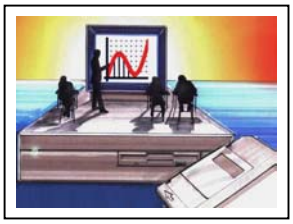

THE DYNAMIC CLASSROOM

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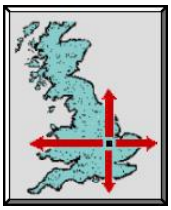
debutler@argonet.co.uk - www.argonet.co.uk/oundlesch



Introduction

Of all the academic subjects, Mathematics has possibly the broadest range of computer-related applications which can help with visualisation and greater understanding. For many teachers this is the great escape from the chalk, but for many though it represents a serious challenge to their well established and perfectly effective teaching styles, throwing up significant training issues.

With more and more classrooms being fitted with projectors, new techniques have to be established to make the best use of them. The key is variety, mixing regular teaching strategies with occasional computer-generated images.

In this presentation Douglas will show a number of lesson plans for secondary and college level mathematics making use of dynamic images from Excel, the Web, geometry software and Autograph. It will go on to show how standard Office tools can help to document the lessons on an intranet system using hyperlinks.

Finally, with pupils the world over tending to find the subject dry and uninteresting, and teachers thinking they have discovered better things to do with their lives, Douglas will try to make the point that technology can have a role to play here in rescuing this dire situation. Technology can help to make the subject appear more lively and relevant, and to add a sparkle to the lessons, thus making the process of teaching and learning the subject more fun, and more effective.

Hardware.

First, to make the best use of technology in the teaching process, the right classroom hardware needs to be in place. Ceiling mounted projectors are the best answer for the time being, but they are still are too expensive for many education authorities to consider. We are about 3-4 years away from affordable large screens (using light-emitting polymers) – see this link to some research papers on this technology:
http://www.argonet.co.uk/oundlesch/class.html.

The companies involved in developing these new 'plastic' screens will undoubtedly have a far reaching impact on education. If they can get the price down far enough it will enable all classrooms to have a large display screen, on which (importantly) the teachers can write with a white-board marker, thus combining their traditional methods with the occasional computer generated image. It will be connected (wireless) to a small portable computer, the local intranet and the internet. It seems a long wait, but we must be ready. Battery technology is also set to improve dramatically, making portable devices easily last a full day – this will remove the need for the final trip-wire, the mains cable! .

New Classroom Teaching Techniques

Many teachers are ill-prepared to make the best use of computer-driven images as part of their teaching. They are anxious about things going wrong which will compromise the effectiveness of the lesson. Interactive White Boards are also being installed in many schools and colleges in many developed countries, giving teachers yet another technological layer to master.

So far as content is concerned, there are various sources of material for the dynamic classroom:

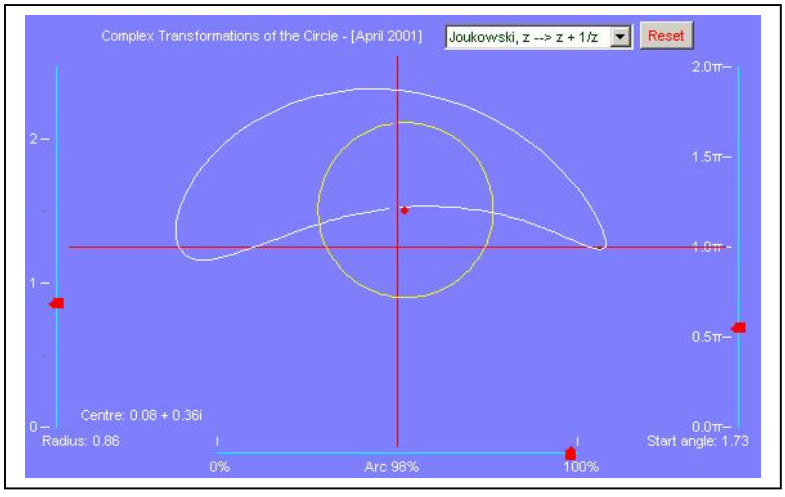
1. Java and Flash resources from the Web
2. Dynamic Software
3. Standard Office tools, including Word/PowerPoint (with hyperlinks) and Excel

1. Java and Flash resources from the Web

A collection of good resources is maintained by the author on:
http://www.argonet.co.uk/oundlesch/mlink.html

and a number will be demonstrated during this talk, covering topics such as

Complex numbers –
transformations of the circle
illustrated here from
"Waldo's Maths Pages"
(by Ron Barrow, UK),
part of a suite of fully interactive Java pages for the secondary and college curriculum.



