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# An introduction to spreadsheets in science

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Electronic spreadsheet programs developed as business tools for accounting and predicting. They quickly replaced the pencil-and-paper versions and have developed complexity and flexibility. A typical spreadsheet program, such as *Microsoft Excel*, now has a usefulness that extends far beyond its original purpose. As a science teacher I now use spreadsheets in a variety of ways with my classes. As a DET science consultant I was often asked about how spreadsheets could be integrated into science education, how we could meet syllabus outcomes in relation to spreadsheets and how science teachers could assist in preparing students for the Computing Skills Assessment exam, now to start with Year 10 in 2006. The purpose of this workshop is to provide an introduction to using a spreadsheet, some ideas for their use in relation to science teaching and especially the Physics syllabus, and some examples and tips for their use. Three short activities lead you into tabulating, calculating, graphing and importing data using a spreadsheet program.

## **What can they do for your students?**

Spreadsheets have the ability to:

- tabulate data
- graph data
- make calculations and re-calculate immediately
- sort and rank data

These features can be used to support learning outcomes in Science in a range of ways:

- Give quick 'what if' answers

Spreadsheets can tabulate, calculate and then graph data as it is entered or altered. This can be used to support exploration of concepts and provide solutions to scenarios. The example here, a greenhouse gas calculator, can be used to support prescribed focus area outcomes relating to physics and society, or for Stage 5. Similar calculators are available on the web and comparing the results from them with one you devise yourself can lead to further discussions with your students.

- Assist in identifying data regularities

An important part of the scientific process is identifying relationships between data. We teach our students to tabulate, graph and provide lines of best fit to do just this. Spreadsheets can support the teaching of all three of these processes. Another possibility is to use the spreadsheet's ability to perform calculations to observe numerical patterns in calculations. In this example students have collected voltage and current values as part of an Ohm's Law activity. The spreadsheet adds, subtracts, divides and multiplies these. Students inspect these manipulations for regularities.

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Ohms Law data to investigate mathematical relationships						
Measured values		Possible relationships				
Voltage (v)	Current (I)	V+I	V-I	VxI	V/I	
2	0.2	2.2	1.8	0.4	10.0	
3.5	0.3	3.8	3.2	1.1	11.7	
5	0.4	5.4	4.6	2.0	12.5	
7	0.6	7.6	6.4	4.2	11.7	
9	0.7	9.7	8.3	6.3	12.9	
11	0.9	11.9	10.1	9.9	12.2	

This column has values which seem to be the same, indicating a relationship

- Sort and rank data

Spreadsheets can sort and rank tables of data. In this regard they resemble flat-file databases. You can use this feature in class data collection activities. The example below, from Stage 4 chemistry, collects information about chemicals at home. The data is collected, tabulated and then sorted to highlight patterns.

- Assist students with calculation answers

Numerical problems can be checked by using the spreadsheet's ability to apply a formula and re-calculate immediately. Conservation of momentum, for example, often presents students with calculation challenges. A template into which the various data is entered provides a guide towards obtaining a solution. You can set up the template or teach your students how to do so. The latter process involves students to a much higher level of engagement with the concept or formula they are learning and manipulating.

- To teach information and computer technology (ICT) outcomes.

We are preparing students for the information age by integrating spreadsheets into our teaching. Spreadsheet use can be developed from Stage 4 as part of teaching the skills of science. The example below, and the workshop practice, uses a simple spreadsheet to tabulate and then graph a heating curve.

- As a regular part of practical work.

Spreadsheets are ideal for supporting practical lessons. Data can be entered and manipulated easily, and graphs (charts) drawn quickly. Lines of best fit (trend-lines) can be added and their gradient is calculated immediately. Data from data-loggers or secondary sources can be imported and then further analysed.

- Provide a modelling tool to explain concepts.

A spreadsheet can provide a simple simulation to illustrate a concept the class is engaging with. The superposition example here will re-calculate and re-graph as your students enter values. I have this on the school intranet and students also use it to check their graphical answers. I also use it to illustrate beats. Some students enjoy the challenge of devising a similar version. There are numerous simulation applets available on the web and I use them a lot. I would not try to devise an animated simulation, for example. Instead, I find that a spreadsheet simulation I devise can complement them and be directly targeted at the syllabus dot point I am trying to illustrate.

