

Introduction to Geogebra

Geogebra is freely available open-source software. It can be downloaded from <http://www.geogebra.org>. The Geogebra website also contains introductory materials, help documents and a user forum.

Geogebra combines geometry, algebra, graphing and statistics. It includes a large number of mathematical and statistical functions, and also a spreadsheet. All these aspects of Geogebra can be made to work together to produce resources which allow students to explore key features of a topic. Alternatively, students can create their own simple constructions.

Key features

The screenshot shows the Geogebra interface with several callout boxes:

- Menu – used to change settings etc**: Points to the menu bar at the top (File, Edit, View, Perspectives, Options, Tools, Window, Help).
- Toolbar – used for adding objects and constructions geometrically**: Points to the toolbar below the menu bar, which contains various geometric construction tools.
- Algebra pane, listing all variables and objects**: Points to the Algebra pane on the left, which lists:
 - Free Objects: $f(x) = x^3$
 - Dependent Objects: $A = (0.62, 0.24)$ and $a: y = 1.15x - 0.48$
- Graphics pane**: Points to the main graphics view, which displays a coordinate plane with a red curve $y = x^3$ and a grey line $y = 1.15x - 0.48$. A point A is marked at the intersection of the two curves.
- Input bar – used for adding graphs and other objects algebraically**: Points to the input bar at the bottom, which contains the text "Input: $y=x^3$ ".

Example 1: demonstrating a geometric result

In a circle, a radius perpendicular to a chord bisects the chord

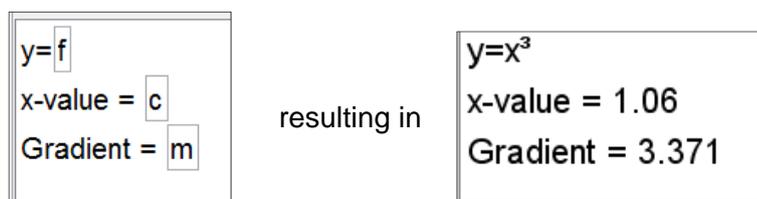
1. Construct a circle using 'Circle with centre and radius' via the Toolbar
2. Mark two points on the circle B and C using 'Point on Object'
3. Add a line through B and C using 'Line through two points'
4. Construct a line through the centre of the circle perpendicular to the chord, using 'Perpendicular Line'
5. Mark the intersection D of the chord and the perpendicular, using 'Intersect two Objects'
6. Construct line segments BD and CD
7. Right-click on each segment and choose 'Object Properties' Set the label to show the Value (in this case the length)
8. You can now drag the points C and D around the circle, showing that the BD and CD are always equal.

Teaching points:

- Does this prove the theorem?
- How can you prove the theorem?

Example 2: gradient of a curve

1. Create a slider (n) going from 1 to 5, with increment 1
2. Enter the graph $y = x^n$
3. Create a point A on the curve and a tangent to the curve through this point
4. Show the gradient of the curve using the 'Slope' tool. This generates a variable for the gradient in the Algebra pane
5. Type $c = x(A)$ to obtain the x-coordinate of A
6. Create a text box, selecting objects from the list to create dynamic text:



7. This construction may be easier to use with the grid switched on (right-click on the graphics pane to access settings).

Teaching points

- Investigate the gradient of the curve for different values of n, and try to find a general result for the gradient of the curve at any point.
- Does this prove the result? How can it be proved?
- Extend the work by changing the settings of the slider to allow negative and/or fractional values of n. Does the rule still work?

Finding out more

Useful tips:

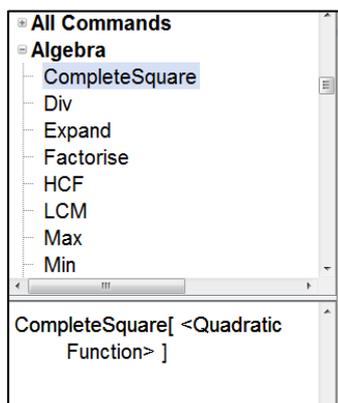
- You can use the 'Move Graphics View' tool to stretch or compress either axis by clicking on the axis and dragging.
- Changing colours and line thicknesses can make a resource look more effective. Right-click on an object and choose 'Object Properties' and then select the appropriate tab.
- Text boxes with dynamic text are useful for helping students to focus on the results that they need.
- You can hide an object that you need as part of the construction but that doesn't need to be visible – this makes the screen less cluttered
- When plotting a trigonometric graph, if you want to use degrees you must enter $y = \sin x^\circ$. The degree symbol appears on a palette at the right-hand end of the input box.

Commands and functions

Geogebra has a large number of mathematical functions and commands built into it. Functions, e.g. \sqrt{x} for a square root and $\exp(x)$ for an exponential, may be used in the equations of graphs or to define a variable.

Commands are typed into the Input box and applied to existing objects. For example, the ComplexRoot command can be applied to a polynomial, e.g. $\text{ComplexRoot}[x^2 - x + 4]$, or $\text{ComplexRoot}[f]$ if you have already defined f .

The easiest way to find out about functions and commands is to look at the Help panel. Toggle the arrow icon in the bottom right corner to show or hide the Help panel. The top part of this panel lists all the functions and commands. Double-clicking on one of these transfers it to the input bar where you just need to add the appropriate variable or object. For commands, the required arguments are shown in the bottom panel.



Further help

More information can be found at www.geogebra.org. Under the Help section you will find the Geogebra manual. There is also a link to the Geogebra User Forum where you may be able to find help.

Exercises to try

1. Demonstrate other circle theorems: e.g. the angle in a semicircle is a right angle, or the angle subtended at the centre is half the angle subtended at the circumference
 - use the 'Angle' tool
2. Construct a resource to investigate polynomial graphs, with the aim of getting students to generalise about the number of roots and number of turning points for a polynomial of degree n
 - use sliders for the coefficients
3. Construct a resource to investigate the relationship between the completed square form of a quadratic function and its graph.
 - use sliders for the values a , b and c in $a(x + b)^2 + c$
4. Investigate the locus of a point which is the same distance from a fixed point as from a fixed line
 - use a slider a for the distance, use the intersection points of a line and a circle
 - construct line segments from the intersection points to the point and the line, then hide the line and circle
 - Go to 'Object Properties' for the intersection points and click 'Trace on' – this traces out the locus as you vary the value of a
 - this could be extended using eccentricity to look at other conics
5. Matrices and transformations: construct a resource to investigate the effects of matrices
 - you can define a matrix e.g. $M = \begin{pmatrix} 2 & 1 \\ 0 & 4 \end{pmatrix}$
 - you can transform a point e.g. $M \cdot A$
 - you can transform an object using `ApplyMatrix[<Matrix>, <Object>]`, e.g. create a triangle using the 'Polygon' tool and transform it
 - you could use sliders to vary the elements of the matrix
6. Complex numbers: construct a resource to investigate the geometrical effects of multiplying or dividing complex numbers
 - entering a complex number such as $2 + 3i$ plots the point $(2, 3)$
 - $\text{abs}(z)$ gives the modulus and $\text{arg}(z)$ gives the argument
 - you can multiply or divide two complex numbers by entering $z \cdot w$ or z/w