2. The use of Dynamic Software in mathematics teaching

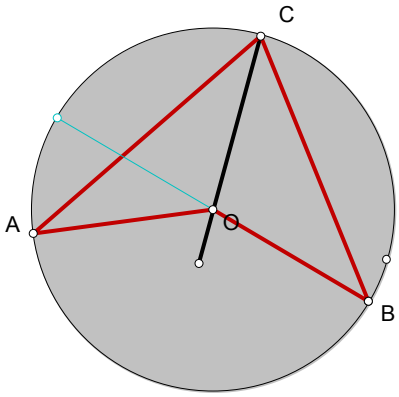
There are countless aspects of the secondary and college level mathematics curriculum for which this approach is effective. But the teachers need to practice making it effective, and training issues are a serious consideration. If the images proceed too quickly the learning can be lost. It is necessary to involve the class at each stage in the process, to get the students to anticipate what is about to happen, maybe to invite a student to draw on the screen first before the computer does it. This is a tried and tested technique, allowing the teacher to determine the pace, and if necessary to force errors from the class to help make good teaching points.

● The Circle Theorems illustrated (dynamically) in **Geometer's Sketchpad**

$m\angle AOB = 141.6°$

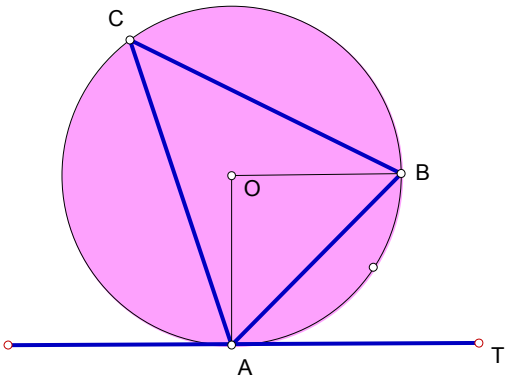
$m\angle ACB = 70.8°$

$\frac{m\angle AOB}{m\angle ACB} = 2.0$



$m\angle TAB = 45.3°$

$m\angle ACB = 45.3°$

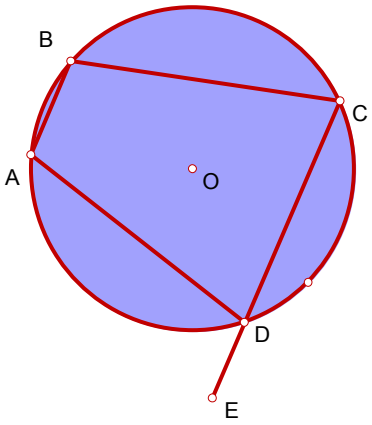


$m\angle EDA = 104.9°$

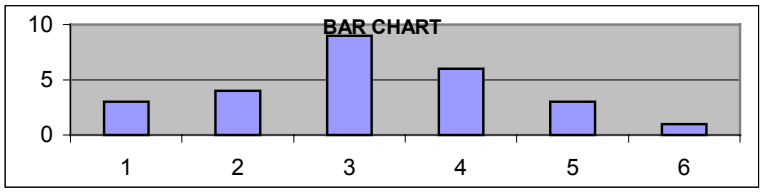
$m\angle ABC = 104.9°$

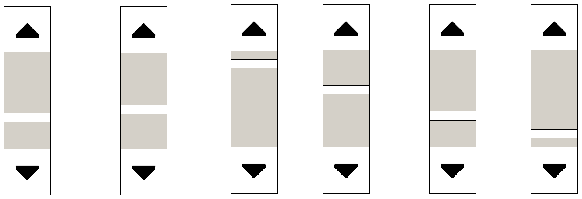
$m\angle CDA = 75.1°$

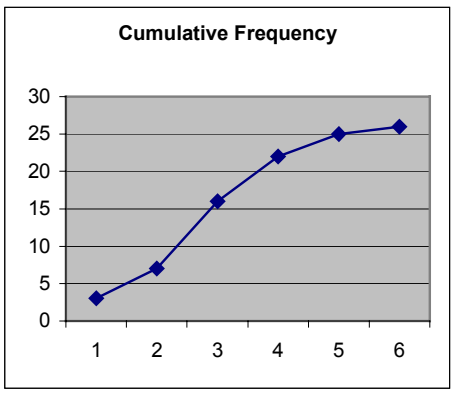
$m\angle ABC + m\angle CDA = 180.0°$



● Dynamic Histograms, in **Excel**
(from Peter Mulkerrin)