## Where and how could you use spreadsheets in teaching the Physics syllabus?

### Some ideas:

#### Syllabus Ref Spreadsheet involvement

- 8.2.1 Check  $v$  calculations
- 8.2.2 Simulate superposition of waves
- 8.2.3 Model modulation
  - Process intensity vs distance experiment data
- 8.2.4 Process Snell's Law experimental data
- 8.3.2 Process Ohm's Law experimental data
  - Check Ohm's Law and field strength problems
- 8.3.4 Process heat and electrical energy experimental data Calculate electrical energy for domestic appliances
  - Check power and energy problems
- 8.4.1 Process average speed experimental data
- 8.4.2 Process Newton's 2nd Law experimental data
  - Check centripetal force calculations
- 8.4.3 Check energy and work calculations
- 8.4.4 Process data for momentum experiments and calculations
- 8.5.2 Demonstrate how  $c$  relates energy to mass
- 8.5.3 Tabulate and graph stellar luminosities to develop a HR diagram
- 8.5.4 Process radiation penetration experimental data
- 9.2.1 Investigate pendulum parameters to determine relationships Check gravitational potential energy calculations
- 9.2.2 Simulate projectile motion
  - Analyse data to investigate satellite orbits
  - Analyse planetary data to investigate Kepler's Law of Periods
- 9.2.3 Check universal gravitation problems
- 9.2.4 Check Lorentz transformation calculations
- 9.3.1 Check motor effect calculations
- 9.3.3 Simulate 3-phase power
  - Process generated current experimental data
- 9.3.4 Check transformer calculations
- 9.4.1 Check  $Bqv\sin\theta$  calculations
  - Simulate Thomson's experiment
- 9.4.2 Check photon calculations

**How else can you use spreadsheets?**

You can use spreadsheets in your administration. I write spreadsheets to:

- design assessment schedules
- keep track of resources and projects
- manipulate marks, including assigning levels of achievement
- assist in making complex resource choices

**Spreadsheet design tips**

- When graphing (a chart in excel-speak) you would most likely wish to graph two variables. The wizard does not default to this. You need to specify 'x-y scatter'. If you wish to add a line of best fit then choose the data-points-only option and add a trendline (excel-speak again) after the wizard has done its work.
- Restricting cell values to only a set of choices is called 'validation'. This can minimise errors in class data entry. Your spreadsheet program may be able to produce a 'form' that will do a similar thing.
- Adding comments to cells can act as reminders or highlight useful data.
- Protecting, hiding and locking cells or sheets can provide a level of tamper- proofing for spreadsheets you leave on your intranet.
- Treat all data, even constants, as variables. Enter these once in a separate table to a large data set. They can then be autofilled. This introduces flexibility
- Simulations can often be designed to put the input data and subsequent graph on one sheet while hiding the large number of requisite calculations on another.

### ***Starting out with spreadsheets***

The following notes will guide you through setting up a simple spreadsheet to tabulate and graph time-temperature data. Using formulae is introduced by adding an index correction. These notes can be readily adapted as an ICT worksheet for Stage 4.

(They have been written for *Excel*, part of the *Microsoft Office* package available in DET schools.)

‘Start, New Office document, Blank workbook, OK’ gets a new *Excel* spreadsheet ready to go.

The cells are labelled by letter and number combinations. The cursor highlights a cell as it moves around. Clicking in a cell activates it for use.

Start by highlighting the Sheet 1 tab at the bottom and renaming it ‘Activity 1’

#### **Activity 1 Tabulating a set of data.**

In cell A1, type ‘Heating water experiment’ Go to cell A3. Type ‘Time (mm)’

In cell B3 type ‘Temperature (Celsius)’

In the A cells column, type from 0 to 15, starting in cell A4

In the B cells column, starting in cell B4, type a set of typical water heating data, starting at 17°, and staying at 101° from 10 to 15 minutes.

Now, to **format** your table:

Select your title and the next cell (ie A1 and A2) and click on the ‘merge and centre’ symbol on the formatting toolbar. Keep the new cell selected and ‘Underline’ your table heading.

Select the cells that constitute your table data and headings and click on ‘format, column, autofit selection’ to get all of your headings’ writing to appear. While selected, centre the data.

