

1.   Press the Chart Wizard Icon on the Menu bar, as shown below.

OR

2.   Go to Insert on the Menu bar and Select Chart.

The Chart Wizard window will appear.
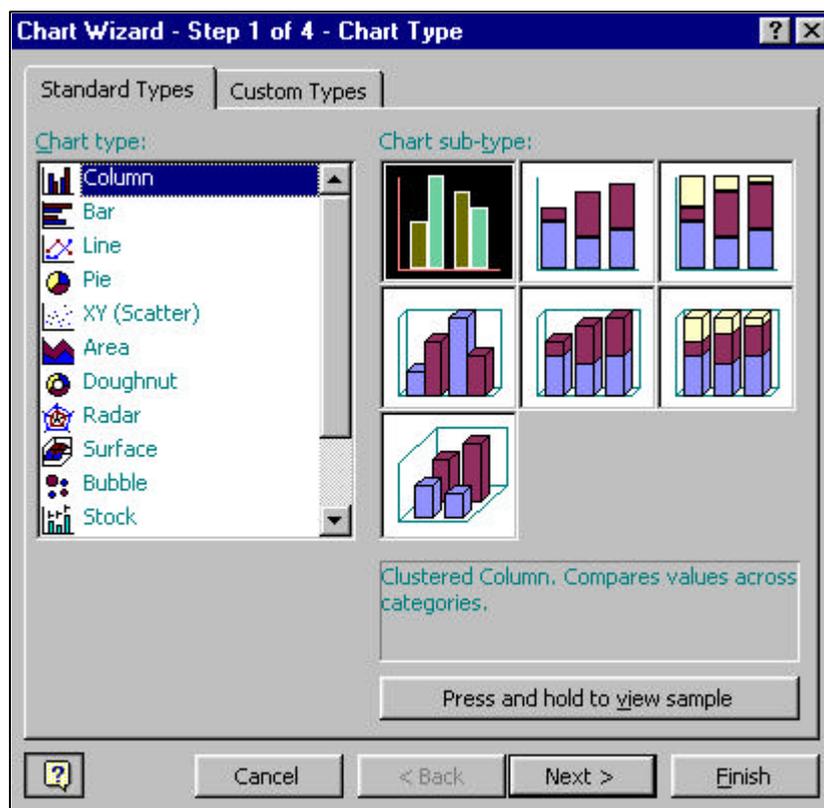
Selecting the chart type

XY (Scatter) chart

1.   Click on the Standard Types tab at the top of the Chart Wizard window.
2.   Select XY (Scatter) from the Chart type options.
3.   Select the top left chart from the chart sub-type options.

The Chart Wizard window will now look like this.

Apple Macintosh users will find that the windows shown in this guide vary slightly from those displayed by Excel for Apple Macintosh. Although each window is arranged slightly differently, it will display the same range of options.
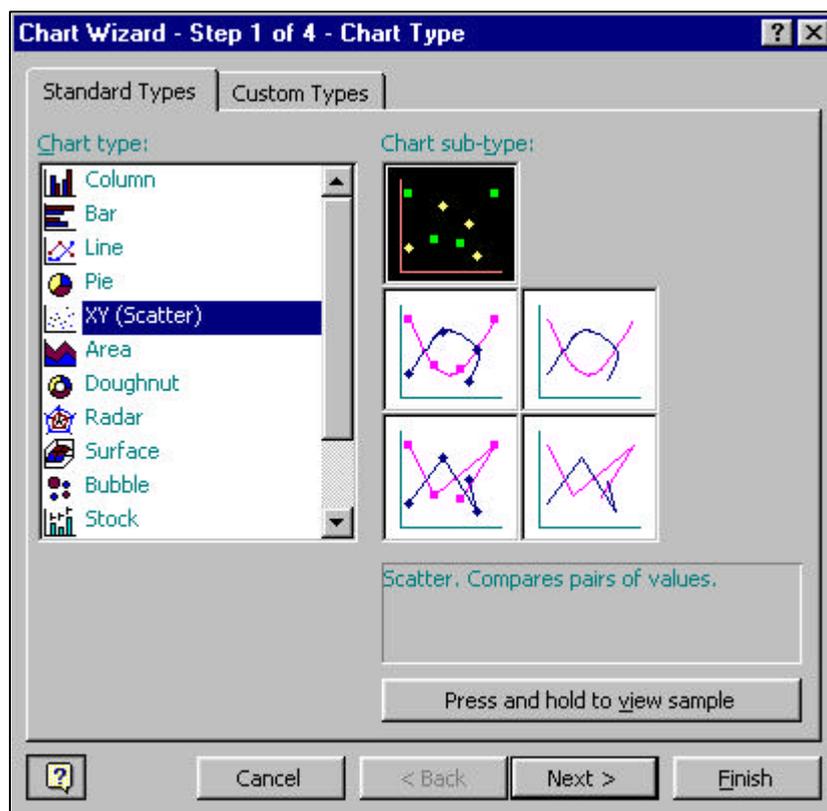
The Scatter Chart Type plots the data points but does not plot a best-fit line. Students must hand draw the best-fit line in order to achieve Outcome 3. The Scatter with data points connected by smoothed lines, chart type may be used for interim charts such as Average intensity of light/lux against Distance/cm, but is not acceptable as the final chart type. Notice that for this chart the data points are joined.

Previewing the chart.

1. Click and hold the mouse on the "Press and Hold to view sample" button at the bottom right-hand corner of the Chart Wizard window, and a sample chart will appear.
2. Releasing the mouse will return the Chart Wizard to the previous screen.
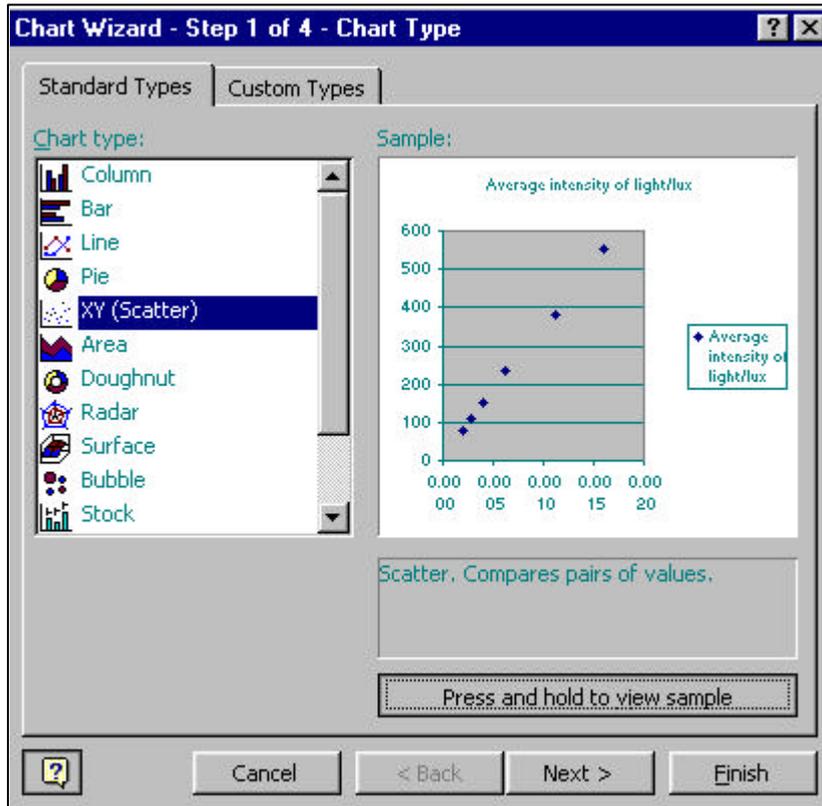
Selecting the chart source data

1.   Press Next > and the Chart Source Data window will appear and look like this.
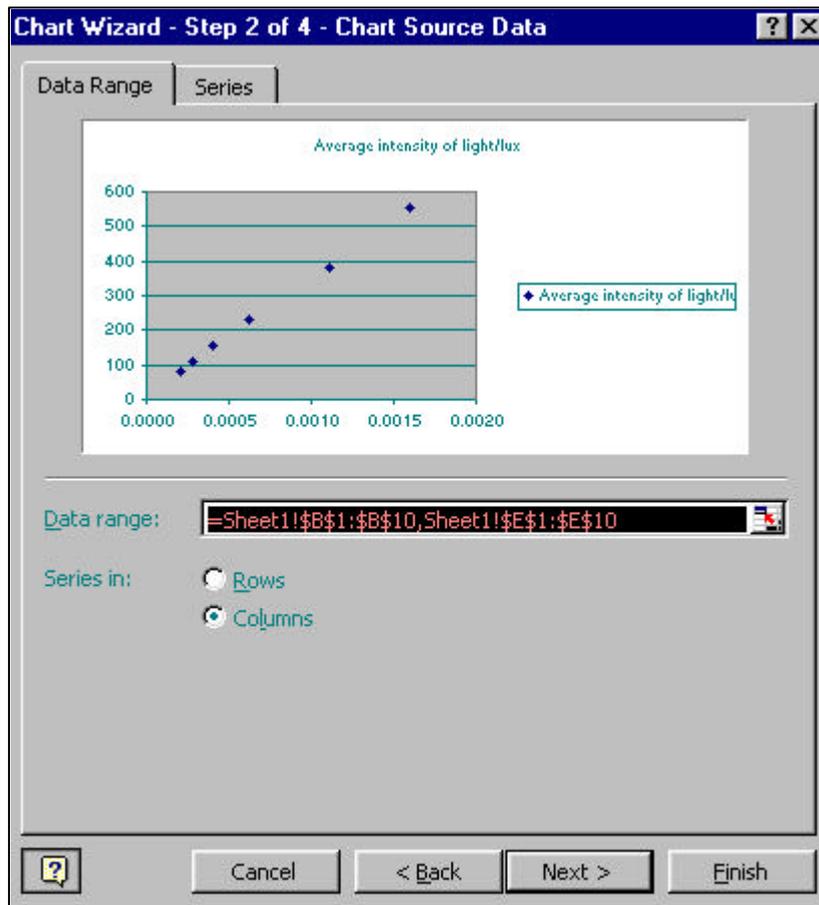
2. Click the mouse onto the dot beside Columns until a black dot appears.

3. Press Next>

Selecting the chart options.

The third page of the Chart Wizard will appear and look like this.
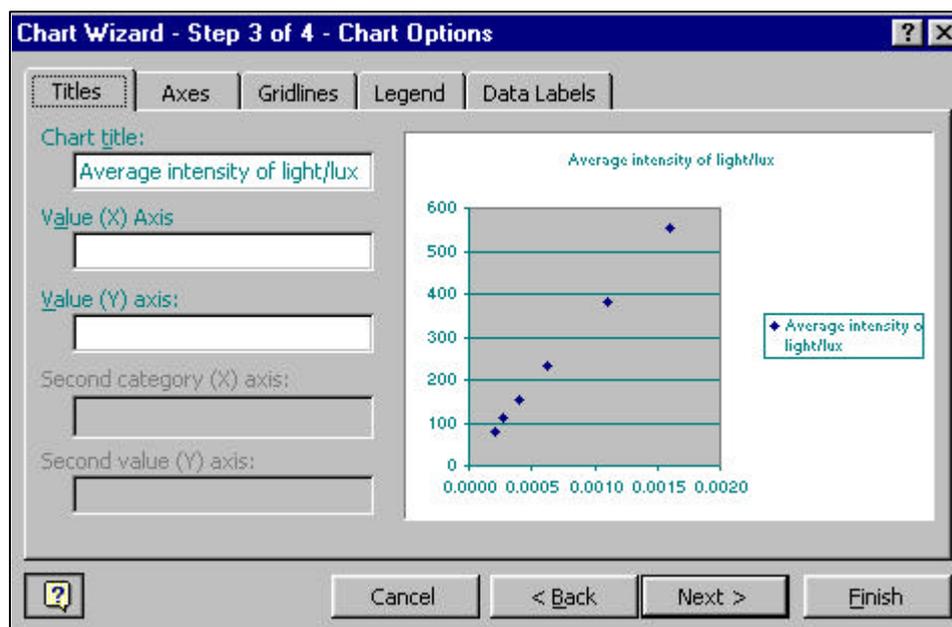
Changing the chart titles.

The Chart Titles window allows the user to input the chart title, the x-axis label and the y-axis label.

1. Click on the Titles tab at the top of the Chart Wizard.
2. In the Chart Title cell, delete the contents and type in Variation of average light intensity with (1/d2). The squared sign will be formatted at a later stage.
3. Click in the Value (X) Axis cell and type in (1/d2)/cm-2. This will be the x-axis label and will be formatted at a later stage.
4. Click in the Value(Y) Axis cell and type in I/lux. This will be the y-axis label.

The Chart Wizard will now look like this.
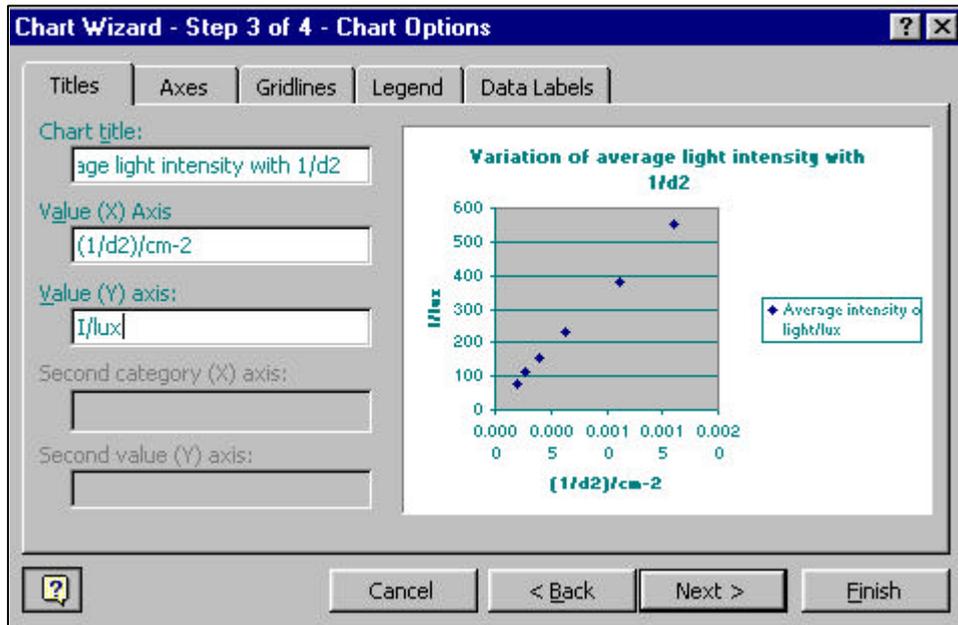
Changing the chart axes.

These options are used to tell Excel to display the scale on the x-axis and the y-axis.

1.   Click on the Axes tab at the top of the Chart Wizard.
2.   Ensure that there is a tick in the Value (X) Axis box.
3.   Ensure that there is a tick in the Value (Y) Axis box.
4.   Check that the Chart Wizard looks like the one below.
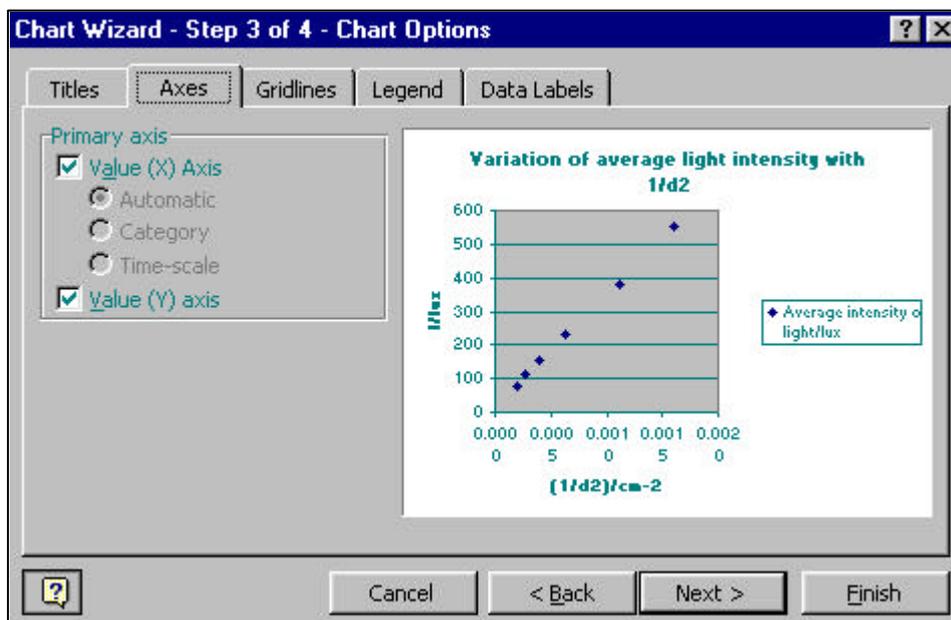
Changing the chart gridlines

There are two types of gridlines on the Chart Wizard.

1.   Major Gridlines
2.   Minor Gridlines

For Example, a scale increases in steps of 10 units with subdivisions every 5 units. If only Major gridlines were chosen then there would be gridlines every 10 units. If Major and Minor gridlines were chosen then there would be gridlines every 5 units. Major gridlines may be used when the user is trying to find a trend, but if any information is to be read off the chart then Minor gridlines must also be shown. In this example Major and Minor gridlines will be applied to both axes.

1.   Click on the Gridlines tab at the top of the Chart Wizard and the following window will appear.
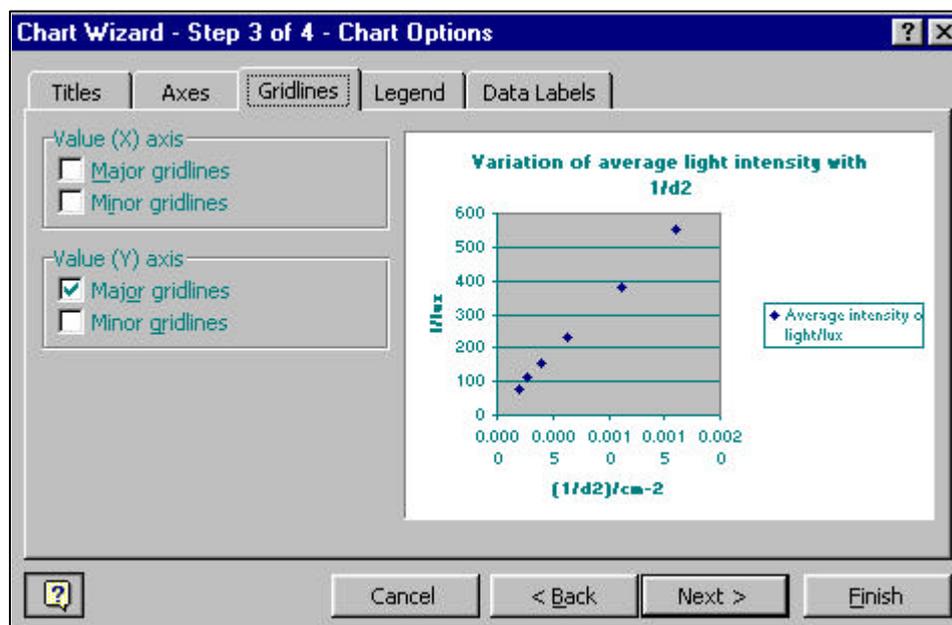
2.   Click the mouse on the box beside the Value(X) Axis Major gridlines.
3.   Click the mouse on the box beside the Value(X) Axis Minor gridlines.
4.   Click the mouse on the box beside the Value(Y) Axis Minor gridlines.