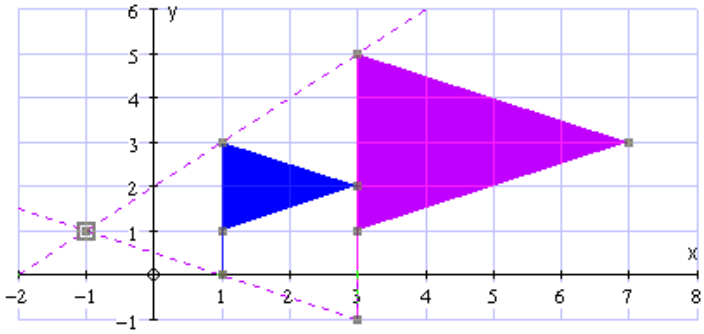


							Σ
Slider	7	6	1	4	7	9	34
f	3	4	9	6	3	1	26
cf	3	7	16	22	25	26	

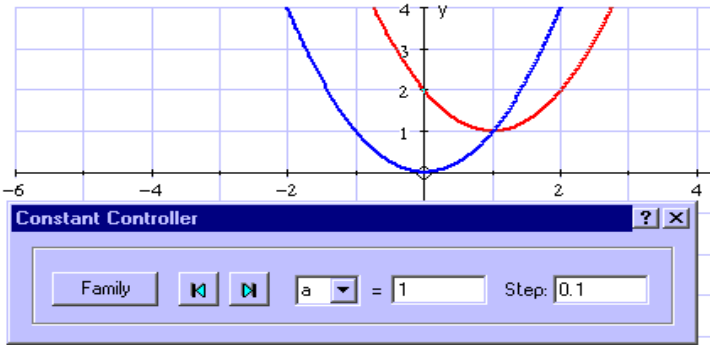
● The use of Autograph

Autograph is a relatively new medium, bringing the world of dynamic and dependent objects to coordinate geometry and statistics. See: www.autograph-math.com for related resources. Some lesson plans follow, showing how dynamic software can add a new dimension to whole-class teaching of secondary and college mathematics.

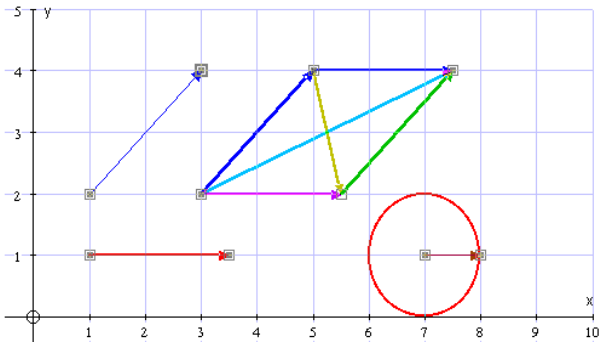
TRANSFORMATIONS
A perfect dynamic situation: the original objects can be moved around, and the parameter that created the second object can be animated. Write on top of the images on the while board to get the students to anticipate the results before the computer.



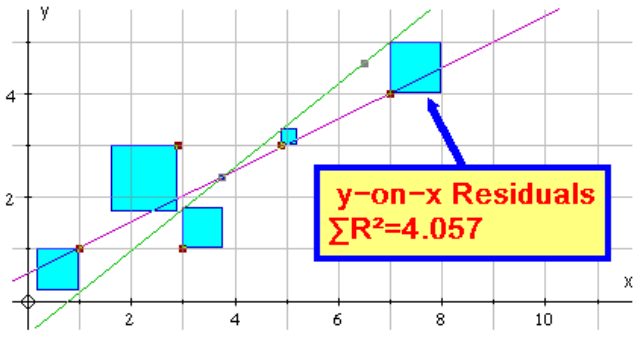
TRANSFORMING CURVES
Several approaches are possible here. Illustrated here is:
$y = x^2$, and $y - b = (x - b)^2$
and then vary a and b
Using function definitions works well too, eg plot $f(x) = x^2$,
then $y = f(ax + b) + c$; vary a, b, c
Then redefine f(x) as sinx.