Also while selected, go to the borders symbol on the formatting toolbar. Use the little ▼ to select the ‘all borders’ and click to get all of your data into the sort of table we are used to.

#### **Graphing the set of data**

Select the cells for your table of data (including the headings).

Click on the ‘**Chart Wizard**’.

Under ‘Chart type’ click on XY scatter. Under sub-chart, click on ‘scatter with data points connected by smooth lines’.

Follow through with the chart wizard to step 3, chart options. You can now give your graph a title, label the axes and indicate the divisions on your axes. Keep going with the wizard to finish putting the chart on the same sheet as your table.

Use the sizing handles to resize and position your chart.

**Print preview** allows you to see your work before printing. On Excel, it will then show the edge of your workspace with dotted lines.

#### **Activity 2 Performing a calculation on a set of data.**

We will use a copy of your table to allow for an index error on the thermometer.

Under the Edit menu, click Move or copy sheet. Tick the ‘Create a copy’

Highlight the Tab of the copy and rename it ‘Activity 2’

Highlight row 2 (click in the shaded ‘2’). This should highlight the row. From the insert menu, insert a row and repeat to insert more until your table starts at A7 Rename your heading in A1 as ‘Index error adjustment’

In A3 type 'Published melting point of ice' and in cell B3 type '0.0'

In A4 type 'Ice melting point as shown by thermometer' and in cell B4 type '1.5' Your thermometer index error is found by subtracting the thermometer reading from the actual temperature. So in cell A5 type 'Index error to be subtracted' Select cell B5 and then click on the formula ' in the formula bar. Now click on B4, the minus symbol on your keyboard and cell B3 and the OK that appeared. You should see 1.5 appear in cell B5

Highlight cells B3 to B5 and use 'format', 'cells' to get the format box. Choose number from the category and give them 1 decimal place.

Now put these temperature indexing cells into a table.

Use your formatting skills to adjust the column widths so that all the writing appears. Go to your temperature table you copied across and add a heading for 'index error' in the next cell along. (C7)

Now click on the first cell beneath this (ie next to your first temperature number). Click on the formula ' and then the cell with your index error value (B5) and then

OK. Your error should appear again.

Copy this cell to the one beneath it in the same way

Now highlight this cell and move the cross to its bottom right. You should see a solid cross appear.

Drag this down the column and it should copy it as a column of error values next to your temps.

Go to cell B7 and add a column heading for 'Corrected temp

Select the first cell beneath this (B8) and click on the in the formula bar Now click on your first temperature number cell, the '-' and the cell next to it for index error value. After 'OK you should see the index error applied.

Now highlight this cell and move the cross to its bottom right. You should see a solid cross appear. Drag this down the column and you should apply the error to all your data.

You can now format the columns to show all headings and data. If you now change any data, the error is automatically applied.

Extension 1 draw a graph which shows both raw and corrected temps against time.

You will have to deselect the index error series of data as the wizard proceeds.

Tip: Selecting the headings as well as the data allows you to keep track of your data series.

**Extension 2** Add columns so that you can get temperature values in Kelvins

### **Activity 3 Import data into Excel**

The following is a table of data from a datalogging experiment using a trolley rolling down an inclined plane.

<b>Time (s)</b>	<b>Displacement (m)</b>	<b>Velocity (m/s)</b>	<b>Acceleration (metres per second squared)</b>
0	0		
0.2	0.044	0.44	2.2
0.4	0.176	0.88	2.2
0.6	0.396	1.32	2.2
0.8	0.704	1.76	2.2
1	1.1	2.2	2.2
1.2	1.584	2.64	2.2
1.4	2.156	3.08	2.2
1.6	2.816	3.52	2.2

Select the table and right click to copy it.

Go to sheet 2 of your spreadsheet, rename it as datalogger, and select cell A1.

Now right-click and paste. The table should appear as a set of cells.

You can now format the cells and graph the data on one set of axes or as three graphs.

### **Some practice**

1. Design a spreadsheet that will allow you to find any one of P, V, n or T, from PV given R as 8.314. Check it against the data from the Chemical Data sheet.
2. Design a spreadsheet to tabulate the heights of the boys and girls in your class. Obtain a class average and average boy and average girl height. You will use the SUM function for this.
3. Design a spreadsheet that graphs two sine waves and their sum.