The Chart Wizard will now look like this.
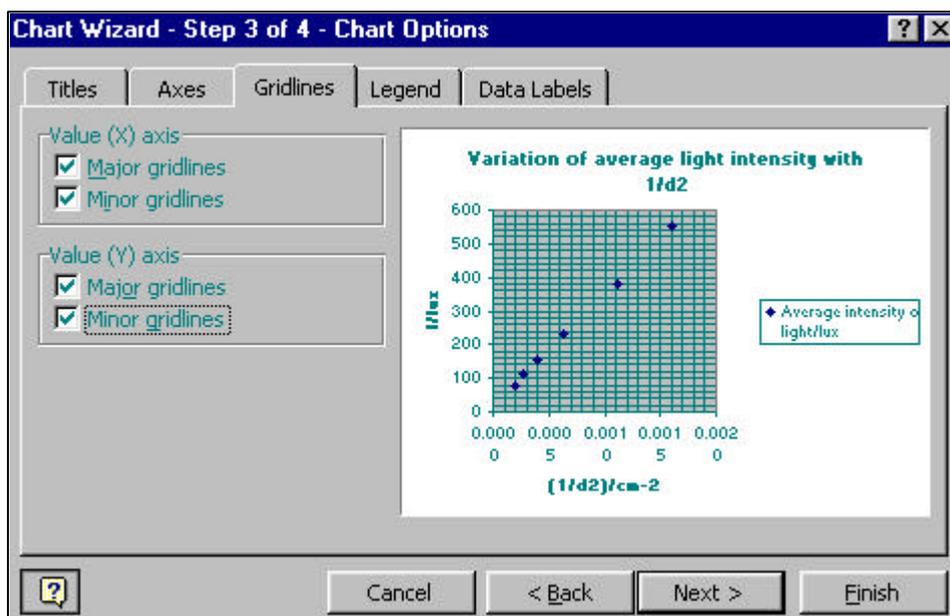
Changing the chart legend

The legend on a chart is similar to a key. It is used to distinguish between sets of data when they are plotted on the same chart. At Higher there will be only one set of data per chart. It is best therefore to remove the legend from the chart. At Intermediate 2 (and Standard Grade), it would be possible to plot cooling curves for different substances on the one chart, using a legend to distinguish between sets of data.

1.   Click on the Legend tab at the top of the Chart Wizard. The Chart Wizard will look like this.
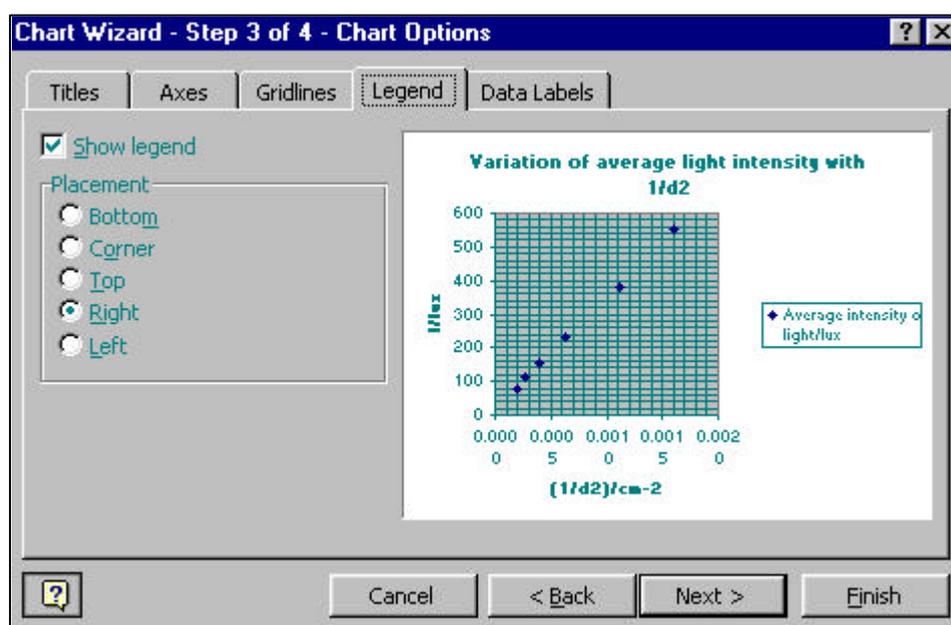
2.   Click on the Show legend box until the tick disappears.
3.   The legend will be removed from the right-hand side of the chart.

The Chart Wizard will now look like this.
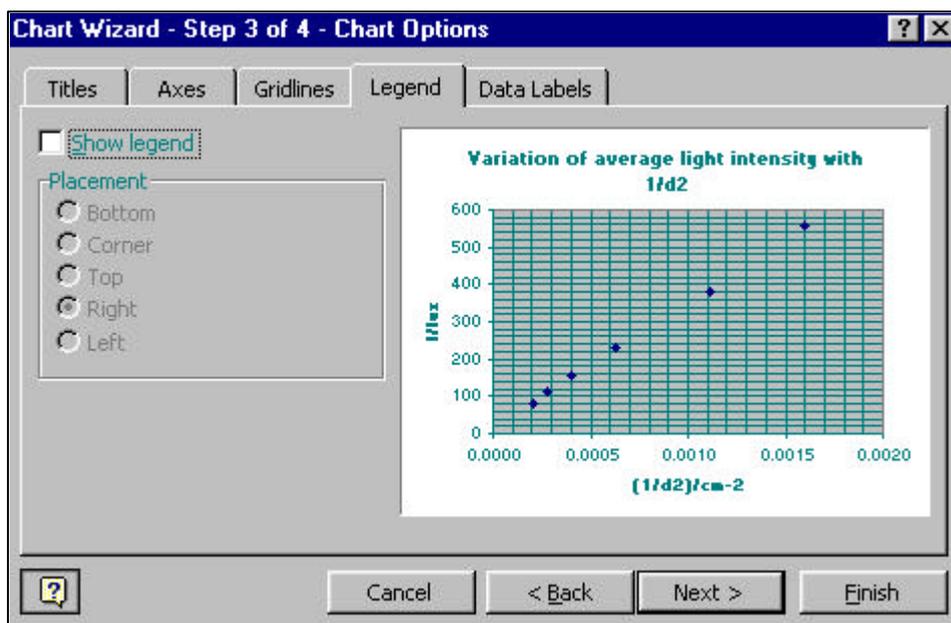
Changing the chart data labels.

The Data labels option allows the user to show the values of each point beside it on the chart. This option is very useful if there are more than one set of data plotted on the same chart. At Higher there will be only one set of data plotted on each chart, so it is best to select None for the data labels.

1.   Click on the Data labels tab at the top of the Chart Wizard.
2.   Ensure that there is a black dot next to None in the Data labels menu.
3.   The Chart Wizard will now look like this.

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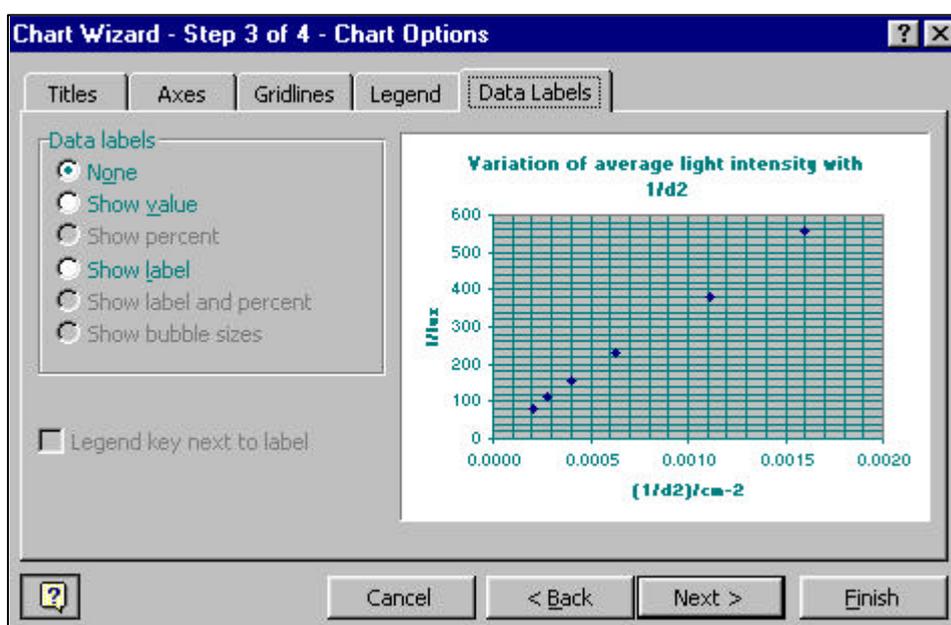
Selecting the chart location.

The Chart Location option allows the user to choose where the chart is to be placed. The chart may be placed on top of the existing spreadsheet or it may be placed onto a sheet of its own. It is best to put the chart onto a new sheet if it is to be imported into a Word document.

1.   Click Next> and the last page of the Chart Wizard will appear.
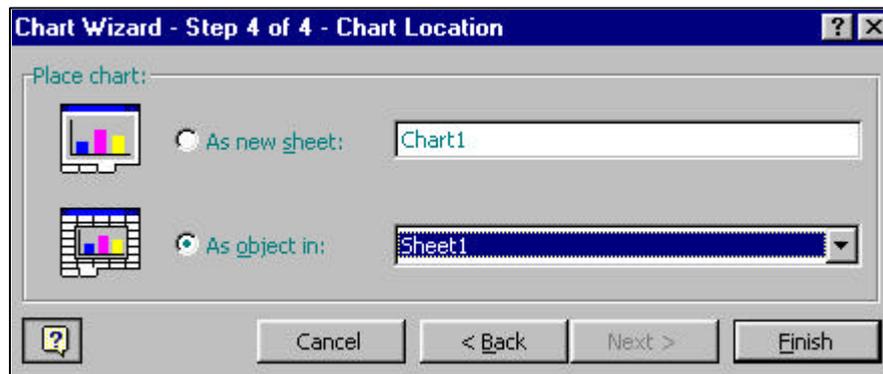
2.   Click on the dot beside "As a new sheet".
3.   Click in the cell beside it and type in the name of the new sheet, Light intensity and distance.
4.   Click on Finish and the graph will appear on a new sheet and look like this.
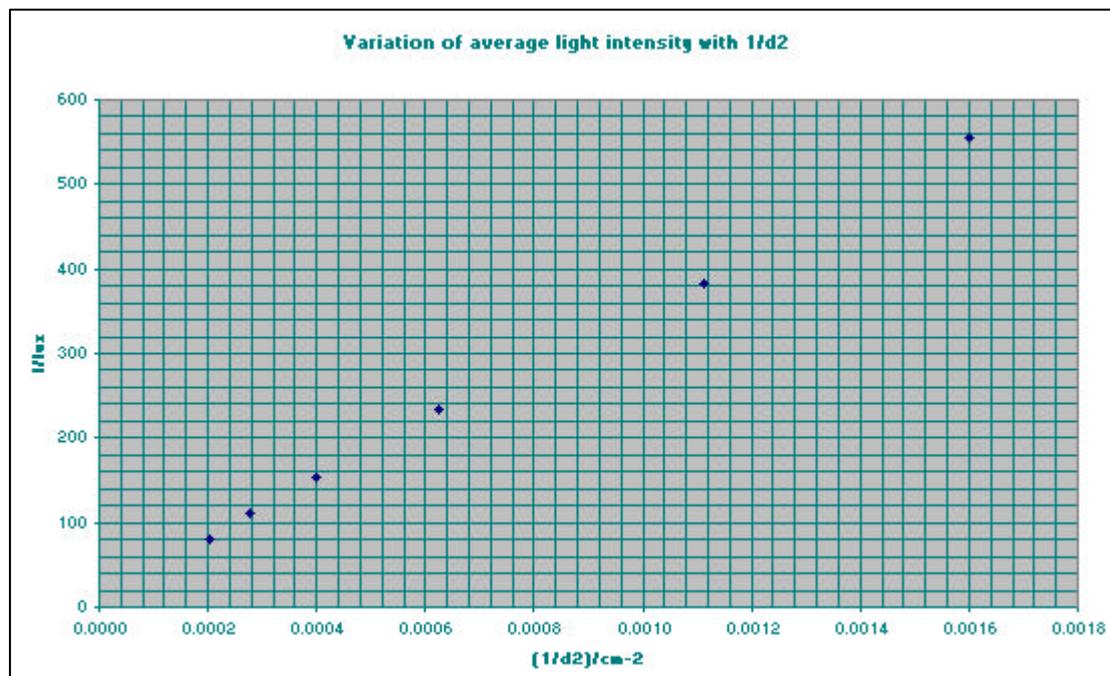
Changing the page set-up.

Excel automatically plots the chart using the Landscape page set-up. This results in a long x-axis and a short y-axis. In some situations it may be advantageous to have the chart set-up so that the x-axis is short and the y-axis is long. This is easily changed.

1.   Go to File on the Menu bar.
2.   Choose Page Setup and the Page Setup window will appear.
3.   Click on the Page tab at the top of the Page Setup window.
4.   Click on the white dot beside Portrait until the dot turns from white to black.
5.   Check that the Page Setup window looks like the one shown below.
6.   Click on OK and the chart will now be presented in Portrait, like the one shown on the next page.

The chart in this example is best plotted with a long x-axis.

7.   Go to file on the Menu bar, choose Page Setup and click on the Page tab.
8.   Click on the dot beside Landscape, then click OK and the chart will return to its previous form.

Variation of average light intensity with 1/d2
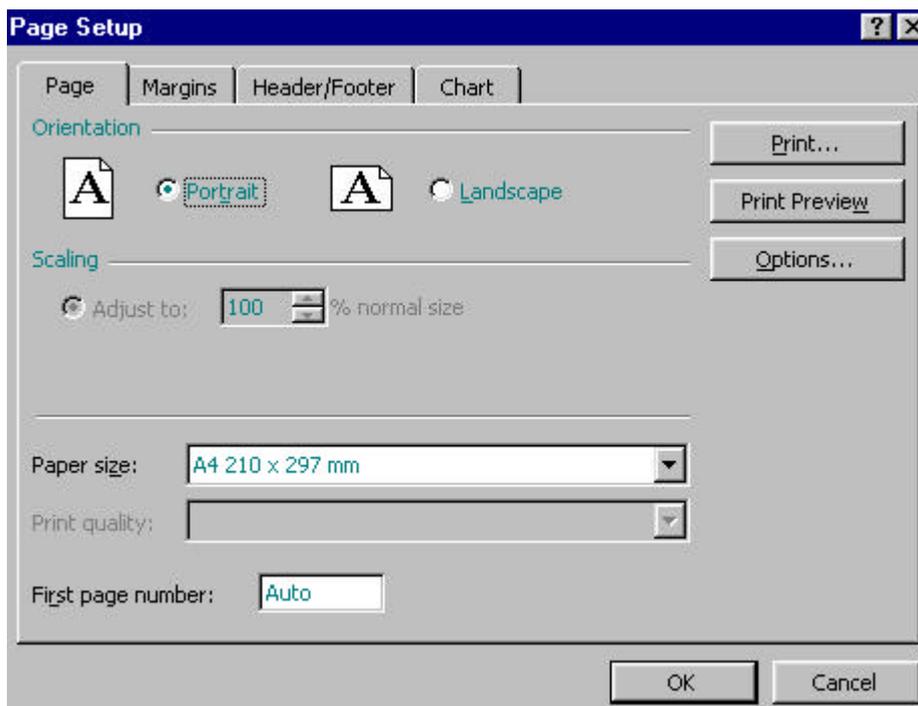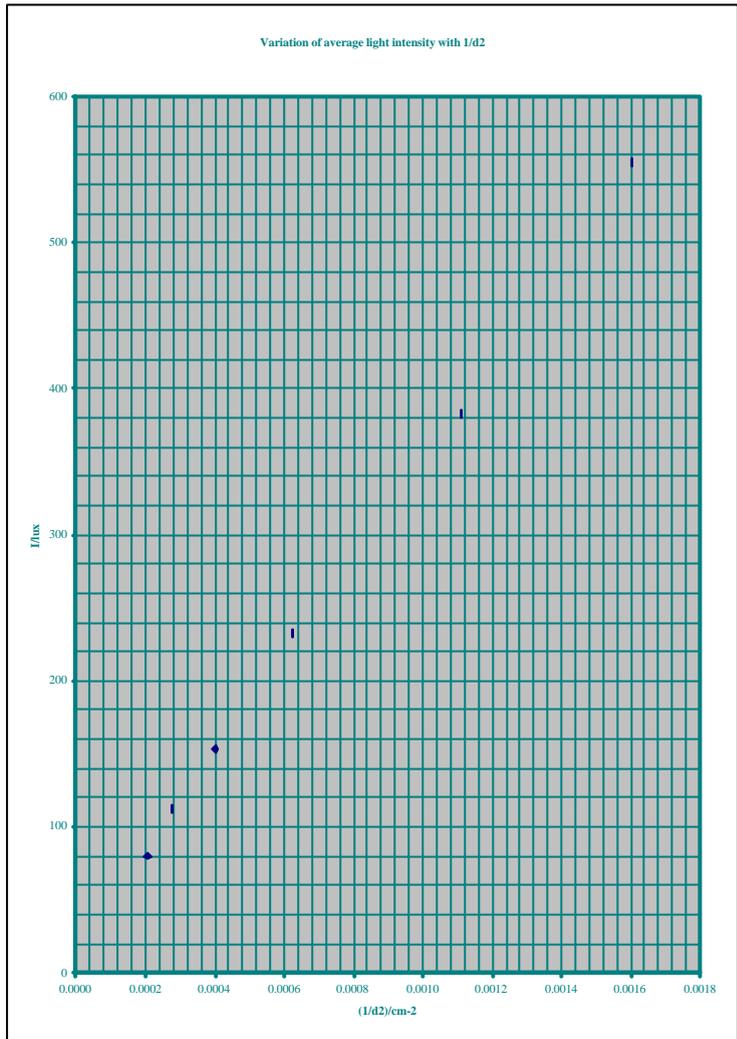
EDITING A CHART