FUN WITH VECTORS
The principle of copying, adding and subtracting vectors can be explored dynamically. Also scalar multiples (vector equation of a line). The difficult concept of a unit vector can be explored by constructing a unit circle over it and varying the parent vector.



ILLUSTRATING RESIDUALS
Here a variable line is constructed through the centroid and another random point. This line and the data set (which is an object) are selected and the y-on-x residuals illustrated as square. Vary the second point to watch the squares minimize.

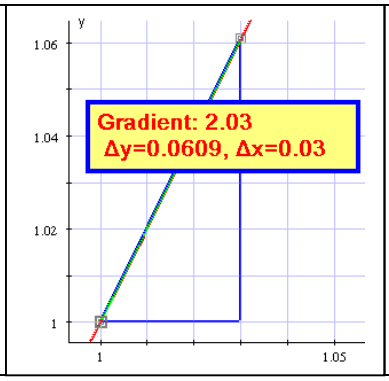


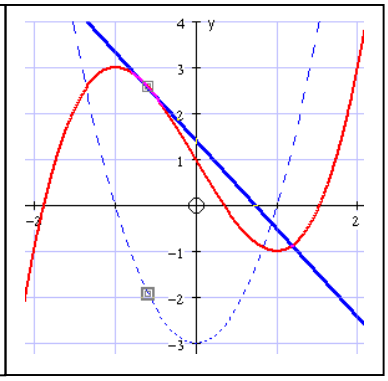
SAMPLE LESSONS USING AUTOGRAPH (2) – the principles of calculus

There are many aspects of the calculus that can be taught very much more effectively with dynamic images. The old thought that a picture is worth a thousand words is never more true, and students gain new insights by observing movement through animation, driven either by the teacher in 'whole-class' presentation, or by the students themselves working through instructions in a lab.

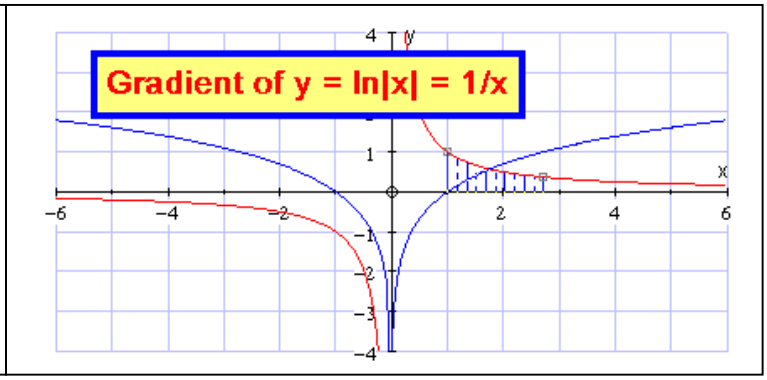
THE CONCEPT OF GRADIENT
(a) zooming in on the gradient of a chord as x2 => x1, observing Δy = 0 and Δx = 0 yet Δy/Δx => 2

(b) Autograph can draw the gradient function slowly, and users can dynamically move a tangent along the parent curve

