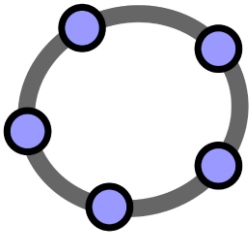

GeoGebra Quickstart

A quick reference guide for GeoGebra 3.0

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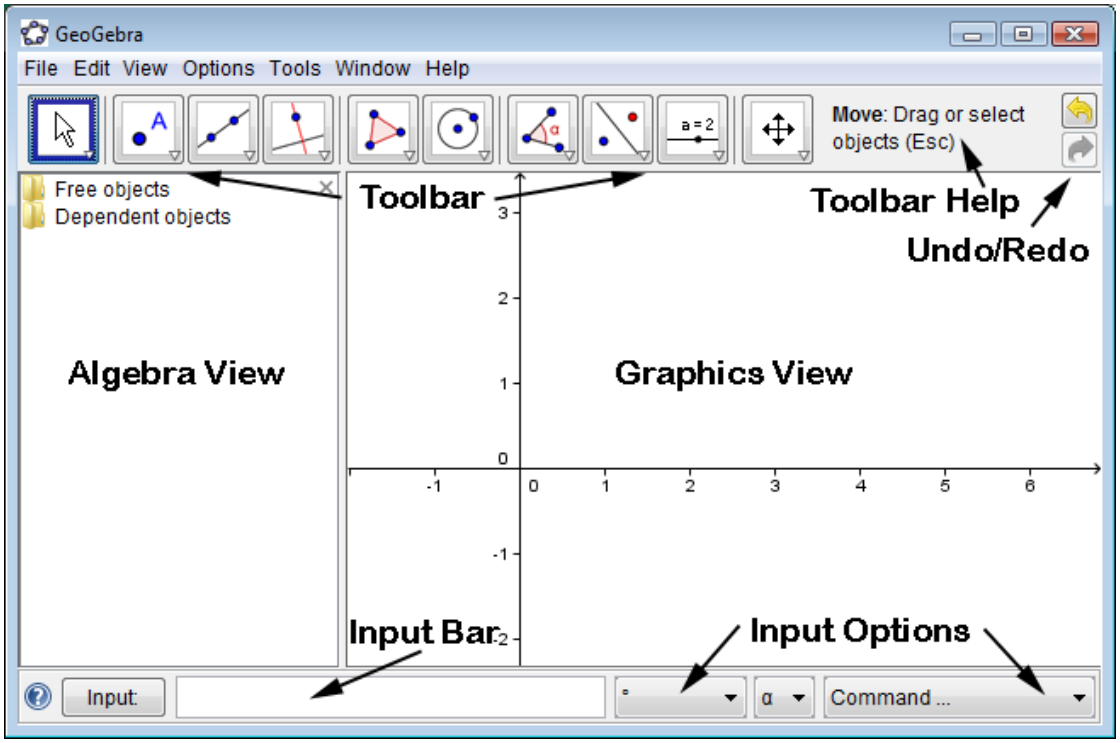
GeoGebra is free and multi-platform educational dynamic mathematics software that joins geometry, algebra, and calculus in an easy to use package.

On the one hand, you can create constructions with the mouse by using a variety of construction tools to create points, vectors, segments, lines, and conic sections. On the other hand, you may directly input algebraic expressions and functions by using a syntax that is based on school-notation (e.g., *g: 3x + 4y = 7* to enter a linear equation, or *c: (x – 2)^2 + (y – 3)^2 = 25* to enter a circle).

The most remarkable feature of GeoGebra is the dual representation of mathematical objects: every expression in the algebra view corresponds to an object in the graphics view and vice versa. No matter how you created these objects in GeoGebra, you can easily modify them using the mouse or additional keyboard input. In addition, a range of commands are available that allow you to create new objects or modify existing ones (e.g., *Centroid*, *Derivative*, *Extremum*, *Perimeter*).



After starting GeoGebra, you will see the window shown above. Using construction tools in the *toolbar* you can create constructions in the *graphics view* by using the mouse. At the same time, the corresponding coordinates and equations are displayed in the *algebra view*. The *input bar* is used to enter coordinates, equations, commands, and functions directly, which are displayed in both, the *algebra* and the *graphics view* immediately after pressing the *Enter*-key. In addition, GeoGebra provides *Undo/Redo buttons* as well as lists of *Input Options* in order to make it easier for you to correct mistakes and enter expressions using the keyboard.