Editing the axes

1.   Double click on the x-axis of the chart. The Format Axis window will appear.
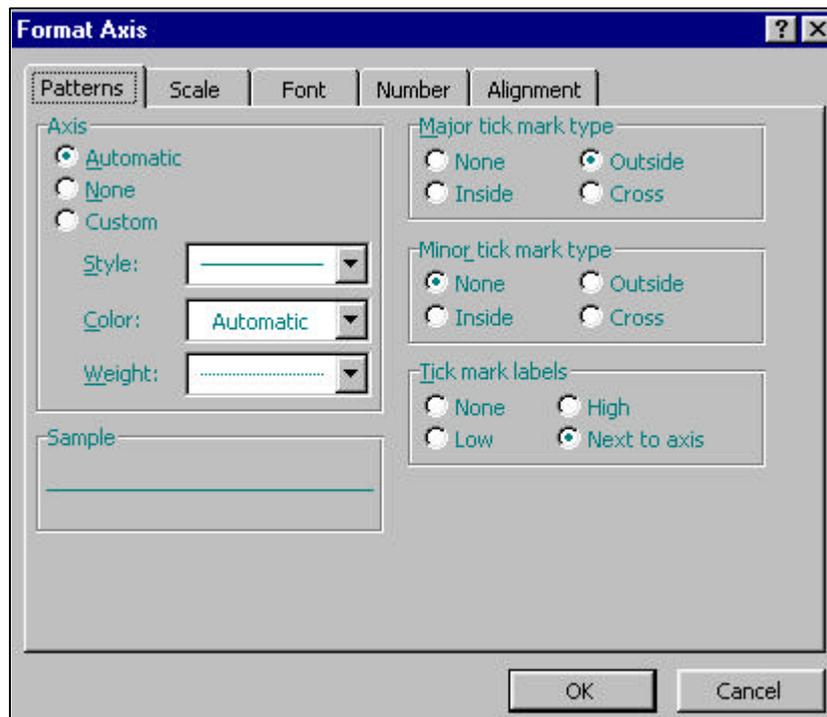
Editing the axis pattern

The line selected by Excel to draw the x-axis is not thick enough. The thickness of the x-axis may be edited by following the instructions given below. It is best not to change the colour of the lines as most printers are only fitted with black ink cartridges and no extra marks will be awarded for colourful charts.

1.   Click on the Patterns tab at the top of the Format Axis window.
2.   Click on the Custom dot in the Axis options.
3.   Drag the Weight menu down and click on the third line down.

The chart needs to have tick marks at the Major gridlines on the axis. The chart is much more legible if there are no Minor tick marks on the axis. To add only Major tick marks

4.   Go to the Major tick mark options. Click on the dot beside Outside. The dot will turn from white to black.
5.   Go to the Minor tick mark options. Click on the dot beside None. The dot will turn from white to black.

There must be a scale on the axis. Excel will draw a scale on the axis if these instructions are followed.

6.   Go to the Tick mark labels options and click on the dot beside Next to Axis.

7.   Check that the Format Axis window looks like the one below.
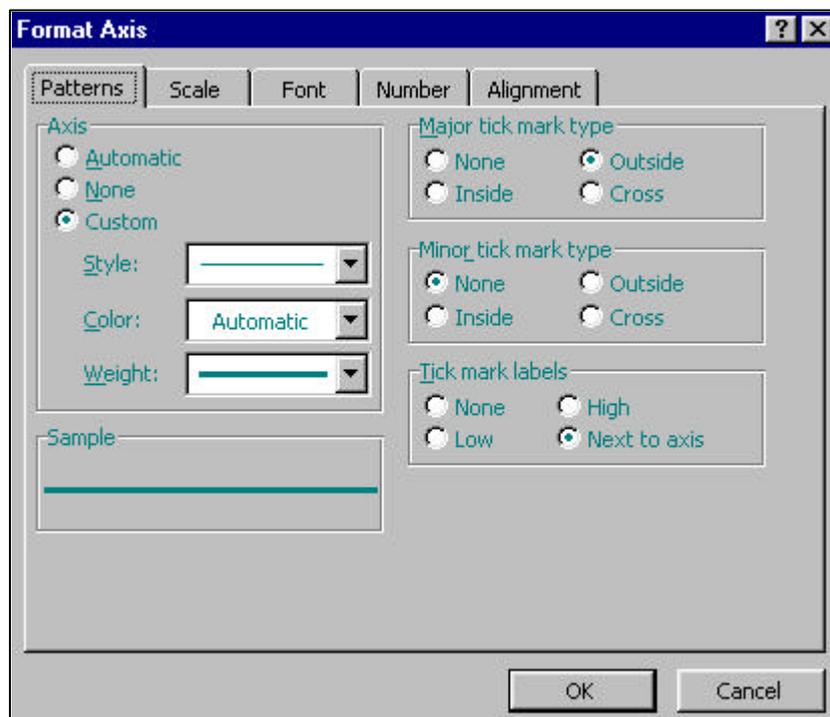
8.   Click on OK and the x-axis will change.

9.   Double click on the y-axis.

10.   Repeat steps 1 to 9.

11.   Click on OK and the y-axis will change.

The chart will now look like this.
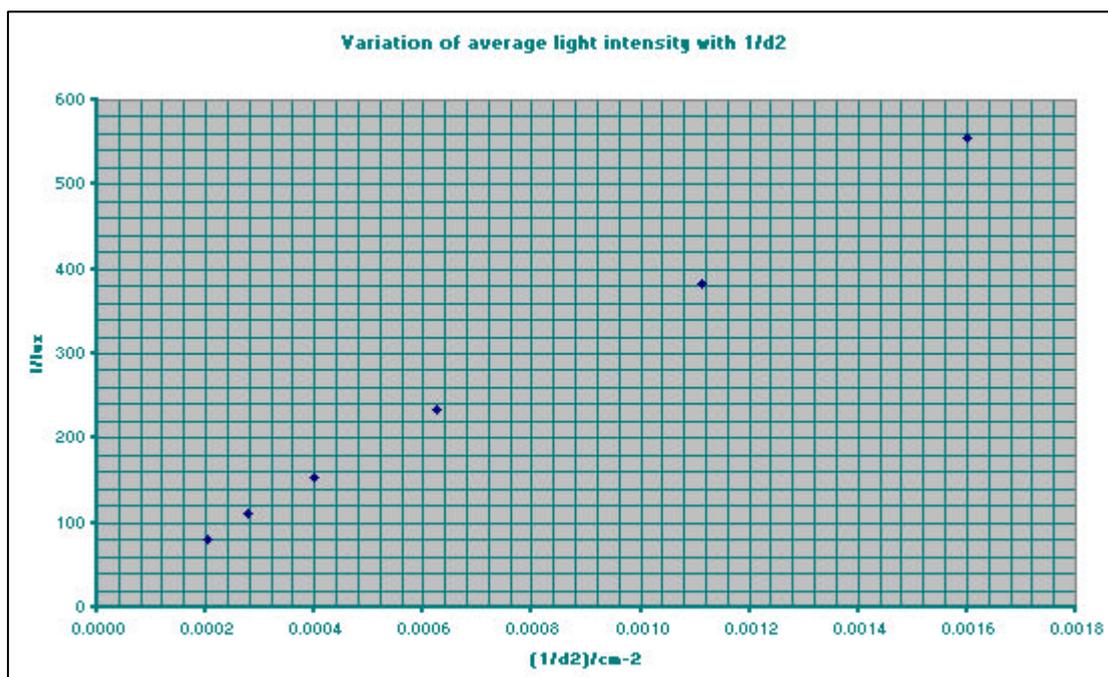

Editing the axis scale

The Format Axis Scale options allow the user to do the following:

- leave Excel to automatically choose the scale on the axis
- set the scale on the axis by setting Maximum and Minimum values, and the size of the Major and Minor units.

The Value (Y) axis crosses at, Logarithmic Scale, Values in reverse order, and values (Y) axis crosses at maximum value options are not needed at Higher. The Logarithmic scale may be useful to students studying Advanced Higher. Excel allows the x-axis, y-axis, or both axes to have a logarithmic scale.

1.   Double Click on the x-axis and the Format Axis window will appear.
2.   Click on the Scale tab at the top of the Format Axis window.

The Format Axis window will look like this.
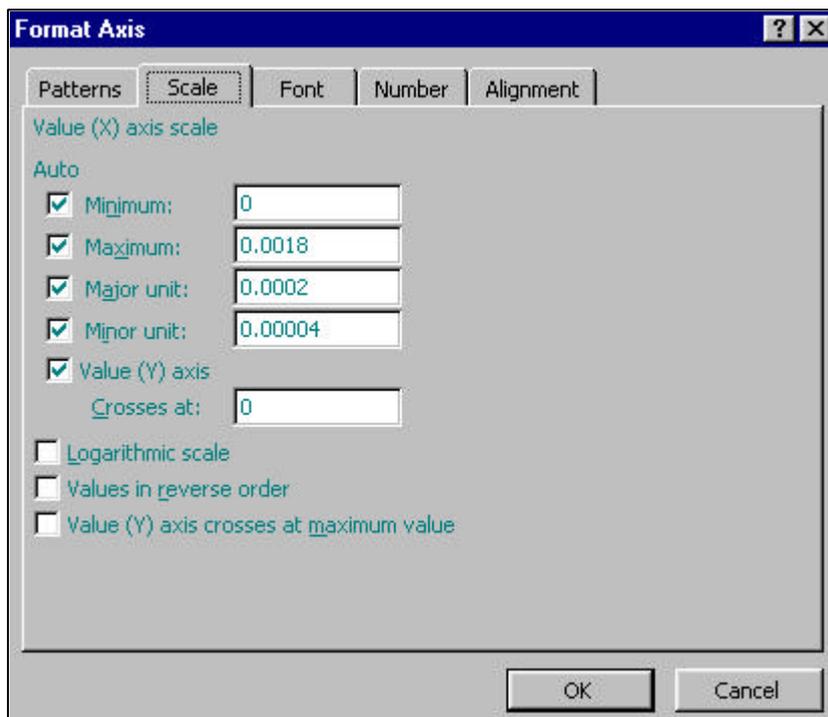
Excel has automatically chosen the scale. The Format Axis Scale options allow the user to change the scale. In this example the scale will be easier to read if the values are edited to show the x-axis scale beginning at 0.0000 and ending at 0.0020 with Major steps of 0.0005 and Minor steps of 0.0001. The minimum is already set to 0 so there is no need to change it.

1.   Click on the long white cell beside Maximum.
2.   Delete the contents and type in the new value of 0.0020.
3.   Click on the long white cell beside Major Unit.
4.   Delete the contents and type in the new value of 0.0005.
5.   Click on the long white cell beside Minor Unit.
6.   Delete the contents and type in the new value of 0.0001.
7.   Check that the Format Axis window looks like the one below.
8.   Click on OK and the chart will change to show the one below.
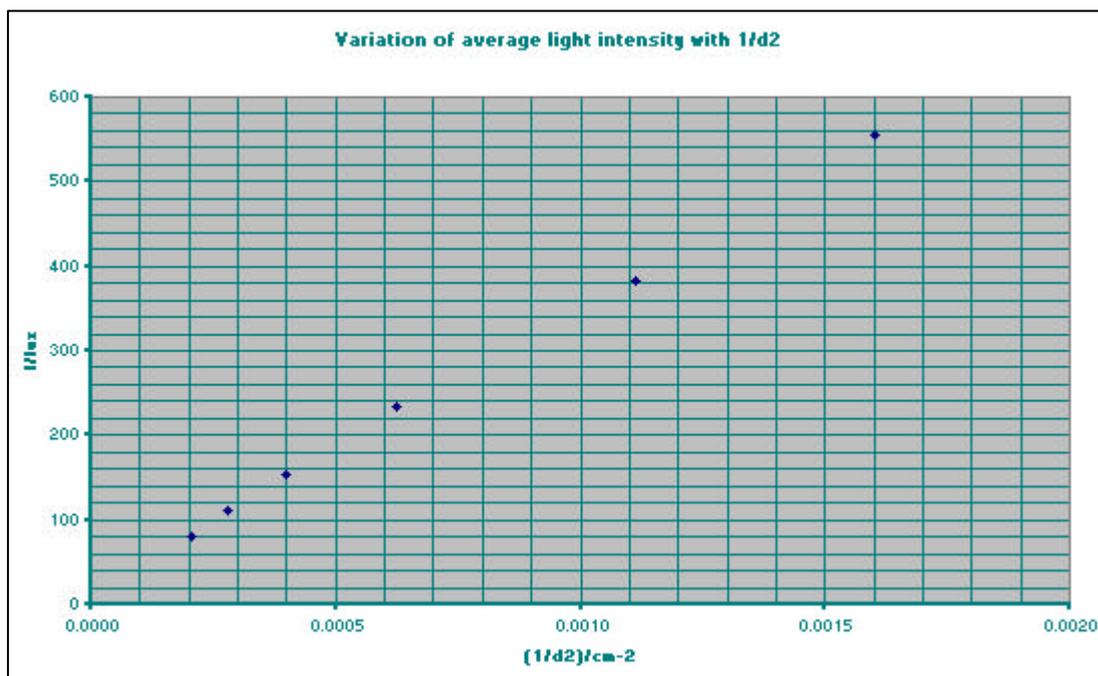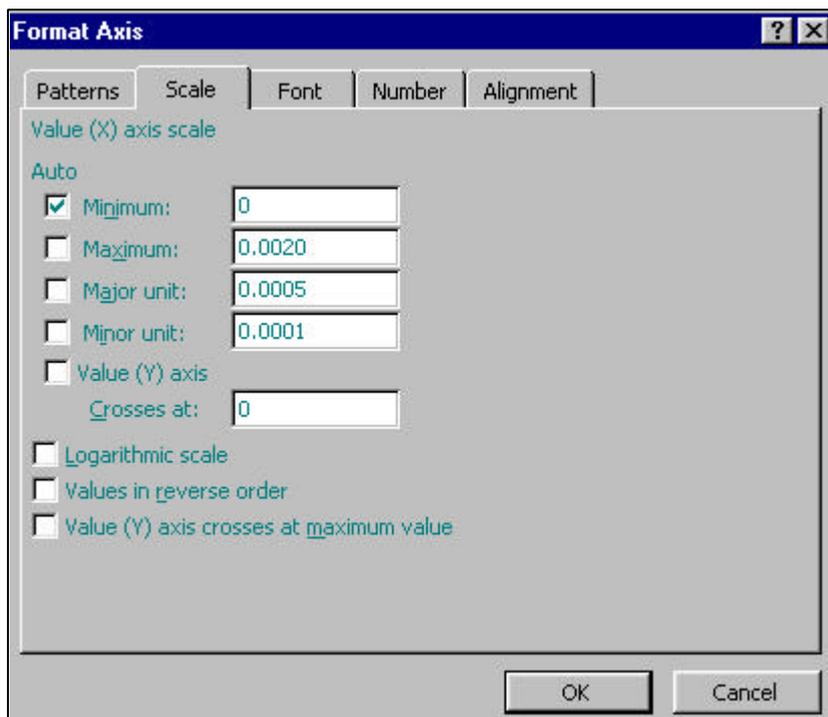
The scale on the y-axis is changed using the same method.

1. Double click on the y-axis to reveal the Format Axis window.
2. Click on the Scale tab.
3. Set the Minimum to 0
4. Set the Maximum to 600
5. Set the Major unit to 50
6. Set the Minor unit to 25
7. Check that the Format Axis window will look like the one below.
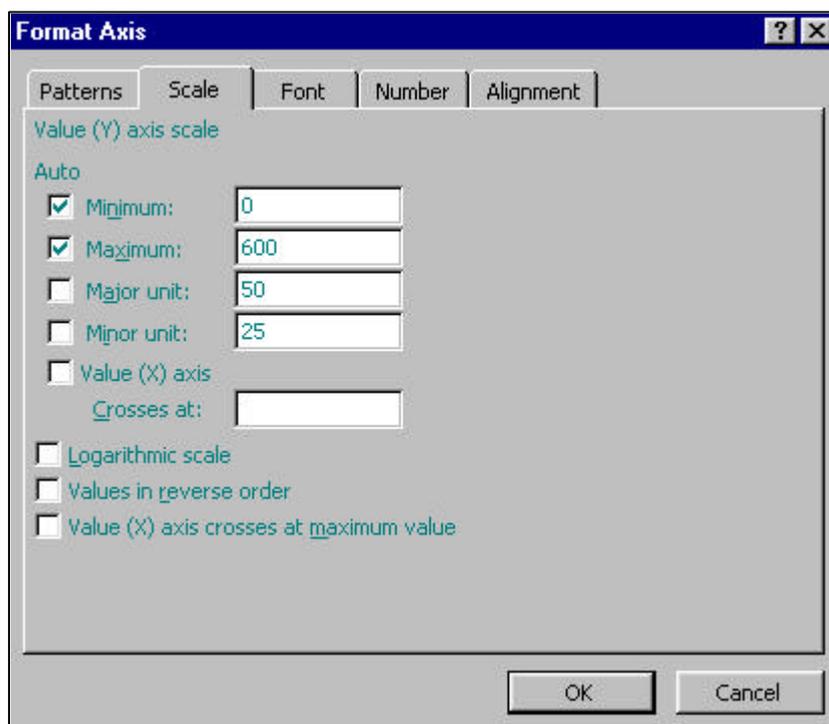
8. Click on OK and the chart will change and look like this.
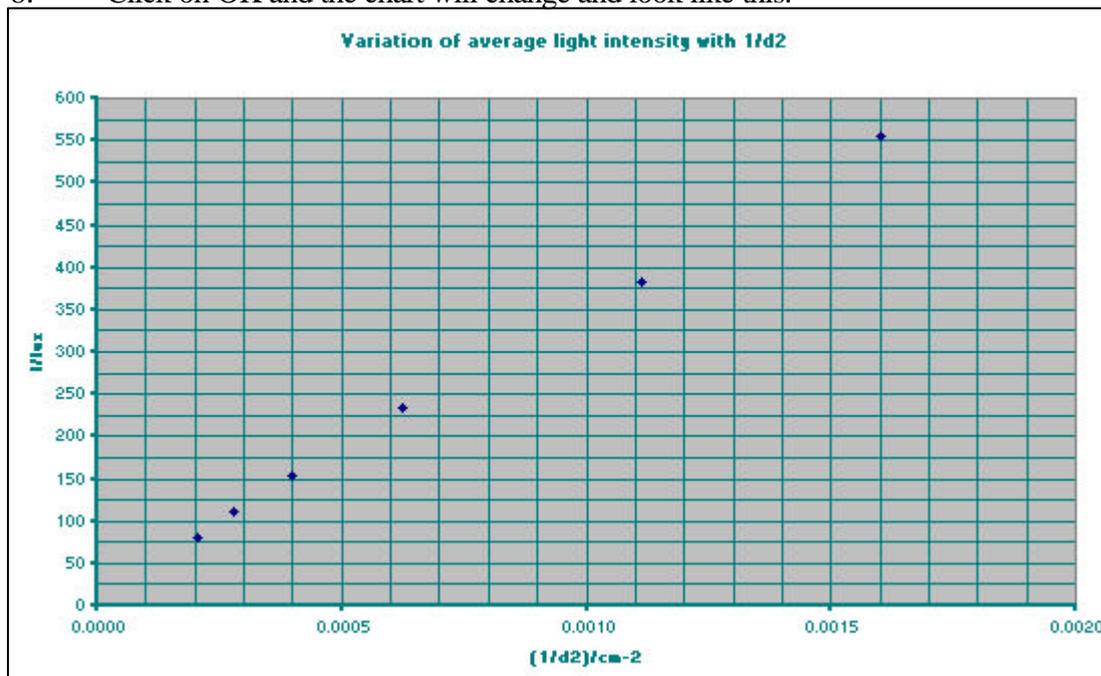
Editing the axis font.