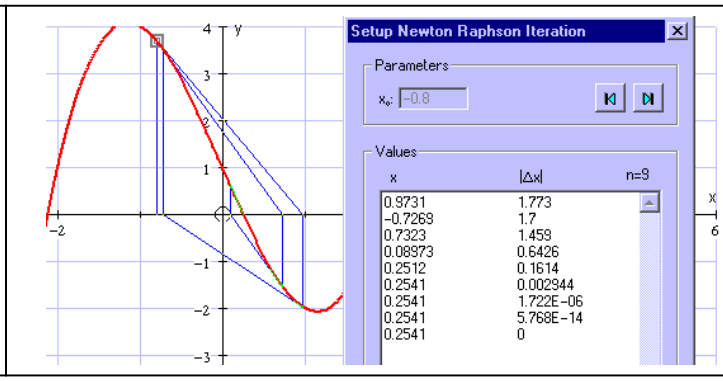




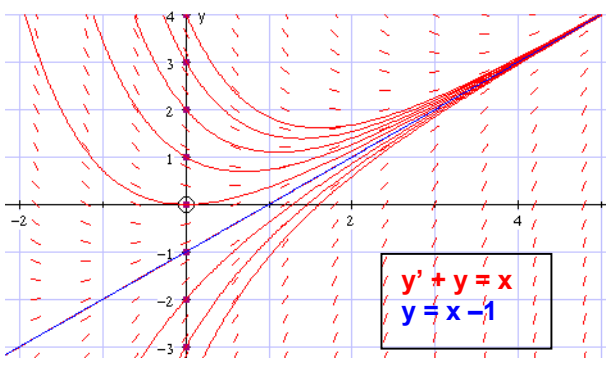
y = 1/x and e and y = lnx
This lesson first shows, by varying the right limit of the area under y = 1.x to find e.
Then plot y = lnx, and show that its gradient is the right branch of y = 1/x. Then develop an argument for y – ln(–x) and finally y = ln|x|



NUMERICAL METHODS
Solving equations by Newton-Raphson, and by the x = g(x) iterative method both lend themselves perfectly to a dynamic approach. The start point can be dragged around, and the equations can have variable parameters.

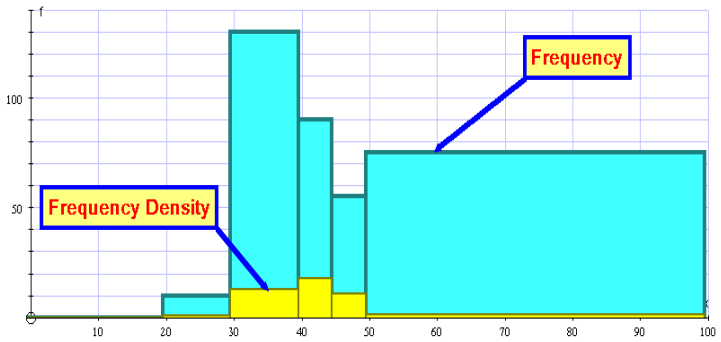


DIFFERENTIAL EQUATONS
Here is a lesson showing the principle of the complimentary function and particular integral. The implicit form of the entry allows the RHS to be changed, say, to sinx. Also, the original equation can have a variable parameter, eg y' + ky = x.

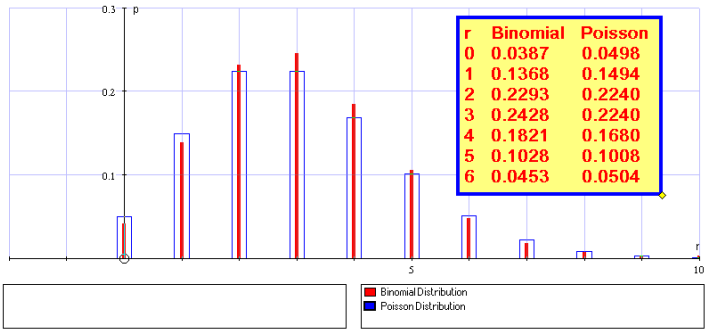


SAMPLE LESSONS USING AUTOGRAPH (3): Probability and Statistics

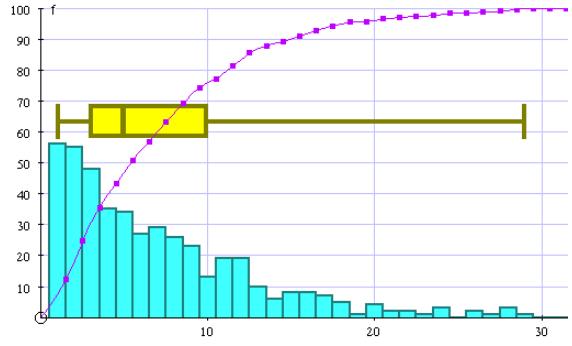
FREQUENCY DENSITY
It is useful to be able to plot a set of grouped data so that students can see the difference between representing the data as **discrete** (displace to the left) or **continuous**, and by **frequency** or **frequency density.**



POISSON APPROXIMATION
Students can get a good insight into the relationship between a binomial distribution and its Poisson approximation by varying the binomial's 'n' and 'p'. Hypothesis tests on the binomial can also be illustrated dynamically.