This *GeoGebra Quickstart* document is meant to facilitate your first contact with the software by guiding you through the following three examples. We recommend for you to work through the instructions and also try out the given tips and tricks.

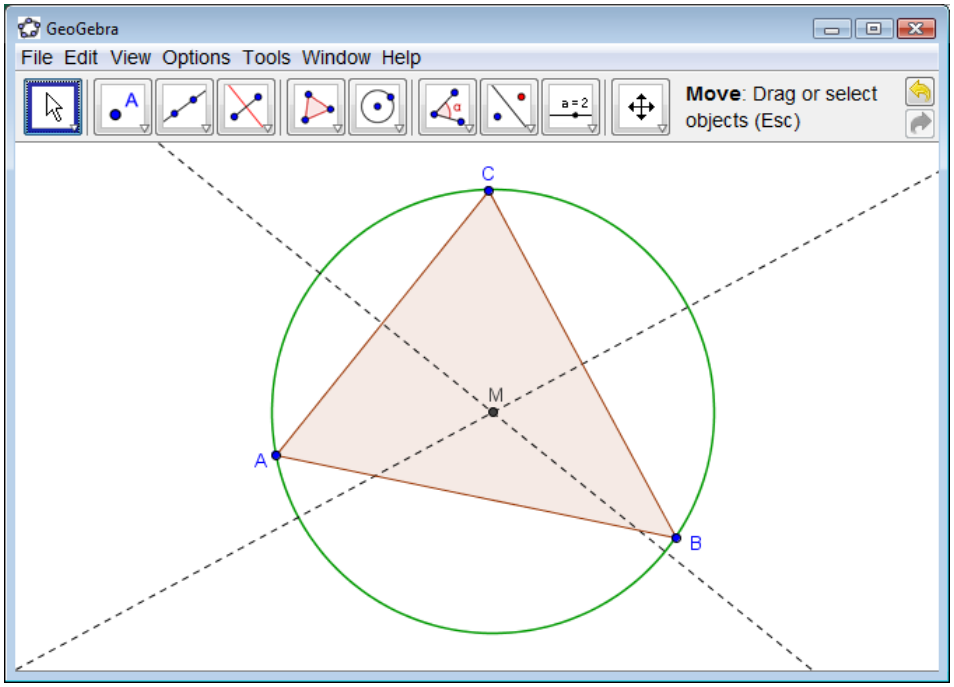
Example 1: Circumcircle of a Triangle
Example 2: Tangents to a Circle
Example 3: Derivative and Slope Function

Please familiarize yourself with the interface of GeoGebra before you actually start your first construction:

- **Open the Toolboxes**: Click on the small arrow in the lower right corner of the icon of any construction tool to open the corresponding toolbox. It contains a selection of similar tools (e.g., point tools, transformation tools).
- **Toolbar Help**: Select different construction tools and read their toolbar help. It gives you the name of the activated tool and explains how to actually use it.
- **Visibility of Algebra View and Input Bar**: *Algebra view* and *input bar* can be hidden or shown using the *View* menu. Just check or uncheck the corresponding menu item to change the visibility status of these interface components.
- **Undo/Redo Buttons and Input Options**: Make sure you know where to find them and to use them in order to facilitate using GeoGebra.

Example 1: Circumcircle of a Triangle

Task*:* Draw a triangle A, B, C and construct its circumcircle using the construction tools as well as commands.



Construction Using the Mouse

Hide the a*lgebra view* and *input bar*. In the *Options* menu, set the 'Labeling' option to 'New points only'.

Select tool *Polygon* from the toolbar. Click in the graphics view three times to create the vertices *A*, *B*, and *C*. Close the triangle by clicking on point *A* again.

Hint: Select tool *Move* and drag the points or their labels to change their position in the graphics view.

Select tool *Line bisector* from the corresponding toolbox. Construct two line bisectors by clicking on two sides of the triangle.

Select tool *Intersect two objects* and click on the intersection of both line bisectors. This will create the intersection point *D* which is the center of your triangle's circumcircle.

Rename this intersection point to 'M': Select tool *Move* and click on the intersection point. When it is highlighted, type the upper case letter 'M' in order to open the 'Rename' dialog window. Click button 'Apply' to apply the name change.

Select tool *Circle with center through point*. Click first on the center point *M* and then on any vertex of the triangle to create the circumcircle.

Drag test: Select tool *Move* and use the mouse to change the position of any of the vertices. If you did the construction correctly, the circumcircle of the triangle will always run through all three of its vertices.