The Format Axis Fonts options allow the user to change the font used for the scale on each axis. When there are long numbers used on the scale, the numbers will overlap each other. By reducing the size of the font, the numbers may be made to fit onto the axis.

If the chart is to be included in a Word document, all of the fonts used on the chart should be the same as that used in the document. The font chosen must have the True Type (see below) symbol beside it. This means that the font printed by the printer will be the same as the font seen on the screen. If a non-TT font is chosen there is no guarantee that the font will be printed the way it is shown on the screen.

True Type font symbol
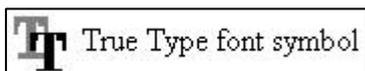
It is best to choose Regular for the font type. If Bold is chosen the font will be illegible when it is set to size 10. The smallest legible regular type font size is size 10.

The Underline option allows the font to be underlined. The colour and background options allow the font colour and font background colour to be changed. These should be left at Automatic (Non-underlined, Black font on a White background) as these are the standard settings for all levels of Physics.

1.   Double click on the x-axis.
2.   Click on the Font tab at the top of the window.
3.   Choose Times New Roman from the Font menu.
4.   Choose Regular from the Font Type menu.
5.   Choose 10 from the size menu.
6.   Check that the Format Axis Font window looks like the one shown below.
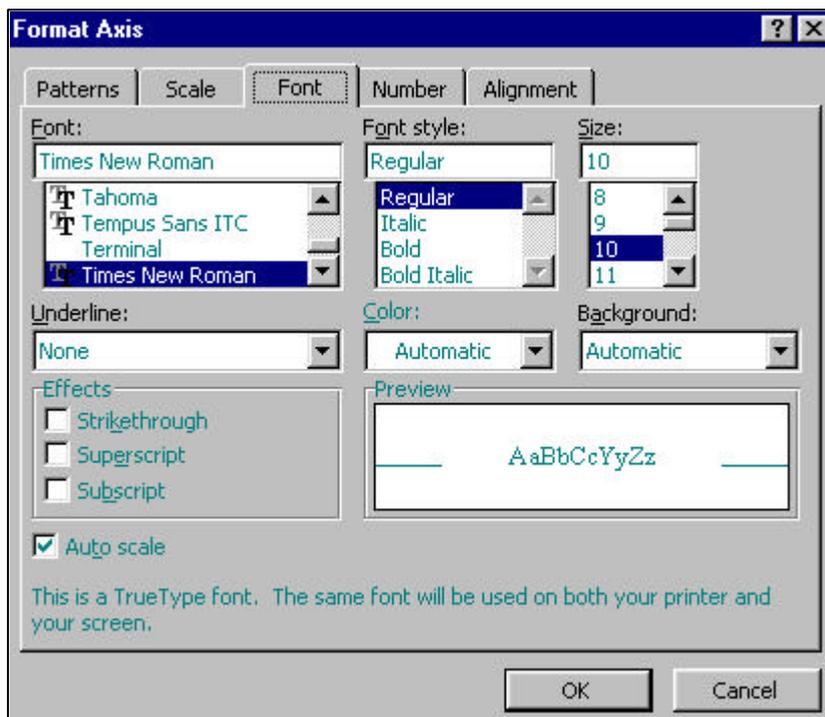
7.   Click on OK and the font on the x-axis will change.
8.   Double click on the y-axis.
9.   Click on the Font tab at the top of the Format Axis window.
10. Repeat steps 1 to 4.
11. Click on OK.

The chart will now look like this.
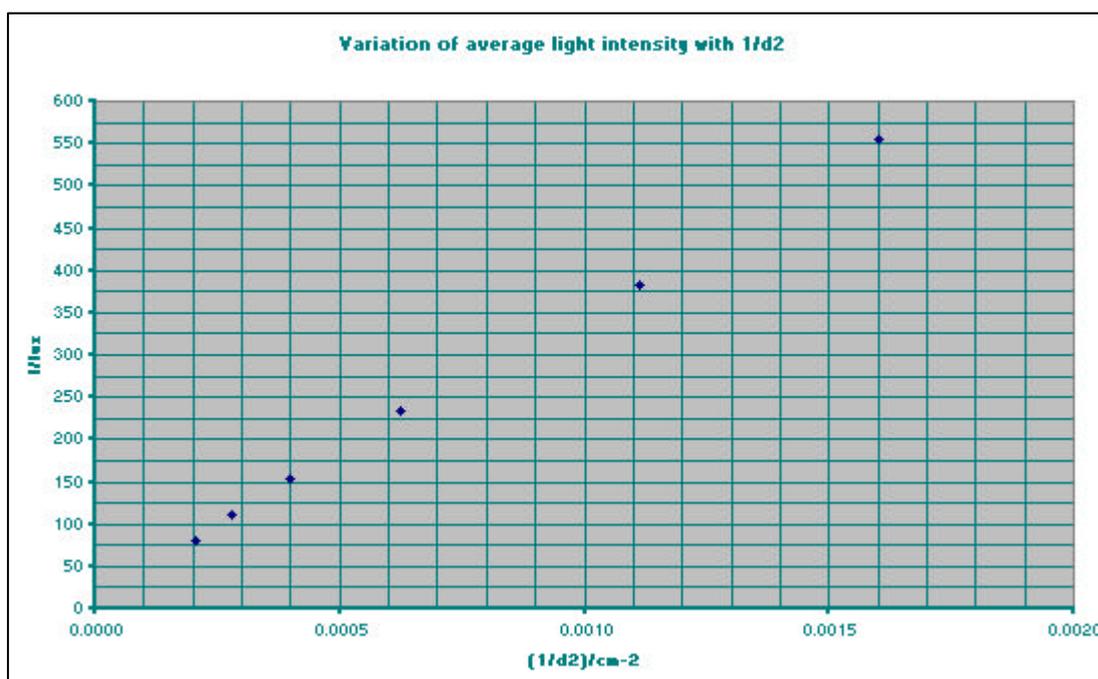
Editing the axis numbers.

The Format Axis Numbers options allow the user to change the format of the numbers on the chart axes. It is identical to the one used to format numbers on the spreadsheets. The numbers on the x-axis and the y-axis have already been formatted.

1.   Double click on the x-axis.
2.   Click on the Number tab at the top of the Format Axis window. The Format Axis Number window will appear and look like the one shown below.
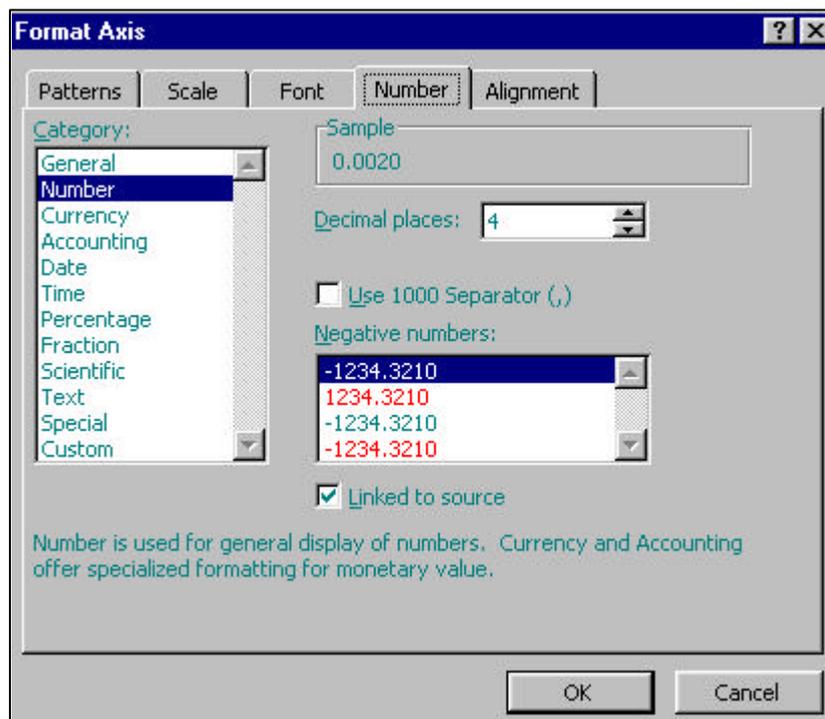
3.   Click on OK.

Editing the axis alignment.

The Format Axis Alignment options allow the user to change the alignment of the text on the axes. When the user has opted to display numbers at the Major ticks and the Minor ticks, there may be a problem with the text overlapping. In order to avoid overlapping the text, the font size may be reduced as above but the Format Axis Alignment option allows the user to align the numbers on the axis at an angle instead of the default Horizontal position. When the top diamond in the alignment window is clicked, the numbers are rotated 90 degrees anti-clockwise. This eliminates the overlap problem. If the scale has been chosen with care, as in this example, then this option should not be needed.

1.   Double click on the x-axis.
2.   Click on the Alignment tab at the top of the Format Axis window.
3.   Check that the Format Axis Alignment window looks like the one below.
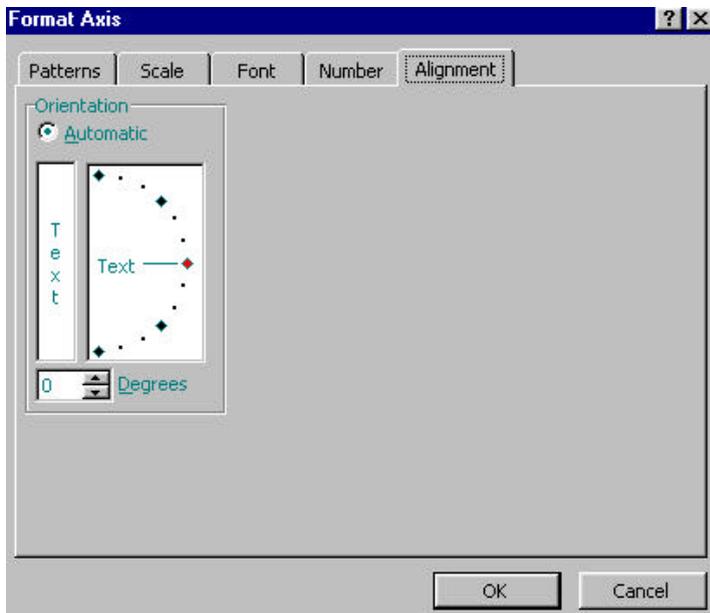
4.   Click OK.

Editing the axis title.

In this example the x-axis title font needs to be formatted to match the font used for the x-axis scale.

1.   Double click on the x-axis title (1/d2)/cm-2.
2.   Click on the Font tab at the top of the Format Axis Title Window.
3.   In the font cell select Times New Roman.
4.   In the Font style cell select Regular.
5.   In the Size cell select 12.
6.   Check that the Format Axis Title window looks like the one below.
7.   Click on OK and the x-axis title will change.
8.   Double click on the y-axis title I/lux.
9.   Repeat steps 3 to 7.
10.   Click on OK.

The chart will now look like the one below.
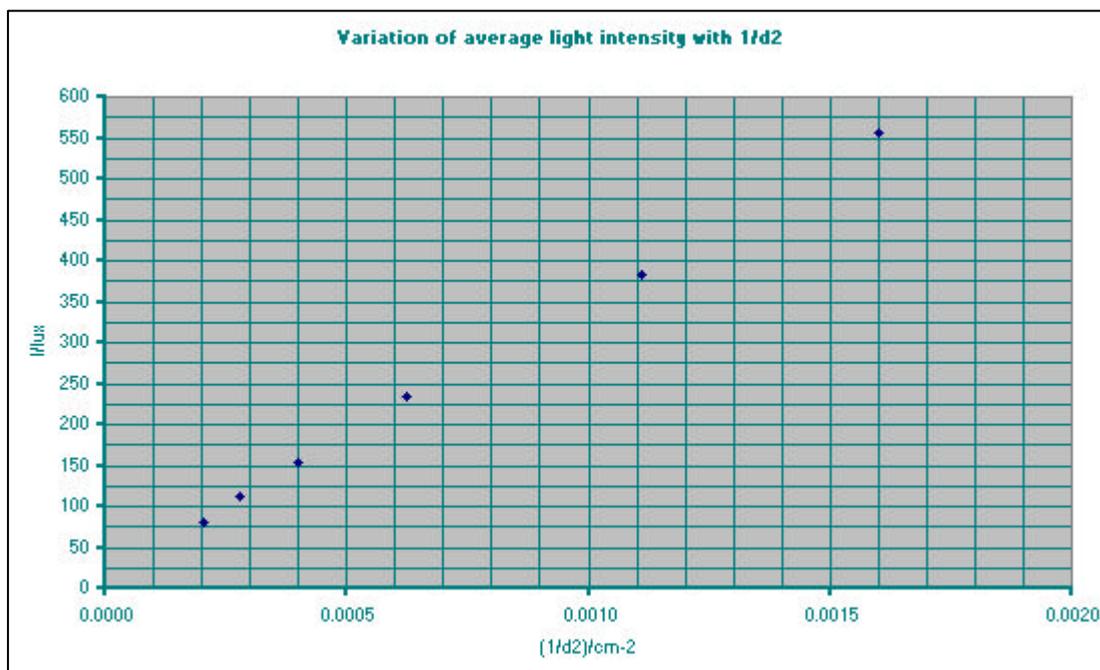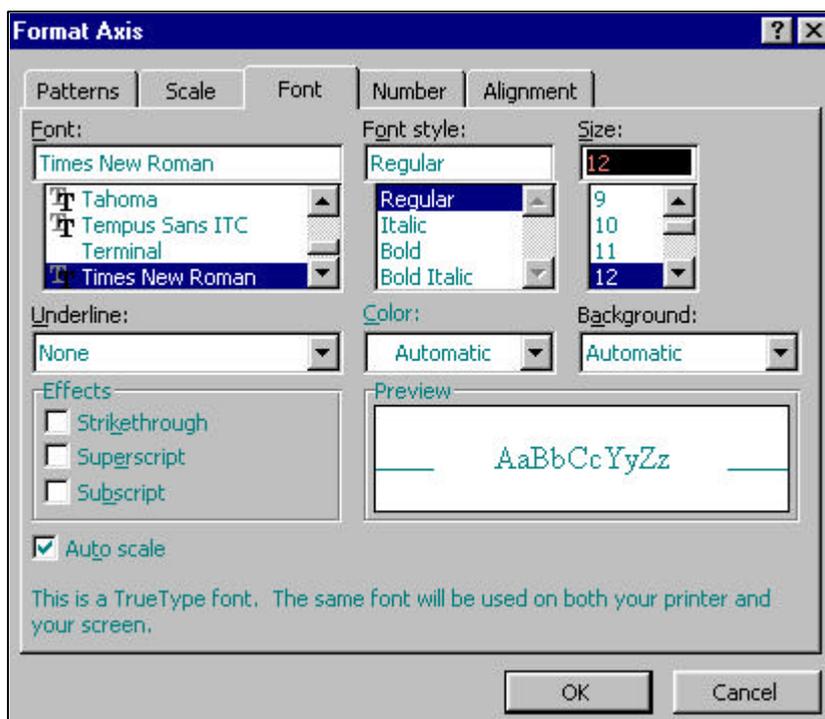
The x-axis title must be formatted to read $(1/d^2)/cm^{-2}$.

1. Single click on the (1/d2)/cm-2. It will now have a grey border.
2. Drag the mouse over the first 2 to highlight it in black. The grey border will disappear.
3. Go to Format on the Menu bar.
4. Click on Selected Axis Title.
5. The Format Axis Title Font window will appear.
6. Click in the box beside Superscript. A tick will appear.
7. Click on OK and the title will now read $(1/d^2)/cm-2$.
8. Single click on the title and it will gain a grey border.
9. Drag the mouse over the –2 to highlight them.
10. Repeat steps 3 to 6.
11. Click OK and the title will now read $(1/d^2)/cm^{-2}$

The Chart will now look like this.
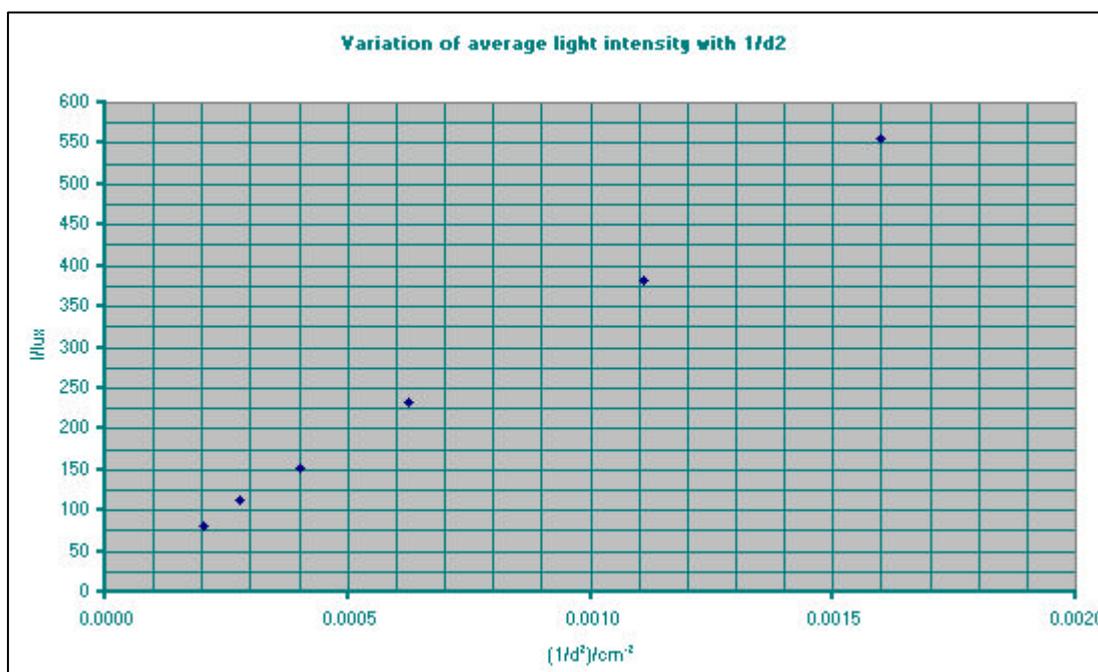
The underline, colour, and background options allow the user to underline the axis title, change its colour and change the colour of its background. The default setting for this is non-underlined black text on a white background. These settings should not be changed at any level of Physics.