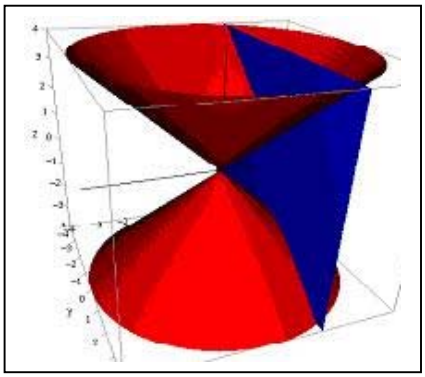


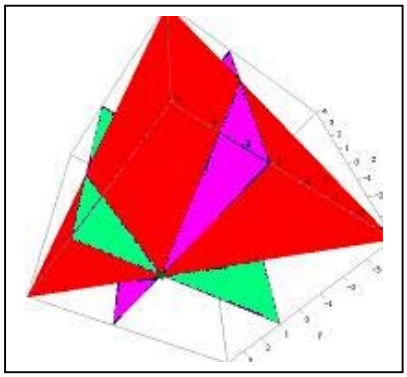
DATA OFF THE NET
The UK Lottery data (6 balls from 49) is collected from all previous results and downloaded to Excel. The distribution of the first ball (in order) copied to *Autograph* offers an unusual bar chart, box and whisker and cumulative frequency diagram.

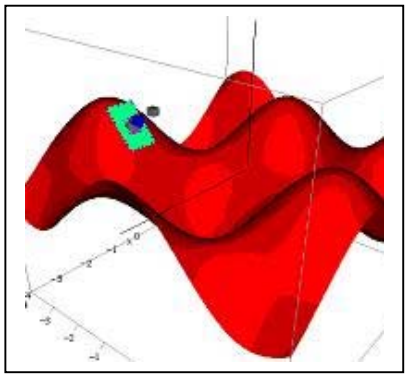


SAMPLE LESSONS USING AUTOGRAPH (4): Excursion in 3D

Autograph is shortly to be extended to explore 3D in a fully interactive object-based environment

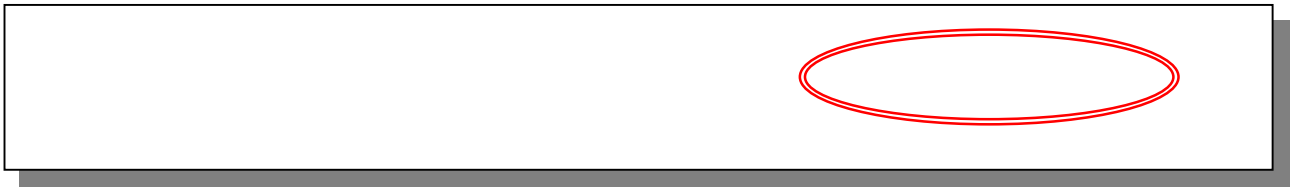






3. The use of standard office tools.

Standard tools, such as MS Office, can be used to help add a sparkle to lesson plans and hand-outs. In particular, Word can be the common denominator of all electronically stored lesson plans and teaching resources for mathematics. First set up some extra tools on the toolbar:



● **WORD documents can contain equations as text**

The UNICODE font system enables each of the major fonts to have its own set of symbols. (though unfortunately a MAC or a PC system prior to W-98 will not display these characters).

Using "Insert" => "Symbol" => "Font" => "Normal Text" you can set up short-cut keys as required so that the current font can use its own symbols. The *suggested* ALT keys to set up are:

ALT	2	3	4	H	R	I	O	0	<	>	+	/	↑	↓
Symbol	²	³	¼	½	√	∫	°	∞	≤	≥	±	÷	↑	↓
ALT	A	B	D	E	F	L	M	N	P	S	T	X	←	→
Symbol	**α**	**β**	**Δ**	**Σ**	**φ**	**λ**	**μ**	**ν**	**π**	**σ**	**θ**	**χ**	←	→

Also available for occasional use (using "Insert" => "Symbol" => "Font" => "Normal Text"):

⅓ ⅔ ¾ ⅛ ⅜ ⅝ ⅞, γεζηικξρςω, ℓ, Γ Π Φ Ω, ≡ ≠ ≈ ∩ ∂

The proper MINUS sign ("–" or "en-dash") is available on Ctrl – using the keypad '–'

Generally, it is worth creating equations and formulae as **text** if possible. These expressions can then be pasted anywhere, eg to an email or in a spreadsheet.