Tips and Tricks

- Show/hide objects: To hide an object, right click on it (Mac OS: *Ctrl*-click) and uncheck 'Show object'. To show an object again, you can either right click (Mac OS: *Ctrl*-click) on it in the *algebra view* or use the *Properties dialog* (see next tip).
- Properties dialog: The appearance of objects (e.g., color, line style) can be changed easily in the *Properties dialog*: Use the right mouse button (Mac OS: *Ctrl*-click) again to click on the object and choose 'Properties' from the appearing context menu.
- Position of graphics view: In order to change the position of the graphics view, choose the tool *Move drawing pad* and use the mouse to drag the graphics view.
- Construction protocol: You can open the *construction protocol* using the *View* menu. It provides a table listing all the steps you took while doing your construction. The *construction protocol* allows you to redo your construction step by step by the use of the arrow keys, or to modify the order of various construction steps

(see the *Help* menu of the construction protocol). In addition, you are able to hide or show different columns of the construction protocol using the *View* menu of the construction protocol window.

- More information: You can find more information about constructions by mouse in the *GeoGebra Help* document (menu *Help*, or online at www.geogebra.org/help - section 'Geometric input').

Construction Using the Input Bar

You can now repeat this construction of a triangle's circumcircle by using the *input bar* instead of the mouse. Open a new graphics view by selecting 'New' from the *File* menu.

Hint: You might want to save your construction before you open a new window.

Show the input bar at the bottom of the GeoGebra window (menu *View*). Type the following commands into the input bar and press the *Enter*-key after every line.

```
A = (2, 1)
B = (12, 5)
C = (8, 11)
```

Hint: You have just created the three vertices for your triangle.

```
Polygon[A, B, C]
l_a = LineBisector[a]
l_b = LineBisector[b]
```

Hint: Objects *a* and *b* are sides of triangle *ABC*. Input `l_a` creates an index *a* for object *l* which is shown as l_a on screen.

```
M = Intersect[l_a, l_b]
Circle[M, A]
```

Hint: Input `M =` names the intersection point *M*.

Tips and Tricks

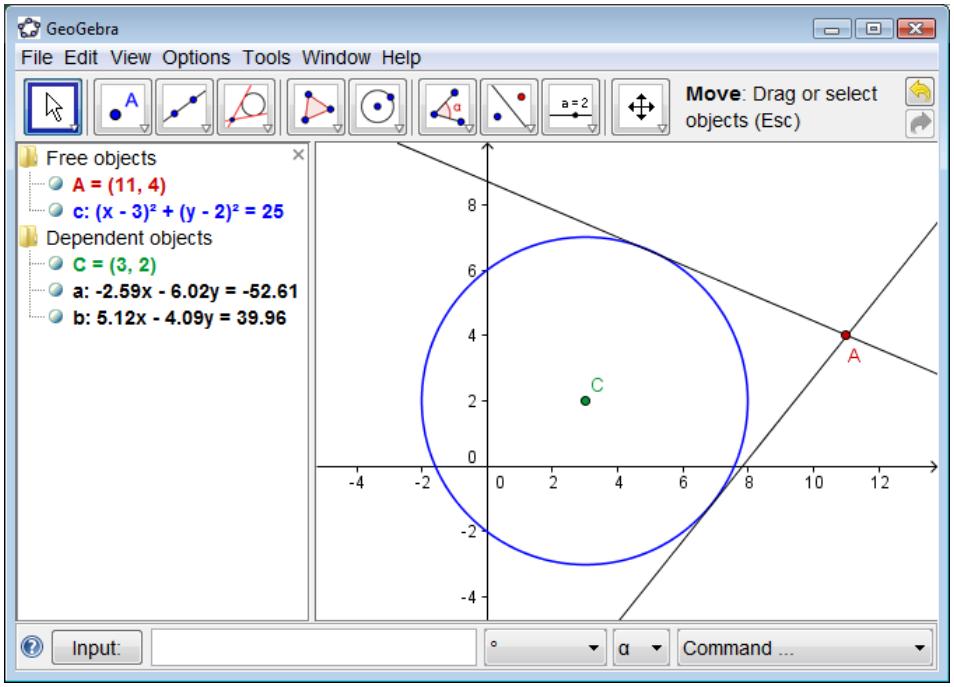
- Automatic completion of commands: After entering the first two letters of a command, GeoGebra tries to complete it automatically. If you want to adopt the suggestion, press the *Enter*-key, otherwise just continue typing.
- List of commands: The input options at the bottom of the GeoGebra window provide a list of all available commands. Therefore, you don't need to type in every command, but you can also select it from the provided list instead.
- Input icon: Clicking at the icon 'Input' at the bottom left activates the mode 'Input bar'. In this mode, you can click on any object in the algebra or graphics view to

copy its name into the input bar. For more tips concerning the input bar click on the question mark in the bottom left corner of the GeoGebra window.