The Patterns tab at the top of the format Axis Title window allows the user to place a border around the axis title and to colour the border and background. This is not required at any level of Physics.

The Alignment tab at the top of the Format Axis Title window allows the user to change the alignment of the axis title. The default setting is for the x-axis title to be aligned horizontally and the y-axis title to be aligned vertically. These are the standard alignments used in Physics and should not be changed

Editing the chart title

The chart title font must be changed to Times New Roman to match the rest of the text on the chart. As it is a title, the size of the font will also be slightly increased.

1.   Double click on the chart title, Variation of average light intensity with 1/d2.
2.   Click on the Font tab at the top of the Format Chart Title window and the following window will appear.
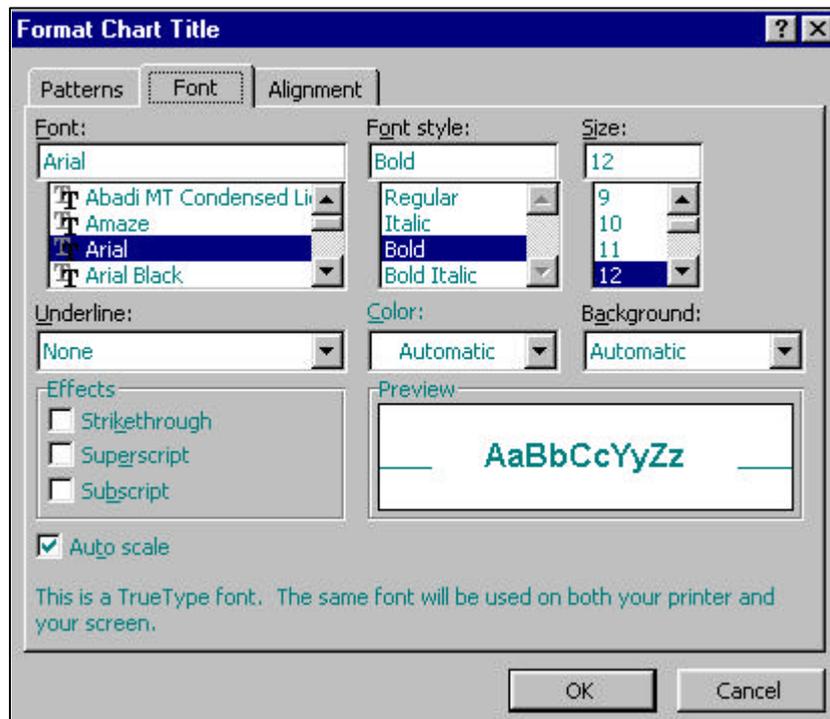
3.   Select Times New Roman from the Font options.
4.   Select Regular from the Font Style options.
5.   Select 14 from the Size options
6.   Click OK and the chart will look like this.

Variation of average light intensity with 1/d2
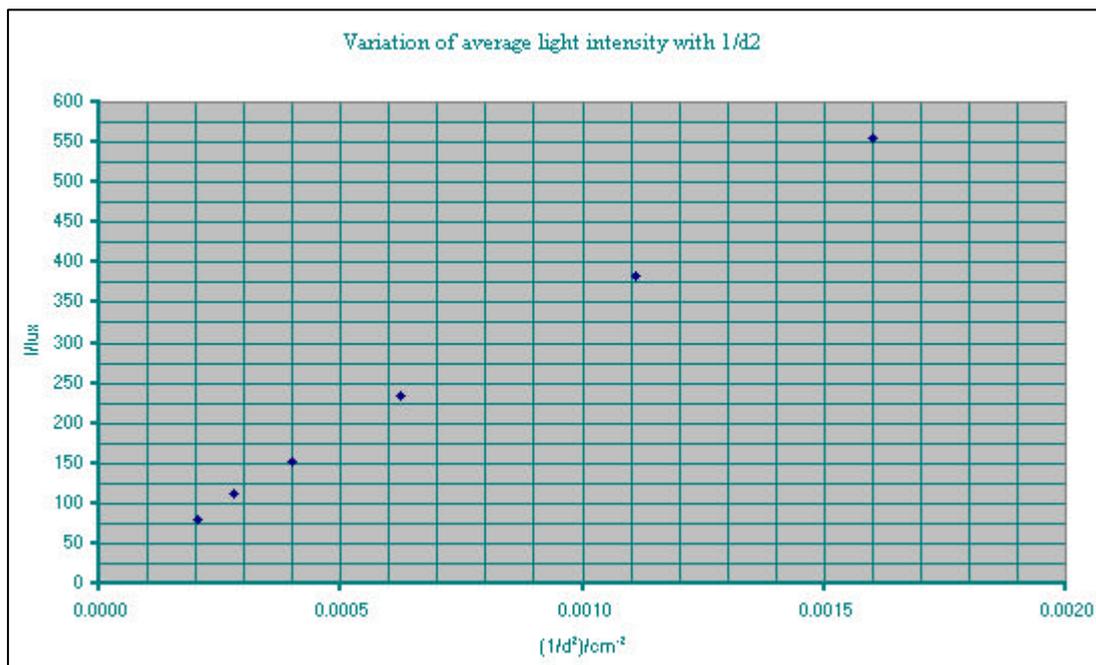
The 1/d2 must be formatted.

1.   Single click on the chart title.
2.   The title will now have a grey border.
3.   Use the cursor to highlight the 2.
4.   Go to Format on the Menu bar.
5.   Click on Selected Chart Title.
6.   The Format Chart Title window will appear.
7.   Click on the box beside Superscript and a tick will appear.
8.   Click on OK and the chart will look like this.

Variation of average light intensity with $1/d^2$
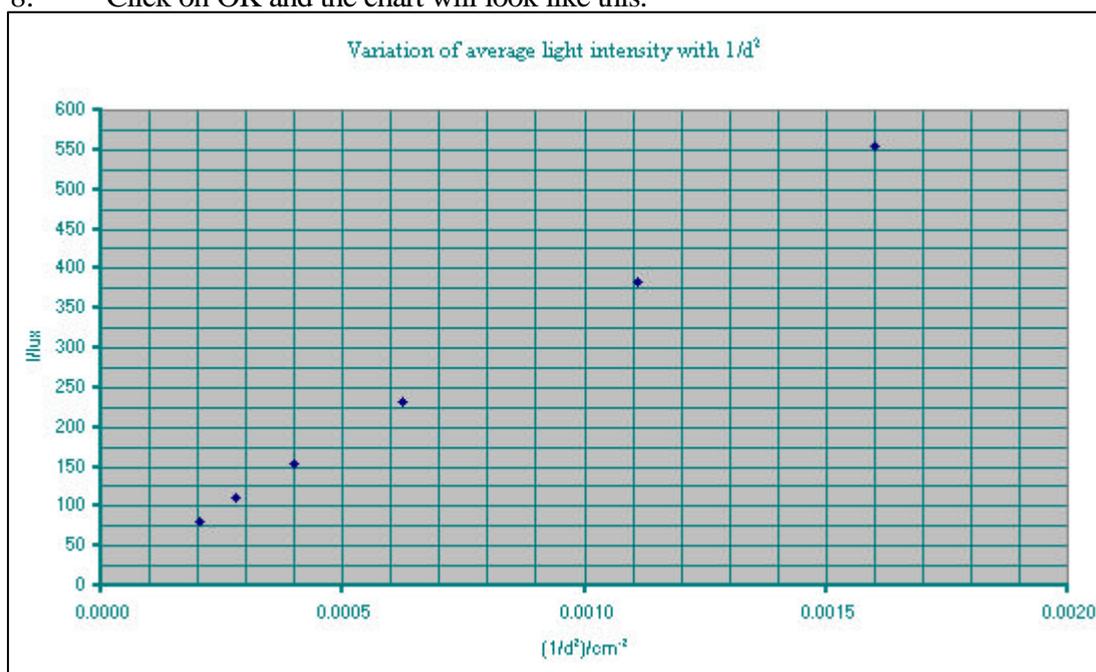
Editing the data series.

The Format Data Series Patterns window allows the user to change the style, colour and size of the markers on the chart. The diagonal cross and the vertical cross are the only markers in Excel that allow the position of the point to be accurately plotted. They are only available when the Background colour is set to No Colour. If more than one set of data are plotted on the same chart it is possible to change the colour of the crosses for each data set by changing the Foreground colour. This is not required at Higher, although may be used at Intermediate 2 for cooling curves or at Advanced Higher.

1.   Double click on one of the data points.
2.   The Format Data Series window will appear.
3.   Click on the Patterns tab at the top of the window.
4.   Go to the Marker options and click on the dot beside Custom.
5.   Choose Black for the Foreground colour (top left-hand colour on the pallet).
6.   Choose No Colour for the Background colour.
7.   Choose X for the Style.
8.   Go to Size. Use the up arrow to increase the size to 10.
9.   Check that the Format Data Series window looks like the one shown on the next page.
10.   Click on OK and the markers will have changed from blue diamonds to black X's.
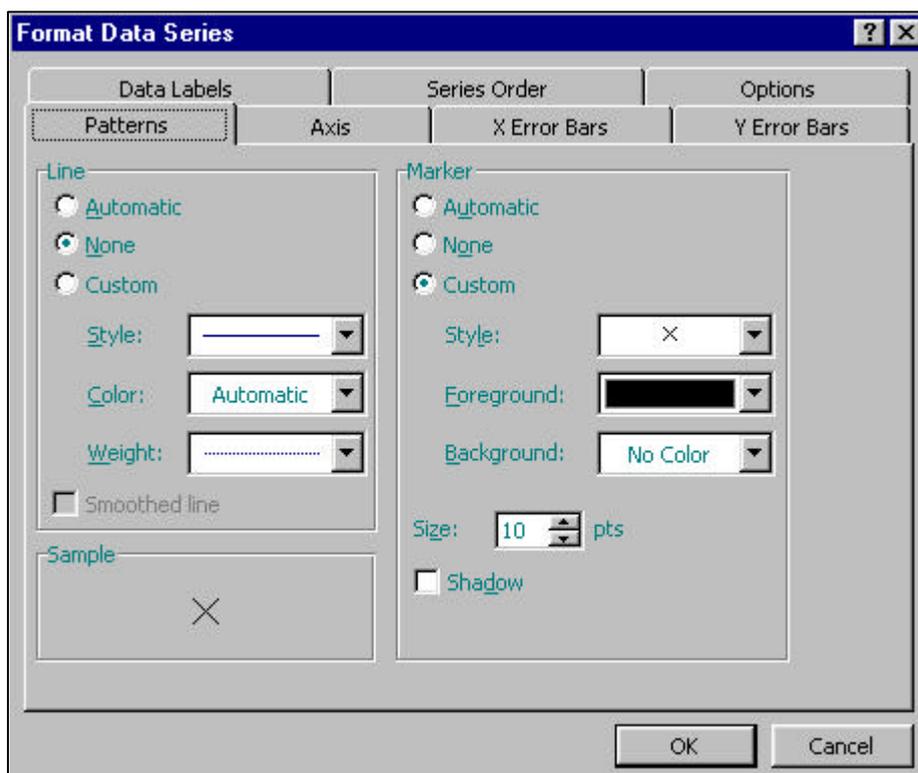
The chart will now look like the one on the next page. In order to include the chart within an Outcome 3 report, the student must now print the chart and hand draw a best-fit line onto the chart.

It will take a novice about 30 minutes to go through all of the instructions in the previous three sections, but with practice, it is possible to enter and analyse the data, plot and edit the chart within about 5 minutes.

Variation of average light intensity with $1/d^2$
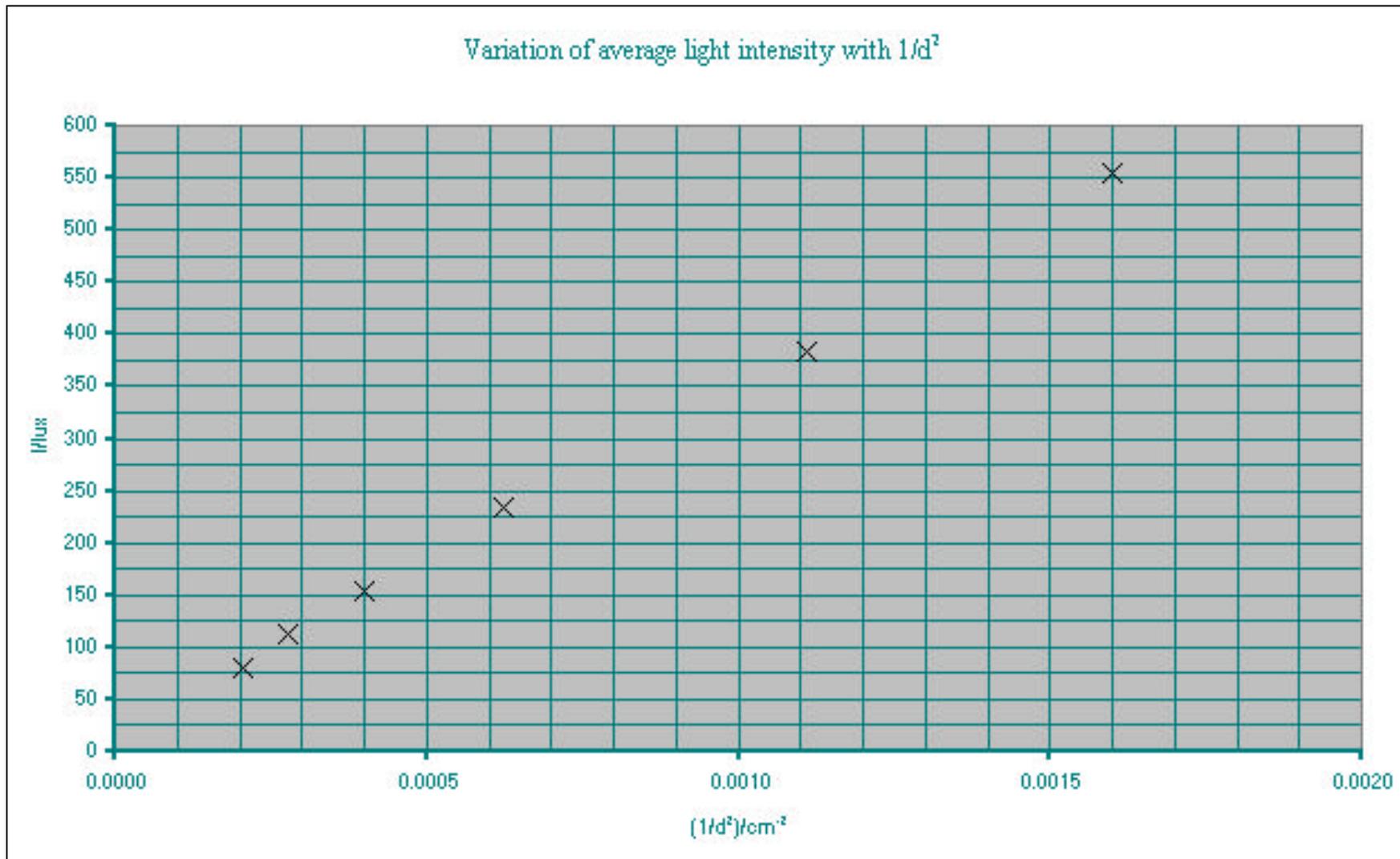
HANDLING UNCERTAINTIES.

Formatting a spreadsheet to handle uncertainties.

The spreadsheet shown below shows a set of student results taken to calculate the half-value thickness of lead for gamma radiation from a ^{60}Co source.

	A	B	C	D	E	F
1	Thickness of lead/mm	Uncorrected count rate/counts per minute	Uncorrected count rate/counts per minute	Uncorrected count rate/counts per minute	Uncorrected count rate/counts per minute	Uncorrected count rate/counts per minute
2	0	816	854	893	831	874
3	6	532	511	522	518	527
4	12	390	392	406	395	399
5	18	315	311	322	313	318
6	24	254	233	229	242	239

These results will be analysed for uncertainties resulting in a spreadsheet with a large number of columns. To keep the spreadsheet compact, it is possible to merge the column headings.

1. Click on cell B1 and drag the mouse over to cell F1. The cells will now be highlighted.
2. Go to Format on the Menu bar and choose Cells.
3. Click on the Alignment tab at the top of the Format Cells window.
4. Click on the box beside Merge cells and a tick will appear in the box.
5. Click on OK. Cells B1 to F1 will have merged.
6. Click on the grey B cell and drag the mouse over to the grey F cell.
7. Go to Format on the Menu bar.
8. Click on Columns and select Width.
9. Type in 8.0 and click on OK. The width of columns B to F will have been reduced.
10. The spreadsheet will now look like the one below.

	A	B	C	D	E	F
1	Thickness of lead/mm	Uncorrected count rate/counts per minute				
2	0	816	854	893	831	874
3	6	532	511	522	518	527
4	12	390	392	406	395	399
5	18	315	311	322	313	318
6	24	254	233	229	242	239

The background count rate during the experiment was 30 counts per minute. This value will have to be used to correct the count rate.