Examples: $\mathbf{y = x\sqrt{(1 - x^2)}}$ $\mathbf{y = \pi \pm \sin^{-1}(\tfrac{1}{2}x)}$

$\mathbf{y = e^{\sin^2 x}}$ $\mathbf{\sigma^2 = (1/n)\Sigma(fx^2) - \mu^2}$

$\mathbf{\chi^2 \sim N(\mu, \sigma^2)}$ $\mathbf{\int \sin^2\theta\cos\theta d\theta = \tfrac{1}{3}\sin^3\theta + c}$

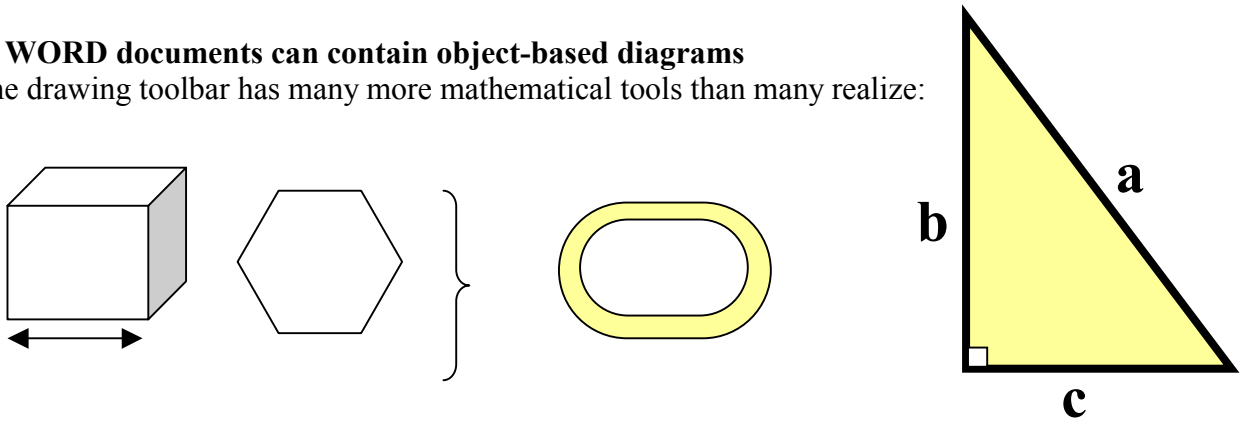
$\mathbf{\int \sin^2\theta d\theta = \int \tfrac{1}{2}(1 - \cos 2\theta)d\theta = \tfrac{1}{2}\theta - \tfrac{1}{4}\sin 2\theta + c}$

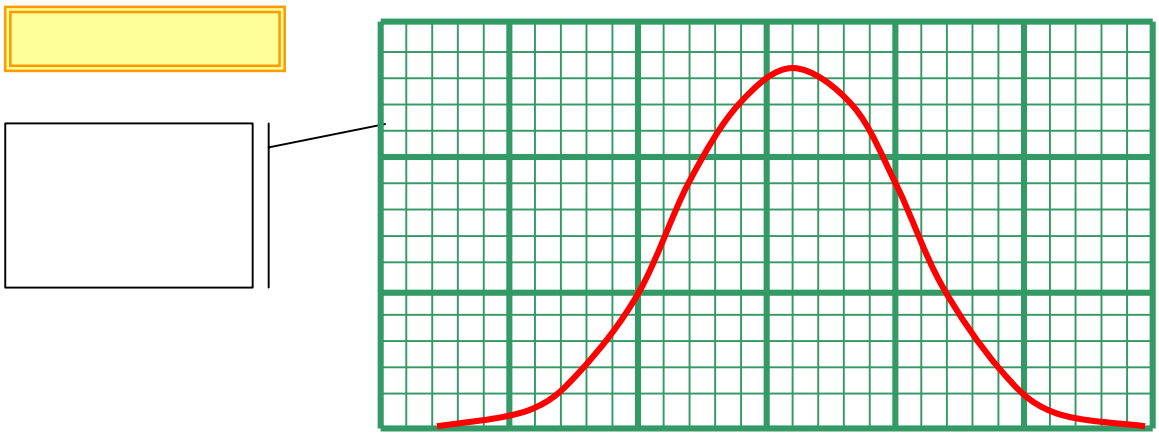
● **WORD documents can contain equations as graphics**