- Combination of input forms: You will obtain especially good results from your work with GeoGebra by combining the advantages of both input forms, mouse and input bar.

Example 2: Tangents to a Circle

Task: Draw circle c: $(x - 3)^2 + (y - 2)^2 = 25$ and construct its tangents through point A = (11, 4).



Construction Using Input Bar and Mouse

Type the equation `c: (x - 3)^2 + (y - 2)^2 = 25` into the input bar and press the *Enter*-key to create circle *c*.
Hint: Exponents can be found in the left most input options list.

Use tools *Zoom in* and *Zoom out* (or the mouse wheel) as well as tool *Move drawing pad* to adjust the graphics view if the circle doesn't fit into the graphics view.

Enter command `C = Center[c]` into the input bar.

Create point *A* by typing in `A = (11, 4)` or using tool *New point*.

Select tool *Tangents* and click on point *A* and circle *c*.

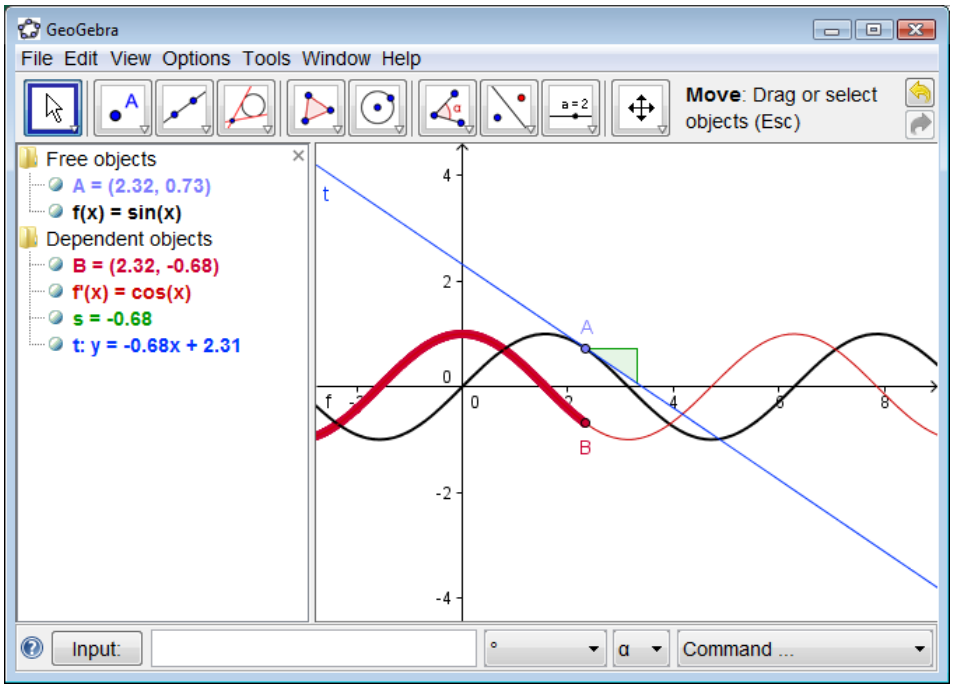
Select tool *Move* and drag point *A* with the mouse to observe the movement of the tangents. Also, try to drag circle *c* and examine its equation in the algebra view.

Tips and Tricks

- Modifying equations: After selecting tool *Move*, you can modify the equation of the circle directly in the algebra view. Just double click the equation and make your changes in the appearing editing field. Press the *Enter*-key to apply your modifications.
- More information: You can find further information about the possibilities of the input bar in the *GeoGebra Help* document (menu *Help*, or online at www.geogebra.org/help - section 'Algebraic input').

Example 3: Derivative and Slope Function

Task: Create function *f(x) = sin(x)* and construct its tangent to a point on the function graph in order to construct the slope function or derivative.



Version 1: Point on Function

Enter function `f(x) = sin(x)` into the input bar and press the *Enter*-key.

Select tool *New point* and click on the function graph. This creates a point *A* on the function graph.
Hint: Wait for the function graph to be highlighted before you click to create the point.

Select tool *Move* and drag point *A* with the mouse to check if it was created correctly: the point needs to be restricted to move along the function graph.