1. Select cell G1 and type in the heading Corrected count rate/counts per minute.
2. Merge cells G1 to K1 using the method given above.
3. Adjust the width of columns G1 to K1 to 8.0 using the above method.
4. Select cell G2 and enter the formula =B2-30. This will correct the count rate.
5. Copy the formula to cells G2 to G6. Repeat this for cell H2 to H6, I2 to I6, J2 to J6, and K2 to K6. The spreadsheet will now look like this.

	A	B	C	D	E	F	G	H	I	J	K
1	Thickness of lead/mm	Uncorrected count rate/counts per minute					Corrected count rate/counts per minute				
2	0	816	854	893	831	874	786	824	863	801	844
3	6	532	511	522	518	527	502	481	492	488	497
4	12	390	392	406	395	399	360	362	376	365	369
5	18	315	311	322	313	318	285	281	292	283	288
6	24	254	233	229	242	239	224	203	199	212	209

Calculating a mean value.

The mean corrected count rate may be calculated by the following method.

1. Select cell L1
2. Enter the heading Mean corrected count rate/counts per minute.
3. Select cell L2 and enter =average(
4. Click and hold the mouse on cell G2 and drag the cursor over to cell K2. The five cells will have a moving dotted border.
5. Release the mouse and the formula will read =average(G2:K2
6. Close the bracket to give =average(G2:K2) and press the return key.
7. The number 823.6 will appear in cell L2.
8. Copy the formula to cells L3 to L6.
9. Use the Format Cells Number window to set the number of decimal places to zero. The spreadsheet will now look like this.

	A	B	C	D	E	F	G	H	I	J	K	L
1	Thickness of lead/mm	Uncorrected count rate/counts per minute					Corrected count rate/counts per minute					Mean corrected count rate/counts per
2	0	816	854	893	831	874	786	824	863	801	844	824
3	6	532	511	522	518	527	502	481	492	488	497	492
4	12	390	392	406	395	399	360	362	376	365	369	366
5	18	315	311	322	313	318	285	281	292	283	288	286
6	24	254	233	229	242	239	224	203	199	212	209	209

Calculating an approximate random uncertainty.

The approximate random uncertainty in the mean is calculated using the formula.

$$\text{Random uncertaint } y = \frac{\text{maximum reading - minimum reading}}{\text{number of readings}}$$

Excel does not have a function specifically designed to calculate the random uncertainty but it may be calculated using a formula created from other Excel functions. It is calculated using the formula

Random uncertainty = (MAX(Array)-MIN(Array))/COLUMNS(Array)

In the Array bracket the user needs to tell Excel which cells to use. In this case it is cells G2 to K2 inclusive (written as G2:K2). Great care must be taken with the positioning of the brackets.

1.   Select cell M1
2.   Enter the column heading Random uncertainty in the mean corrected count rate/counts per minute.
3.   Select cell M2 and type =MAX(
4.   Click and hold on cell G2 and drag across to cell K2.
5.   Close the array bracket and the formula will look like this =MAX(G2:K2)
6.   Type in the rest of the formula shown above inserting G2:K2 each time the word Array appears.
7.   Press the Return key and cell M2 will display the answer 15.4.
8.   Copy the formula to cells M3 to M6.
9.   Use the Format Cells Number window to set the number of decimal places to zero and the spreadsheet will look like this.

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Thickness of lead/mm	Uncorrected count rate/counts per minute					Corrected count rate/counts per minute					Mean corrected count rate/counts per minute	Random uncertainty in the mean corrected count rate/counts per minute
2	0	816	854	893	831	874	786	824	863	801	844	824	15
3	6	532	511	522	518	527	502	481	492	488	497	492	4
4	12	390	392	406	395	399	360	362	376	365	369	366	3
5	18	315	311	322	313	318	285	281	292	283	288	286	2
6	24	254	233	229	242	239	224	203	199	212	209	209	5

Calculating a percentage uncertainty.

To calculate the approximate random uncertainty as a percentage uncertainty, the following formula is used.

$$\text{Percentage uncertaint } y = \frac{\text{random uncertaint y in the mean}}{\text{mean value}} \text{ x } 100$$

1. Select cell N1
2. Enter the column heading Percentage uncertainty in the mean corrected count rate.
3. Click on cell N2 and type in the formula =(M2/L2)*100
4. The answer 1.868933…will appear in Cell N2.
5. Copy the formula to cells N3 to N6.
6. Use the Format Cells Number window to change the number of decimal places to zero. Columns L, M, and N will look like this.

L	M	N
Mean corrected count rate/counts per minute	Random uncertainty in the mean corrected count rate/counts per minute	Percentage uncertainty in the mean corrected count rate
824	15	2
492	4	1
366	3	1
286	2	1
209	5	2

Calculating an absolute uncertainty.

The manufacture of the lead states that the thickness has an uncertainty of +/- 5%. This percentage will be used to calculate the absolute uncertainty in the thickness of the lead. The Absolute uncertainty is calculated using the formula

$$\text{Absolute uncertaint } y = \frac{\text{percentage uncertaint y}}{100} \text{ x reading}$$

1. Select cell B2. Go to Insert on the Menu bar and select Columns
2. Repeat step1 and two new columns will have been inserted.
3. Select cell C1 and enter the heading Percentage uncertainty in the thickness of lead.
4. Enter the value 5 into cells C2 to C6.
5. Select cell B1 and enter the heading Absolute uncertainty in the thickness of lead/mm
6. Select cell B2 and enter the formula =(C2/100)*A2
7. The answer of 1.2 will appear in cell B2.
8. Copy the formula into cells B3 to B6.
9. Use the Format Cells Number window to set the number of decimal places to 1 and the first 3 columns of the spreadsheet will look like this.

|	A	B	C
1	Thickness of lead/mm	Absolute uncertainty in the thickness of lead/mm	Percentage uncertainty in the thickness of lead.
2	0	0.0	5
3	6	0.3	5
4	12	0.6	5
5	18	0.9	5
6	24	1.2	5

It is now possible to plot an XY Scatter chart of the Mean corrected count rate/counts per minute (column N) against the Thickness of lead/mm (column A). The chart should be placed on a new sheet entitled Half-thickness. The x-axis scale settings should be set to Maximum 26, Minimum 0, Major unit 1, Minor unit 0.25. The y-axis scale settings should be set to Maximum 850, Minimum 0, Major unit 50, Minor unit 5. The x-axis and y-axis Major gridlines are made thicker to make the chart more legible. This is achieved by following these instructions.

1.   Go to View on the Menu bar and chose Zoom. Select 200% and click on OK.
2.   Move the cursor over the gridlines until a cream box with Value (X) Axis Major Gridlines appears. Double click and the Format Gridlines window will appear.
3.   Click on the Patterns tab at the top of the window.
4.   In the Line option pull down the Weight menu and click on the second line down.
5.   Click on OK and the x-axis Major gridlines will become thicker.
6.   Repeat steps 2 to 5 for the y-axis Major gridlines.
7.   Use the View Zoom 100% option to return the view to full size.

The Page set up of the chart is also changed to Portrait to allow the y-axis scale to be enlarged from Excels' original choice.

The chart should look like the one on the next page.

Variation of Mean corrected count rate/counts per minute with the thickness of lead/mm
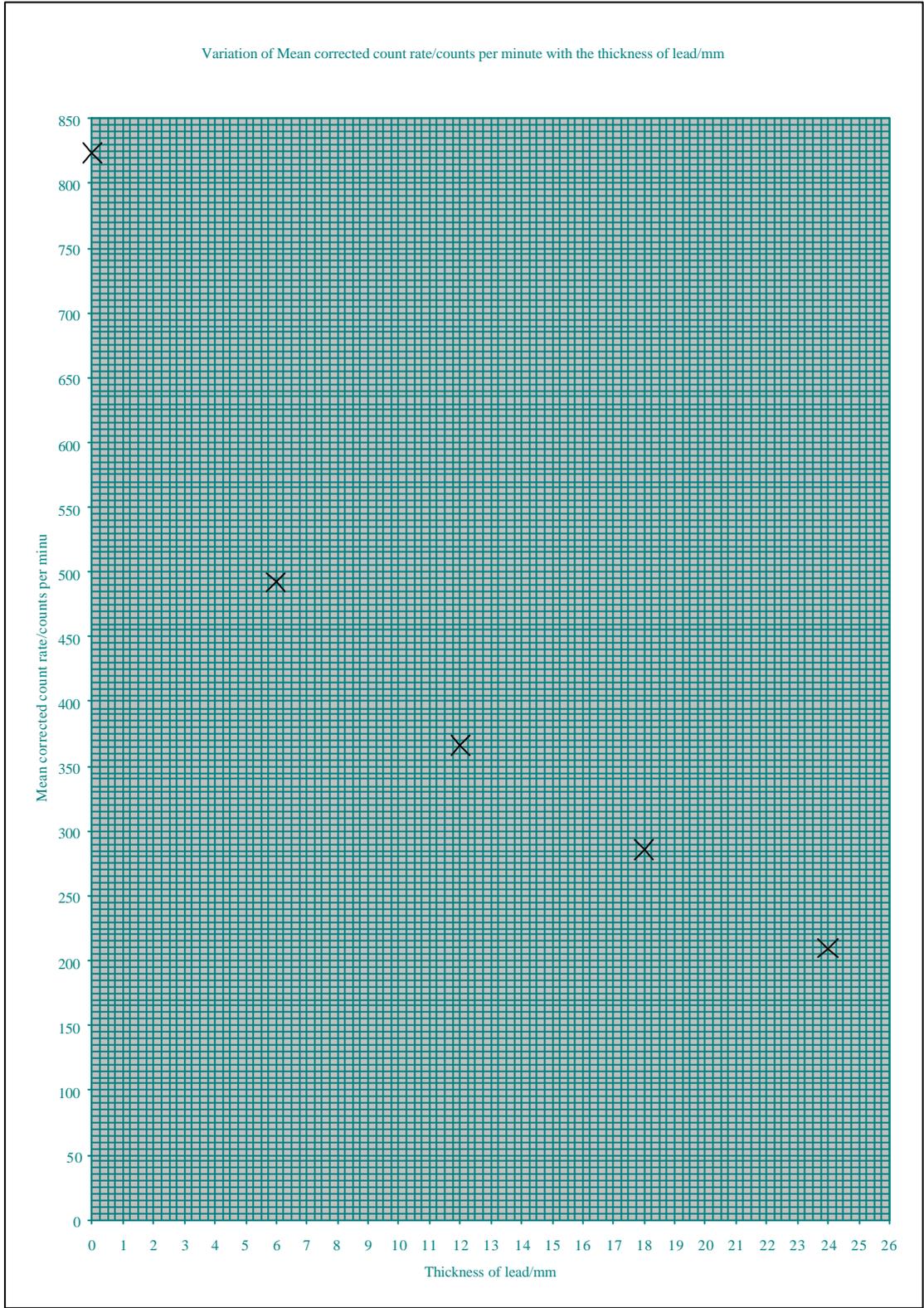
Plotting error bars on a chart.

Errors bars are only required at Advanced Higher Physics. Excel can plot error bars for each data point on a chart. There are three options for plotting error bars.

1.   Fixed percentage error bars
2.   Fixed value error bars.
3.   Custom error bars.

Fixed percentage error bars.

The manufacturer gave the percentage uncertainty in the thickness of the lead as   ± 5%.

1.   Double click on one of the data points. The Format Data Series window will appear.
2.   Click on the X Error Bar tab at the top of the Format Data Series window.
3.   The Format Data Series window will look like this.
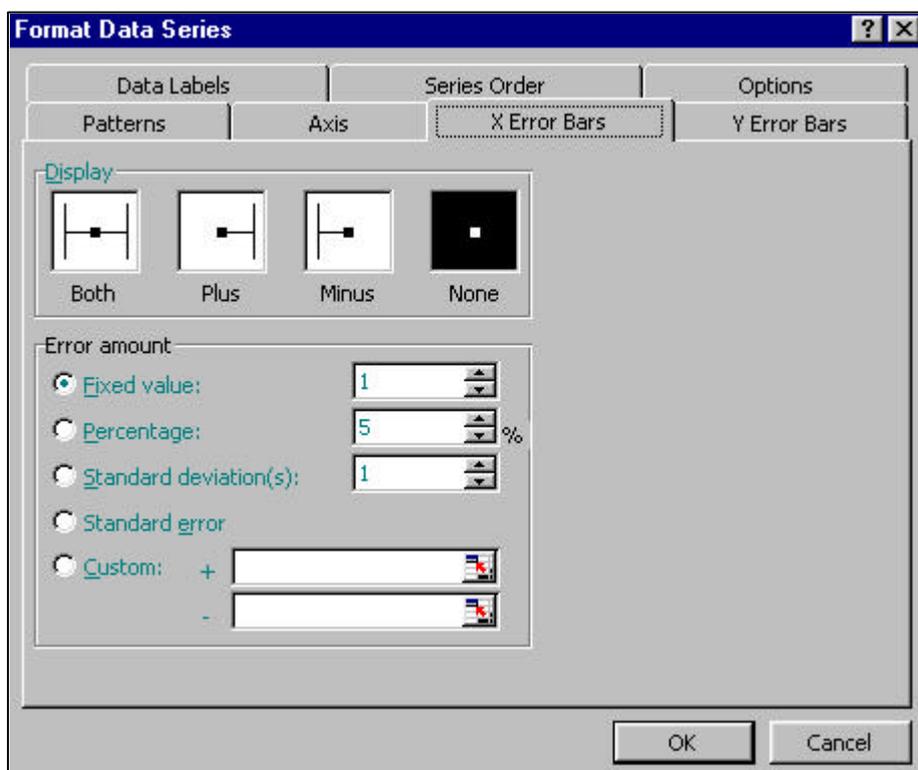
4.   Go to the Display options and click on the white box above Both.
5.   Go to the Error amount options and click on the dot beside Percentage.
6.   Check that the Percentage error amount is set at 5%. If it is not, use the up and down arrows to change the value to 5%.
7.   Check that the Format Data Series window looks like the one below.
8.   Click on OK and the chart will now display x-axis error bars as shown below.
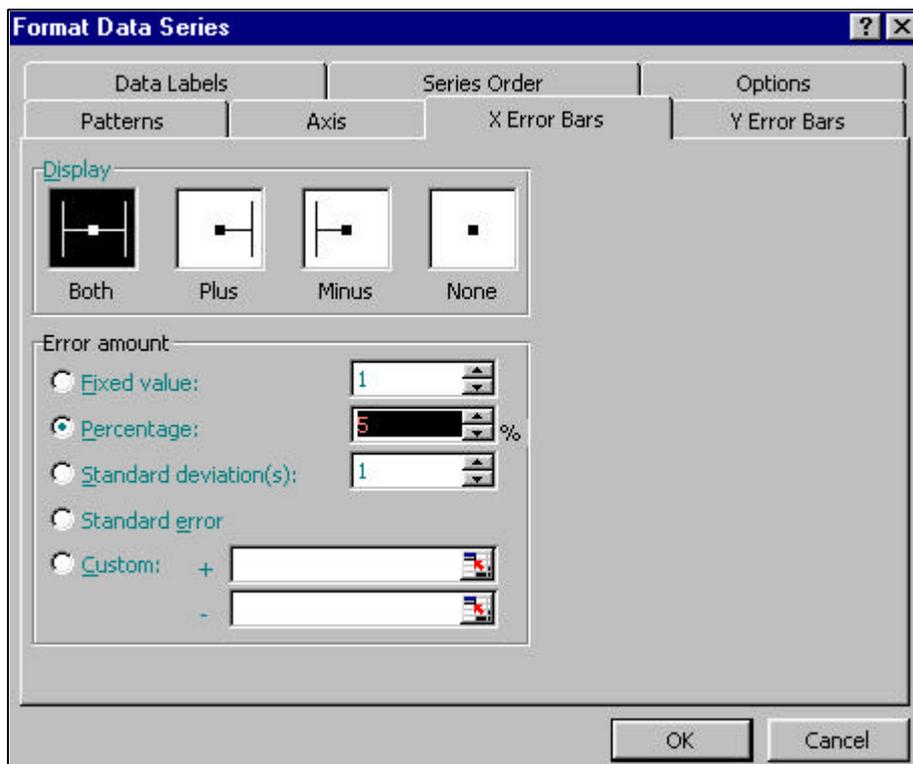
To plot a set of fixed percentage error bars for the y-axis values, the same method as above would be used but in step 2 the user would click on the Y Error Bars tab at the top of the Format Data Series window.

If the percentage uncertainty is not a whole number then the user may delete the value in the cell beside Percentage and enter the desired value for example ± 4.8%.

Variation of Mean corrected count rate/counts per minute with the thickness of lead/mm
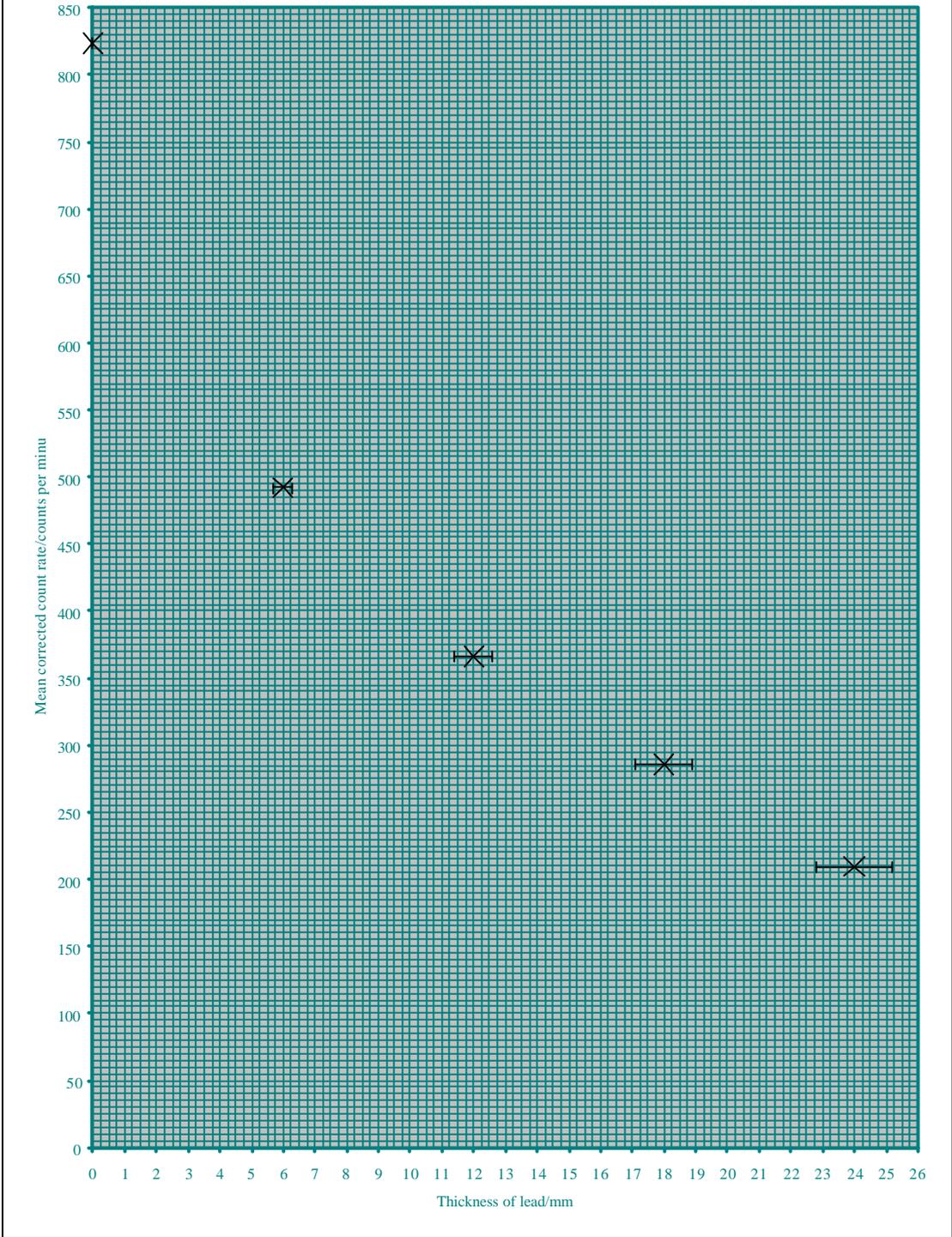
Fixed value error bars.