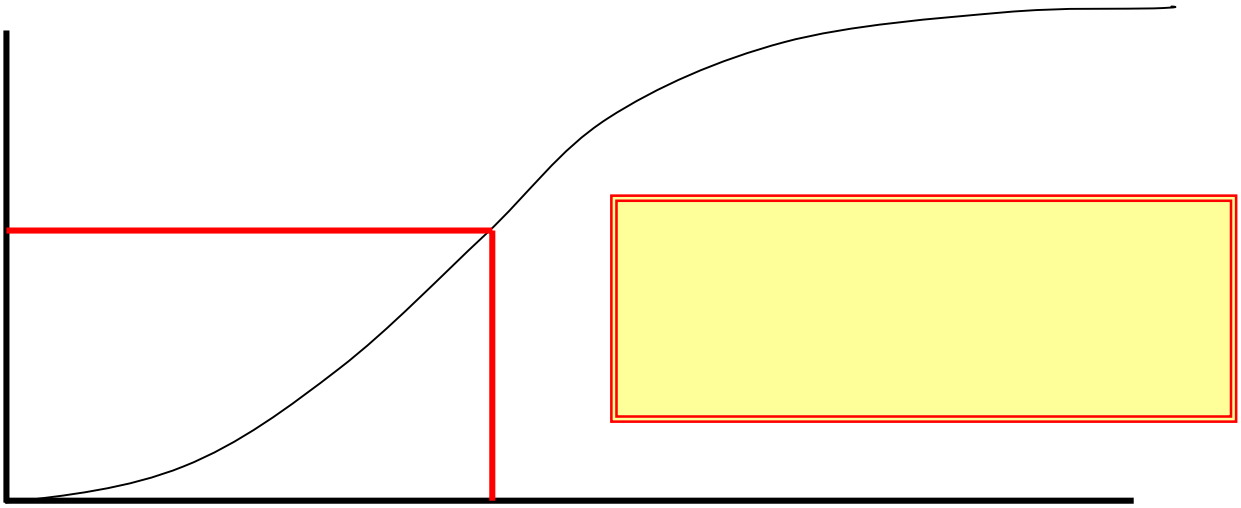
These can be edited only using the Equation editor. Equations created this way are graphics and require format and layout control, Short-cuts can be placed in the "Auto-correct" list when selected in 'move with text' mode.

eg type "qf <ENTER>" for the quadratic formula: $x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

● **WORD documents can contain object-based diagrams**
The drawing toolbar has many more mathematical tools than many realize:







Points to note: the use of SHIFT and CTRL is crucial when creating these objects (Shift: makes the object regular, Ctrl make it centred). Also ensure that "Snap to Grid" is ON, so that objects fit together neatly (use "ALT" to over-ride this).

To put these diagrams together, users need to appreciate the concept of a selectable OBJECT, and the multiple-selection and grouping of objects (using SHIFT) - the basis of all modern dynamic software.

● **WORD documents can contain HYPERLINKS, using** 
linking to bookmarks in the same document, eg back to the start
linking to files on the hard drive (eg an Excel file)

linking to web pages (URLs), eg www.argonet.co.uk/oundlesch
eg, some useful web links from the Oundle site with dynamic images for the classroom:

MATHEMATICAL RESOURCES

UK	PLUS - Maths magazine - NRICH - Online Maths Club
	Count-on (MathsYear 2000)
AUSTRALIA	Maths300 (Lessons on the Web)
JAPAN	Mathematical JAVA applets
SWEDEN	TIPTOP Virtual Laboratory - JAVA applets

MATHEMATICAL ENTERTAINMENT

Ron Knott's Fibonacci pages
Integer Lists to full accuracy
History of Mathematics (St Andrews)

STATISTICAL RESOURCES

DATA SETS [there are further data resources on the Autograph site]

DASL: USA Data and Story Library
The UK Lottery
Data from UN, by country
Statistical web resources from Sidney Tyrrell, Coventry University, UK

● **WORD documents can contain items pasted from other applications**
eg a graph or text from Autograph, Excel or the Web – these are often best placed in a text box for greater layout control.

Conclusions:

Mathematicians have been teaching the subject with nothing more that a writing surface and a piece of chalk for centuries, and to good effect, certainly with the more able – these are pupils who can, by and large, visualise the subject for themselves. The real beneficiaries in the new, visual approach are the next ability level down. The rewards to them can be considerable, and there is every chance that this approach can help numbers who want to take the subject further to rise.