Select tool *Tangents*. Click on point *A* and function *f*.

Change the tangent's name to *t*: Select tool Move and click on the tangent. Type in 't' to open the 'Rename' dialog window and click the 'Apply' button.

Enter command `s = Slope[t]`
Hint: This calculates the tangent's slope and draws its slope triangle.

Select tool Move and drag point *A* with the mouse to examine the movement of tangent *t*.

Enter `B = (x(A), s)` to create a point *B* that has the same x-coordinate as point *A* and the slope of the tangent as its y-coordinate.
Hint: `x(A)` gives you the x-coordinate of point *A*.

Turn on the *trace* of point *B*: Click on point *B* with the right mouse button (Mac OS: *Ctrl*-click) and select 'Trace on' from the appearing context menu.

Select tool *Move* and drag *A* with the mouse. Point *B* will leave a trace that draws the slope function or derivative of function *f*.

Check your construction: Type the command `Derivative[f]` into the input bar. Check if the trace of point *B* exactly matches the graph of the derivative.

Tips and Tricks

- Change the function's equation: Enter a different function into the input bar (e. g. `f(x) = x³ - 2x²`) to overwrite the initial function *f*. Note that your construction immediately adapts to this change.
- Dragging a function graph: Select tool *Move* and drag the function graph with the mouse. Observe the changing equations of the function and its derivative.

Version 2: Point at x = a

You are now going to create another version of the last construction. Open a new GeoGebra window by selecting 'New' from the *File* menu. Type the following commands into the input bar and press the *Enter*-key after every line.

```
f(x) = sin(x)
a = 2
```
Hint: Number *a* is not displayed in the graphics view by default.

```
T = (a, f(a))
```
Hint: This creates a point *T* on the function graph with x-coordinate *a*.

```
t = Tangent[a, f]
```
Hint: This creates a tangent to function *f* at position *a*.

```
s = Slope[t]
B = (a, s)
```
Hint: This creates a point *B* with x-coordinate *a* and slope *s* as a y-coordinate.

```
Derivative[f]
```

Change the value of number *a* in one of the following ways:

- Arrow keys: Select tool *Move* and click on number *a* in the *algebra view*. You can now change the value of number *a* by pressing the arrow keys on your keyboard. At the same time, point *T* and tangent *t* will move along the function graph.
- Sliders: You can also change the value of number *a* by using a slider: right-click (Mac OS: ctrl-click) on number *a* in the *algebra view* and select 'Show object' from the appearing context menu. You are now able to drag the point of the slider with the mouse to change the value of number *a*.
  Note: Numbers are displayed as sliders in the graphics view of GeoGebra.

Tip: Sliders and also the arrow keys can be very useful to examine parameters of equations, for example the parameters *p* and *q* in the quadratic equation $y = x^2 + p\,x + q$.

Version 3: Tangent in Parametric Form

GeoGebra is able to deal with vectors and also parametrical representations of lines. Therefore, it is possible to construct a tangent *t* without using tool *Tangents* or command *Tangent[].*

Remove the tangent from your last construction: Click on the tangent with the right mouse button (Mac OS: *Ctrl*-click) and select 'Delete' from the appearing context menu.

Enter the following commands into the input bar to create a vector *v* and tangent *t* in parametric form:

`v = (1, f'(a))`
Hint: `f'(a)` gives you the derivative of function *f*.

`t: X = T + r v`
Hint: Vector *v* is the direction vector of tangent *t*. Instead of parameter *r* you could also use any other letter that is not used in your construction as a parameter.

Tips and Tricks

- Tangent with direction vector: There is an additional possibility to construct the tangent by using the direction vector *v* and command *Line*: `t = Line[T, v]`
- More information: You can find further information about the commands of GeoGebra in the *GeoGebra Help* document (menu *Help*, or online at www.geogebra.org/help - sections 'Algebraic input', 'Commands'). You can also download the *GeoGebra Help* document as a pdf-file at *www.geogebra.org/help*.

Further Information

Please visit GeoGebra's homepage www.geogebra.org to find more information as well as the most recent version of GeoGebra.

GeoGebra also allows you to easily create interactive web pages, so called *dynamic worksheets*, that can be used with every Internet browser (e.g., Firefox, Safari, Internet Explorer). You can find examples and additional information on GeoGebra's web page.

GeoGebra Homepage	www.geogebra.org
GeoGebra User Forum	www.geogebra.org/forum
GeoGebraWiki - pool of educational materials	www.geogebra.org/en/wiki