The student carrying out the experiment believes that the uncertainty in the thickness of the lead is ± 1 mm.

1. Double click on one of the data points. The Format Data Series window will appear.
2. Click on the X Error Bar tab at the top of the Format Data Series window.
3. The Format Data Series window will look like this.
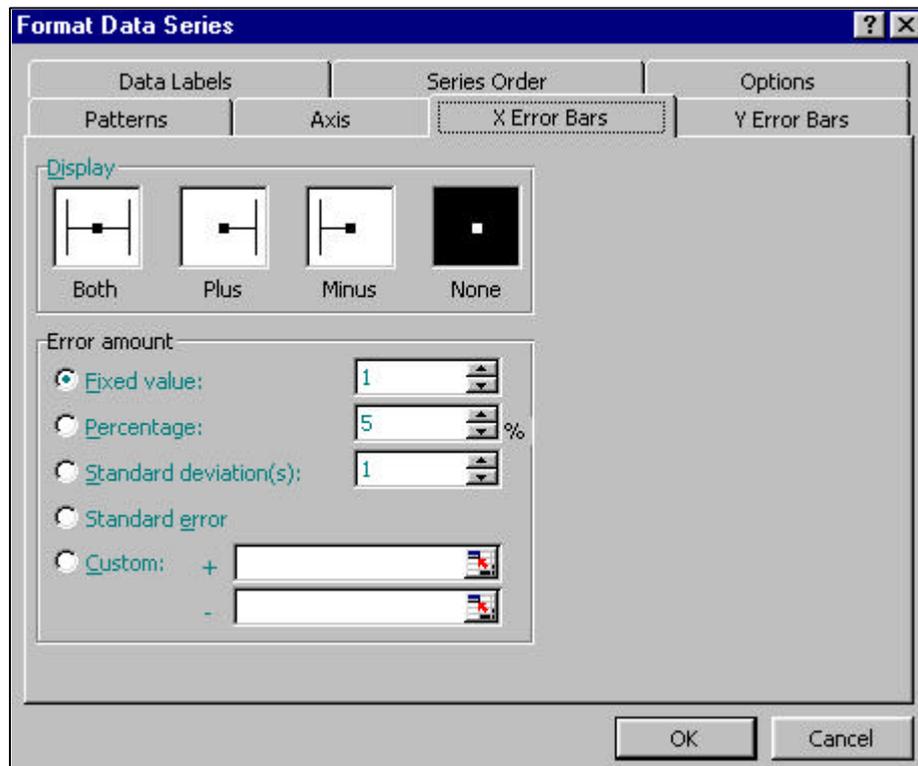
4. Go to the Display options and click on the white box above Both.
5. Go to the Error amount options and click on the dot beside Fixed value until the dot turns from white to black.
6. Check that the Fixed value amount is set at 1. If it is not, use the up and down arrows to change the value to 1. This will apply an uncertainty of ± 1 mm.
7. Check that the Format Data Series window looks like the one below.
8. Click on OK.
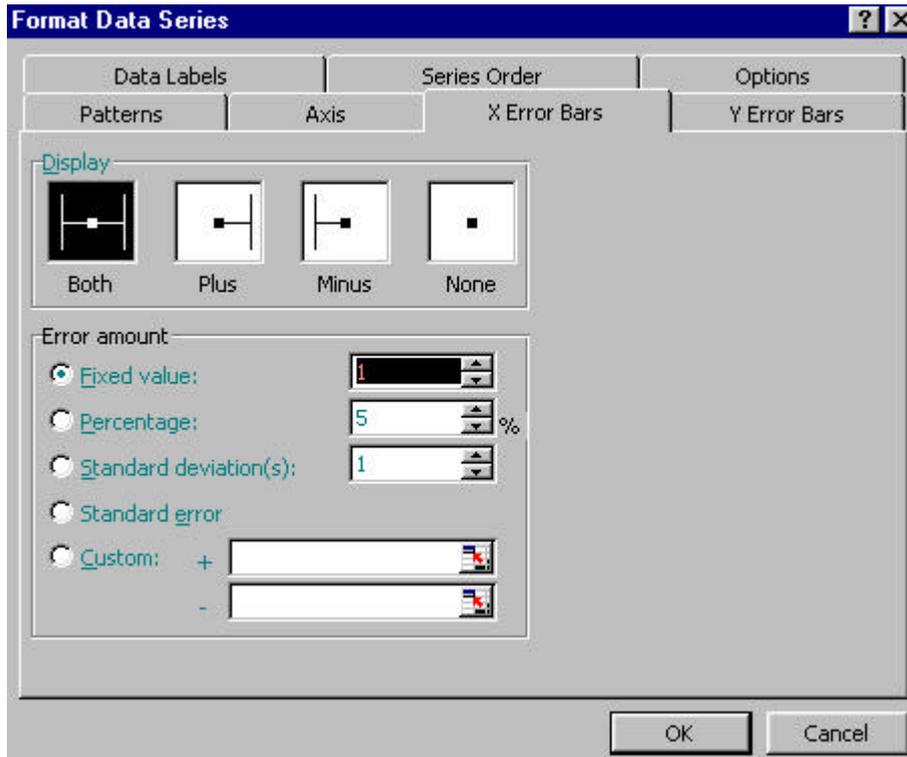
Excel has adjusted the scale on the x-axis to range from –3 to 26. This is because it has plotted error bars of ± 1 mm for the thickness of 0 mm. A negative thickness does not make sense. It is not possible to remove the error bars around that point, unless the data is removed from the spreadsheet. It is possible to remove the negative error bar by re-setting the range of scale on the x-axis from 0 to 26. This is achieved by

9.   Double click on the x-axis and the Format Axis window will appear.
10.   Click on the Scale tab at the top of the window and reset the Minimum value to 0.
11.   Click on OK and the chart will change to the one shown on the next page.

If the fixed value uncertainty is not a whole number then the value in the cell beside The fixed value error amount may be deleted and the desired value inserted, for example ± 0.5 mm.

Variation of Mean corrected count rate/counts per minute with the thickness of lead/mm
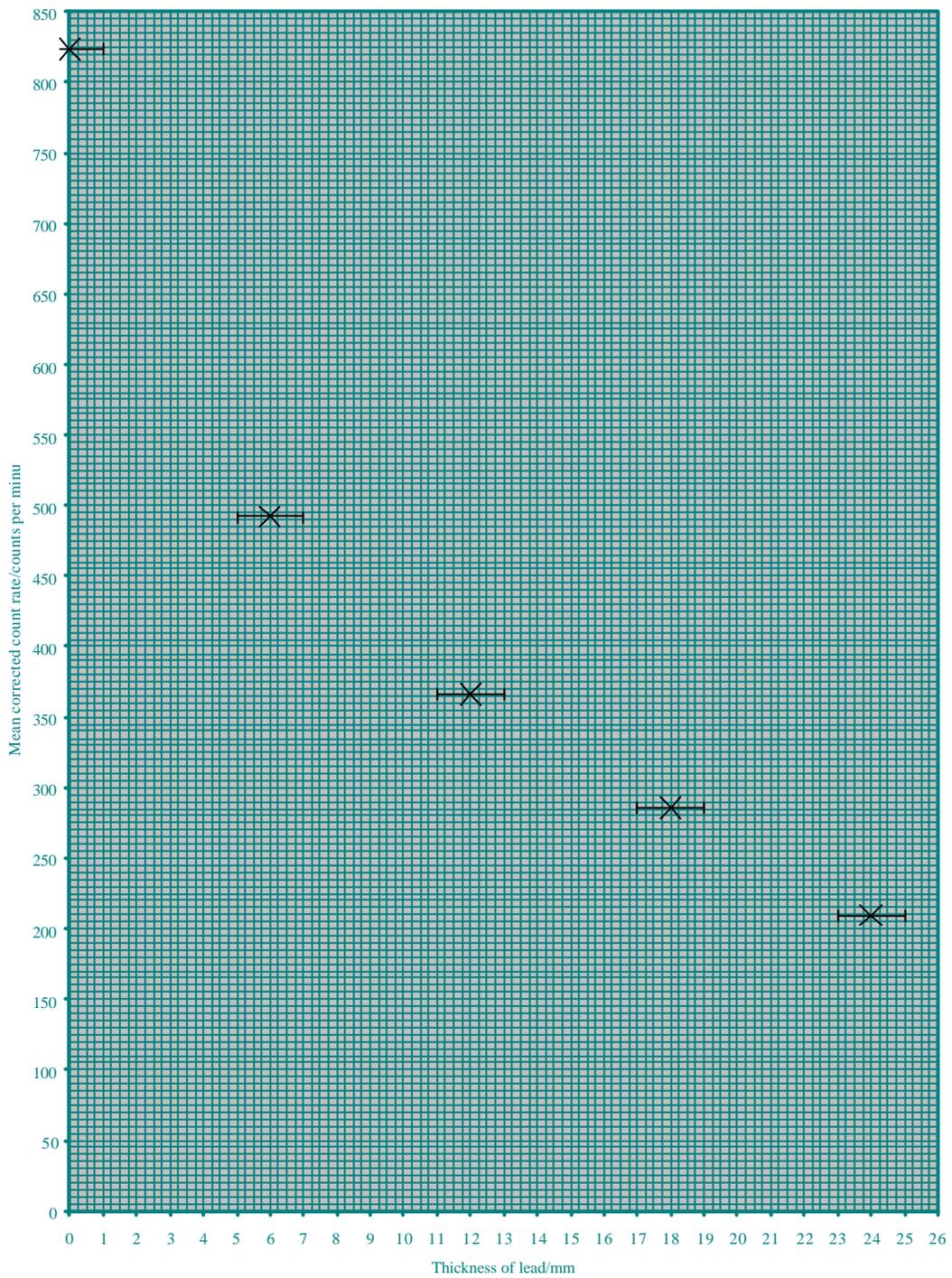
Custom error bars.

The approximate random uncertainty in the Mean corrected count rate/counts per minute is not a constant value.

It is possible to plot the random uncertainty as error bars.

1.   Double click on one of the data points.
2.   The Format Data Series window will appear.
3.   Click on the Y Error Bars tab at the top of the Format Data Series window.
4.   Go to the Error amount options and click on the dot beside Custom, until it turns from white to black.
5.   The bottom left-hand corner of the screen will look like this.

6.   Click on the Sheet1 tab.
7.   The original spreadsheet will appear behind the Format Data Series window.
8.   Use the arrows at the bottom right-hand side of the screen to move the spreadsheet until the whole of column O (Random uncertainty in the mean corrected count rate/counts per minute) is visible.
9.   The screen will look like this.
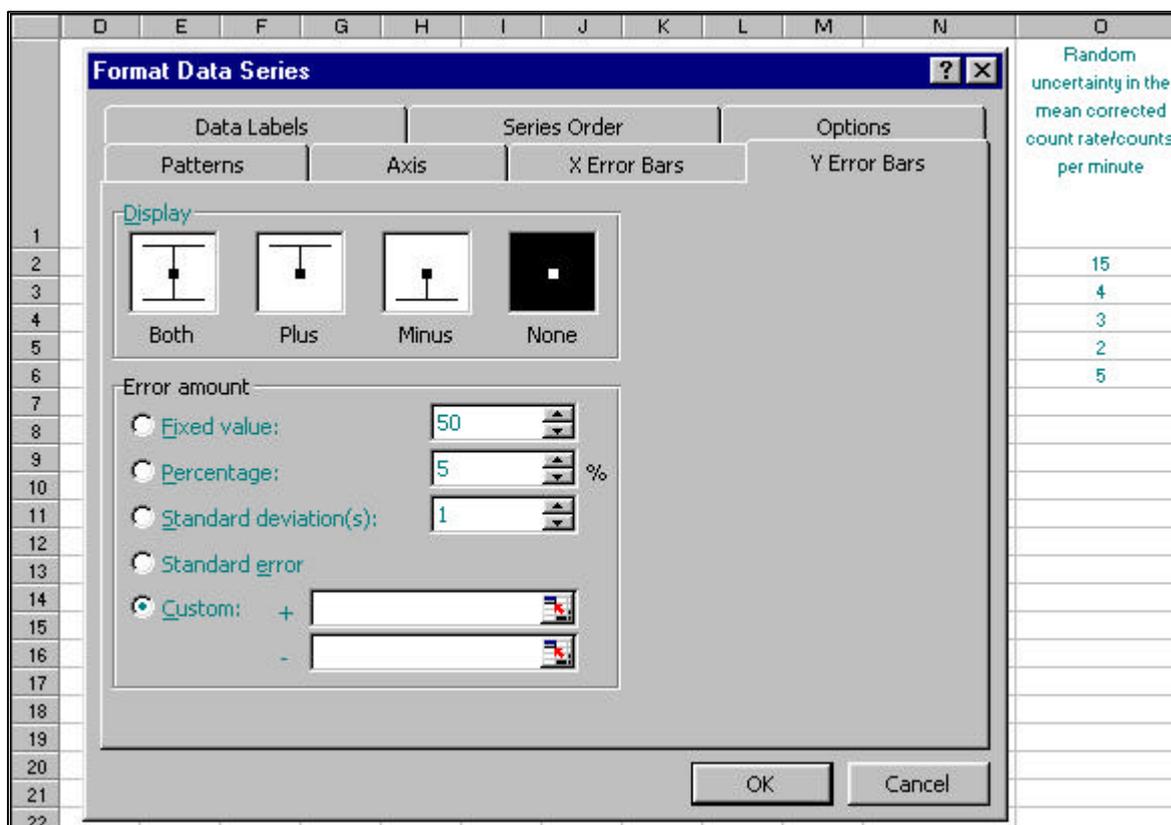
10. Click and hold the mouse on cell O2 and drag the mouse down to cell O6. The Format Data Series window will disappear and the screen will change to look like this.


	D	E	F	G	H	I	J	K	L	M	N	O
												Random uncertainty in the mean corrected count rate/counts per minute
1												
2	816	854	893	831	874	786	824	863	801	844	824	15
3	532	511	522	518	527	502	481	492	488	497	492	4
4	390	392	406	395	399	360	362	376	365	369	366	3
5	315	311	322	313	318	285	281	292	283	288	286	2
6	254	233	229	242	239	224	203	199	212	209	209	5

Format Data Series - Custom +
=Sheet1!$O$2:$O$6
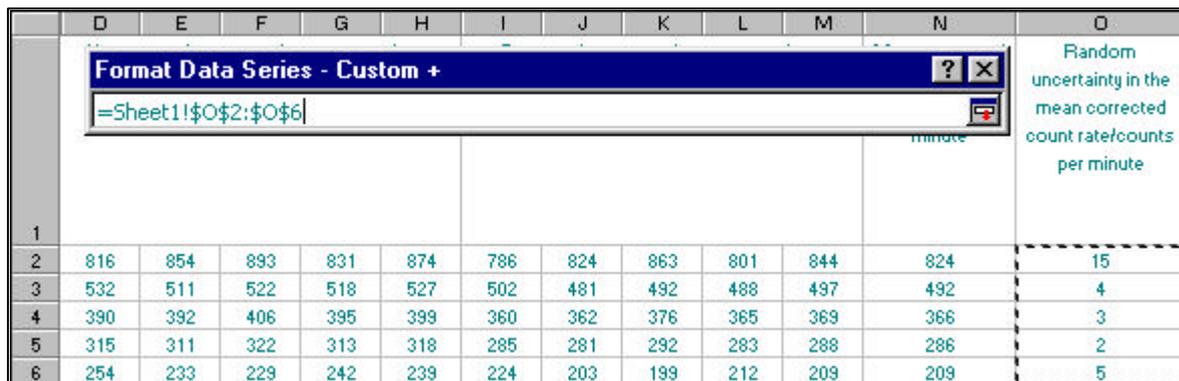
11. Release the mouse and the screen will change to look like this.

Format Data Series

Data Labels | Series Order | Options
Patterns | Axis | X Error Bars | Y Error Bars

Display
Both   Plus   Minus   None

Error amount
○ Fixed value: 50
○ Percentage: 5   %
○ Standard deviation(s):   1
○ Standard error
● Custom: +   =Sheet1!$O$2:$O$6
             -

OK   Cancel
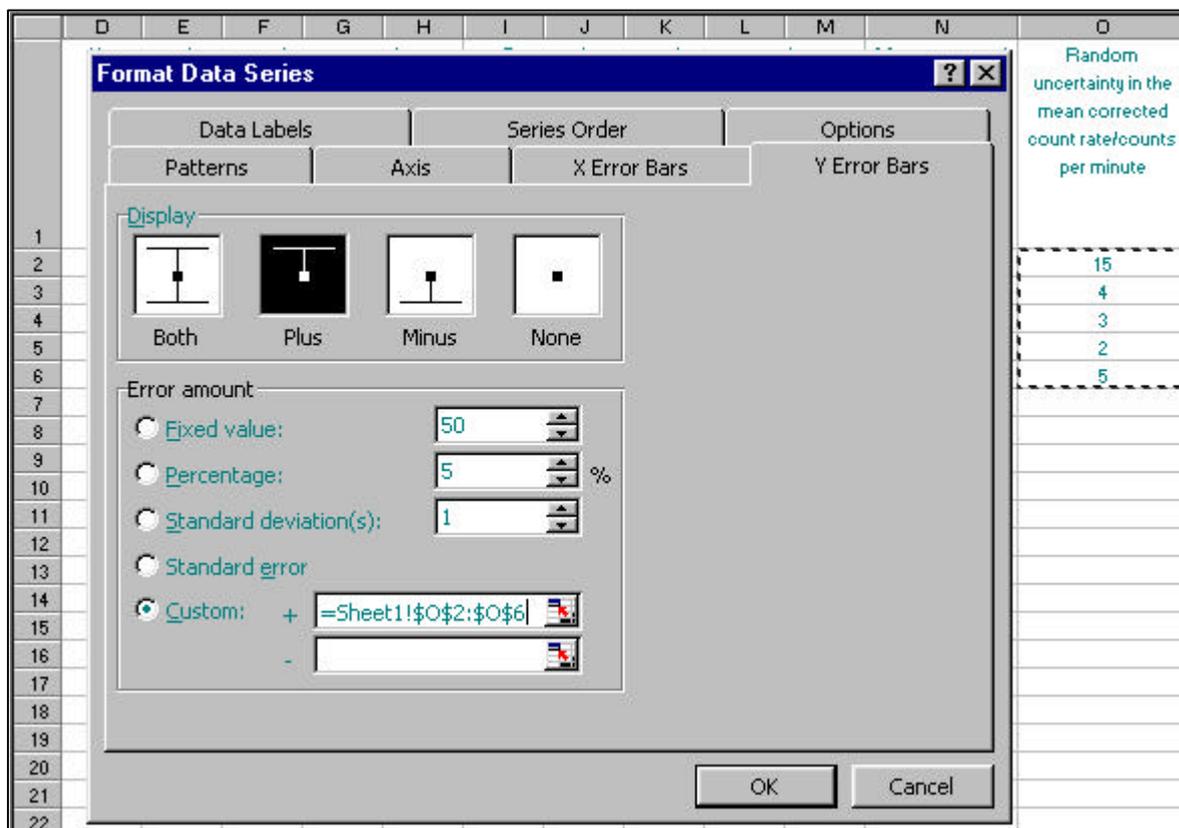
12. Go to the Error amount options and click in the – cell beside Custom.
13. Repeat steps 6 to 10, release the mouse and the Format Data Series window will look like the one on the next page.
14. Click on OK and the chart will now display the random uncertainty as the y-axis error bars and will look like the one shown on the page after next. The error bars will be very small and hard to see.

15. Go to View on the Menu bar and click on Zoom.
16. Select a magnification of 200%.
17. The y-axis error bars will now be visible, although they are still small.
18. Go to Edit on the Menu bar and click on Undo Zoom. The magnification will return to 100%.
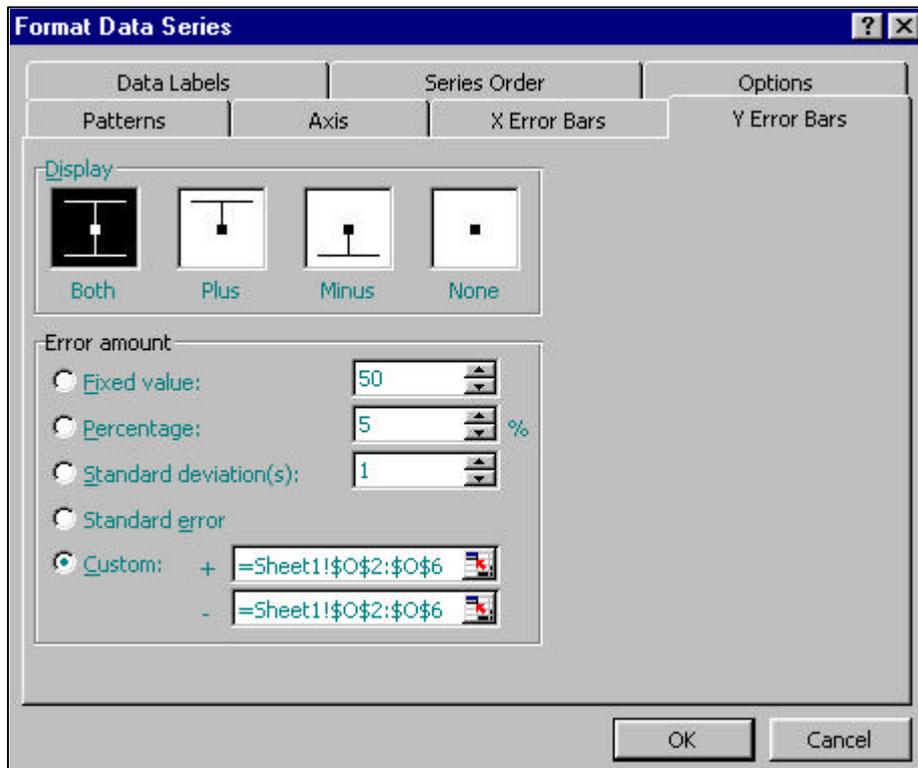
Using the Custom option in the Error amount it is possible to have asymmetrical errors such as + 1 mm and – 0.5 mm. There should not be a need for this even at Advanced Higher.

Variation of Mean corrected count rate/counts per minute with the thickness of lead/mm
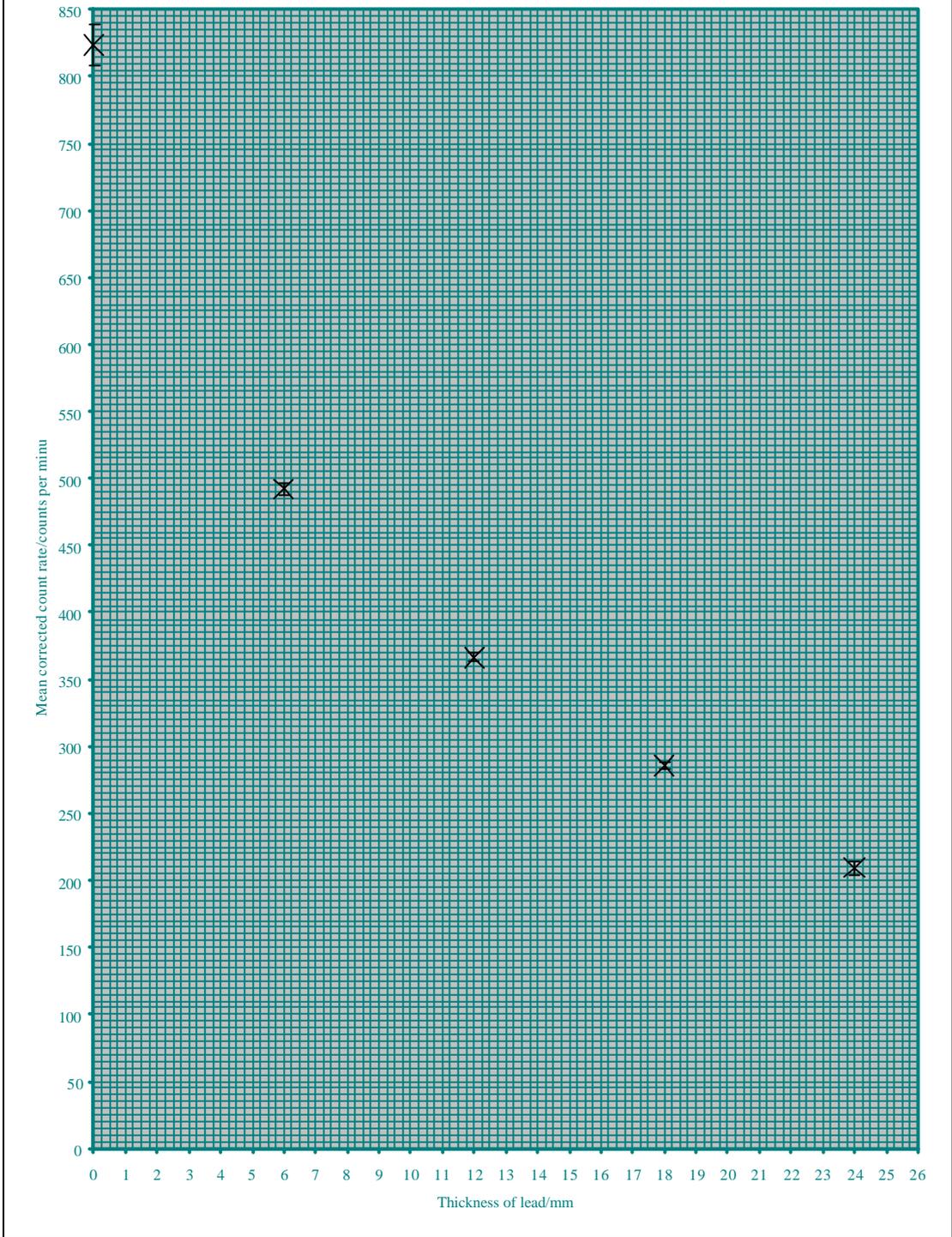
CONSTRUCTING FORMULAE

Arithmetic operators.

The four basic arithmetic operators used in the construction of a formula are shown below.

MATHEMATICAL OPERATION	EXCEL OPERATOR	EXAMPLE
Addition	+ (Plus sign)	3+4
Subtraction, Negation	- (Minus sign)	9-2 or –2
Multiplication	* (Asterisk)	6*7
Division	/ (Forward slash)	12/2

They are used with brackets to create simple formulae. Excel follows the BODMAS order of operations – brackets before division, multiplication, addition and subtraction. Excel always carries out calculation placed inside brackets first so great care must be taken with the positioning of brackets.

Example 1

The data in the spreadsheet below are to be used to calculate the acceleration of an object using the formula

$$a = \frac{(v-u)}{t}$$

	A	B	C	D
1	$u/m\ s^{-1}$	$v/m\ s^{-1}$	t/s	$a/m\ s^{-2}$
2	6	16	5	
3				

1. On a piece of paper, write the formula using the Excel operators. The formula becomes a=v-u/t.
2. Brackets must be placed around the change in velocity to tell Excel to calculate it first and then divide by the time. The formula reads a=(v-u)/t.
3. Cell A2 contains the value for u, cell B2 contains the value for v, and cell C2 contains the value for t. The formula becomes a=(B2-A2)/C2.
4. Select cell D2, type in the formula =(B2-A2)/C2 and press the Return key.
5. The answer 2 will appear in cell D2.

^ Operator.

The ^ (hat) operator is used to raise the power of a number. It is located on the number 6 key.

Example 2

The data in the spreadsheet below are to be used to calculate s using the formula

$$s = ut + \frac{1}{2}at^2$$

	A	B	C	D
1	u/m s^{-1}	a/m s^{-2}	t/s	s/m
2	10	2	4	
3				

1. On a piece of paper, write the formula using the Excel operators changing the half to 0.5. A multiplication operator must be placed between all of the terms that are to be multiplied. The formula becomes s=u*t+0.5*a*t^2.
2. Insert brackets around the u*t and the 0.5*a*t^2. The formula become s=(u*t)+(0.5*a*t^2)
3. Cell A2 contains the value for u, cell B2 contains the value for a, and cell C2 contains the value for t. The formula becomes s=(A2*C2)+(0.5*B2*C2^2).
4. Select cell D2, type in the formula =(A2*C2)+(0.5*B2*C2^2) and press the Return key.
5. The answer 56 will appear in cell D2.

SQRT(number) Function.

The SQRT(number) function calculates the square root of the number placed into the brackets. Excel is not sensitive to upper or lower case lettering. It will automatically change any lower case letters in a function to upper case letters, for example, SqRt will be changed to SQRT.

Example 3

A student wishes to calculate the velocity of an object using the formula

$$E_k = \frac{1}{2}mv^2$$

After rearranging, the formula becomes

$$v = \sqrt{\frac{2E_k}{m}}$$

The data to be used are shown in the spreadsheet below.

	A	B	C
1	E_k/J	m/kg	v/m s^{-1}
2	128	4	

1. On a piece of paper, write the formula using the Excel operators and functions. The formula becomes v=SQRT(2*E_k/m)
2. Insert brackets around the 2*E_k. The formula becomes v=SQRT((2*E_k)/m). The outer brackets are part of the SQRT() function. The inner brackets tell Excel to calculate 2*E_k before it divides by m.
3. Cell A2 contains the value for E_k and cell B2 contains the value for m. The formula becomes v=SQRT((2*A2)/B2).
4. Select cell D2, type in the formula =SQRT((2*A2)/B2) and press the Return key.
5. The answer 8 will appear in cell D2.

PI() Function

The mathematical constant π is used in many Physics calculations, especially at Advanced Higher. Excel does not have a symbol for π but has a function PI(). The PI() function returns a value of π accurate to 15 digits. When using the PI() function, nothing is placed inside the brackets.

Example 4

A student has to calculate the period of a simple pendulum using the formula

$$T = 2p\sqrt{\frac{l}{g}}$$

The required data are shown in the spreadsheet below.

	A	B	C
1	l/m	g/m s^{-2}	T/s
2	0.5	9.81	

1. On a piece of paper, write the formula using the Excel operators and functions. The formula becomes T=2*PI()*SQRT(l/g)
2. Cell A2 contains the value for l and cell B2 contains the value for g. The formula becomes T=2*PI()*SQRT(A2/B2)
3. Select cell D2, type in the formula =2*PI()*SQRT(A2/B2) and press the Return key.
4. The answer 1.4185 will appear in cell D2.

AVERAGE(number 1, number 2,…) Function.

The AVERAGE function is used to calculate the arithmetic mean of a series of numbers. The numbers may be placed directly into the function or if a large amount of data is being analysed, the array of data may be entered.

Example 5

A student wants to find the mean of the readings shown in the spreadsheet below.

	A	B	C	D	E	F
1	time/s	time/s	time/s	time/s	time/s	mean time/s
2	4	3	5	4	6	

1.   Select cell F2 and type in =AVERAGE(
2.   Click on cell A2, hold down the mouse button and drag over to cell E2.
3.   Release the mouse button and close the bracket to give =AVERAGE(A2:E2)
4.   The answer 4.4 will appear in cell F2.

The main advantage of following this method is that the user does not have to re-type all of the data, risking typing errors in the process. The array of cells A2:E2 is linked to the formula. If the formula is copied to cell F3, the array A3:E3 would be used in the calculation.

Trigonometric Functions.

The six basic trigonometric functions are shown in the table below.

TRIGONOMETRIC FUNCTION	EXCEL FUNCTION
sin	SIN(angle in Radians)
cos	COS(angle in Radians)
tan	TAN(angle in Radians)
$\sin^{-1}$	ASIN(angle in Radians)
$\cos^{-1}$	ACOS(angle in radians)
$\tan^{-1}$	ATAN(angle in radians)

Excel uses Radians as its unit of angle. There are however, two very useful conversion functions available.

CONVERSION	EXCEL FUNCTION
Degrees to Radians	RADIANS (angle in Degrees)
Radians to Degrees	DEGREES(angle in Radians)

Example 6

A student is to calculate the Refractive Index of a material using the formula,

$$n = \frac{\sin \boldsymbol{q}_a}{\sin \boldsymbol{q}_m}$$

and the data given in the spreadsheet below.

	A	B	C	D	E
1	θ_a/degrees	θ_m/degrees	$\sin\theta_a$	$\sin\theta_m$	n
2	30	22			
3					

1.   On a piece of paper, convert the 30 degrees to Radians using the conversion function given above. The formula becomes $\sin\theta_a$=RADIANS(θ_a)
2.   Insert the sin function into the formula. The formula now reads $\sin\theta_a$=sin(RADIANS(θ_a)).
3.   Cell A2 contains the value for θ_a. The formula becomes $\sin\theta_a$=sin(RADIANS(A2)).
4.   Select cell C2, type in the formula =sin(RADIANS(A2)), and press the Return key.
5.   The answer 0.5 will appear in cell C2.
6.   Copy the formula to cell D2 and the answer 0.37461 will appear.
7.   The formula for Refractive Index is

$$n = \frac{\sin \boldsymbol{q}_a}{\sin \boldsymbol{q}_m}$$

8.   Select cell E2, type =C2/D2 and press the Return key.
9.   The answer n=1.3347… will appear in cell E2.

Example 7

A student knows the refractive index of a semi-circular prism and the angle of incidence of a ray of light within the prism θ_m. The student wants to predict the angle of refraction of the ray of light as it passes from the prism into the air.

For angles less than the Critical Angle, the predicted angle of refraction is calculated using the formula

$$\boldsymbol{q}_a = \sin^{-1}\left(n\sin \boldsymbol{q}_m\right)$$

	A	B	C
1	θ_m/degrees	n	Predicted θ_a/degrees
2	30	1.34	

1. On a piece of paper write the formula to calculate $\sin\theta_m$ in radians
   θ_a=SIN(RADIANS(θ_m))
2. Multiply the formula by n to give θ_a=n*SIN(RADIANS(θ_m))
3. Take the inverse sin of the formula giving θ_a=ASIN(n*SIN(RADIANS(θ_m)))
4. Cell A2 contains the value for θ_m, and cell B2 contains the value for n. The formula now becomes θ_a=ASIN(B2*SIN(RADIANS(A2)))
5. If this formula were used in cell C2 it would return an answer of 0.73420…. This is the correct angle but it is measured in radians. Use the DEGREES() function to convert the answer to degrees, giving the finished formula of θ_a=DEGREES(ASIN(SIN(RADIANS(A2))/B2)).
6. Select cell C2, type in =DEGREES(ASIN(SIN(RADIANS(A2))/B2)), and press the return key. Be very careful with the brackets.
7. The answer of 42.0670648… will appear in cell C2.

Logarithmic Functions

Excel has four logarithmic functions shown in the table below.

LOGARITHMIC FUNCTION	EXCEL FUNCTION
$Log_{10}N$	LOG10(number)
Log_xN	LOG(number, base)
LN N	LN(number)
EXP	EXP(number)

Example 8

1. Entering =LOG10(1000) would return an answer of 3.
2. Entering =LOG(4,2) would return an answer of 2.
3. Entering =LN(5) would return an answer of 1.60944…
4. Entering =EXP(1) would return an answer of 2.7182..
5. Entering =EXP(LN(5)) would return an answer of 5.

These functions are not required at Higher but could be used at Advanced Higher.