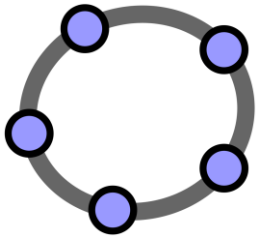


GeoGebra

www.geogebra.org

Introduction of GeoGebra

Background Information about GeoGebra

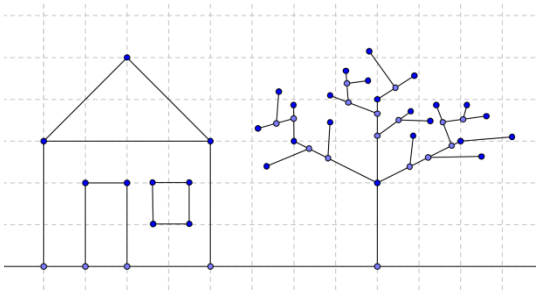
GeoGebra is dynamic mathematics software for schools that joins geometry, algebra, and calculus.
On the one hand, GeoGebra is an interactive geometry system. You can do constructions with points, vectors, segments, lines, conic sections as well as functions while changing them dynamically afterwards.
On the other hand, equations and coordinates can be entered directly. Thus, GeoGebra has the ability to deal with variables for numbers, vectors, and points. It finds derivatives and integrals of functions and offers commands like *Root* or *Vertex*.
These two views are characteristic of GeoGebra: an expression in the Algebra View corresponds to an object in the Graphics View and vice versa.

GeoGebra's User Interface

GeoGebra's user interface consists of a Graphics View and an Algebra View. On the one hand, you can operate the provided geometry tools with the mouse in order to create geometric constructions in the Graphics View. On the other hand, you can directly enter algebraic input, commands, and functions into the Input Bar by using the keyboard. While the graphical representation of an object is displayed in the Graphics View, its algebraic numeric representation is shown in the Algebra View.

Drawings

Preparations



- Hide the *Algebra View* and *coordinate axes* (*View* menu).
- Show the *coordinate grid* (*View* menu).

Draw a Picture with GeoGebra

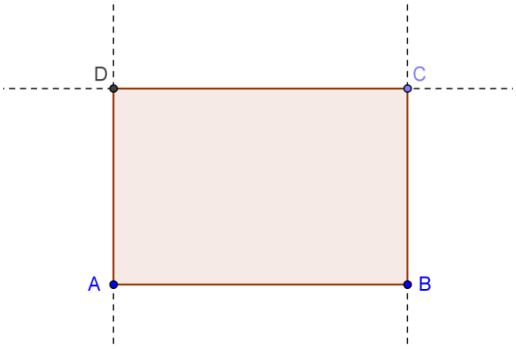
Use the mouse and the following selection of tools in order to draw figures in the Graphics View (e.g. square, rectangle, house, tree,…).

	**New Point** Hint: Click in the Graphics View or an already existing object to create a new point.	**New!**
	**Move** Hint: Drag a free object with the mouse.	**New!**
	**Line through Two Points** Hint: Click in the Graphics View twice or on two already existing points.	**New!**
	**Segment between Two Points** Hint: Click in the Graphics View twice or on two already existing points.	**New!**
	**Delete Object** Hint: Click on an object to delete it.	**New!**
	**Undo / Redo** Hint: Undo / redo a construction step by step.	**New!**
	**Move Graphics View** Hint: Click and drag the Graphics View to change the visible part.	**New!**
	**Zoom In / Zoom Out** Hint: Click in the Graphics View pad to zoom in / out.	**New!**

Rectangle Construction

Preparations

- Open new GeoGebra file.
- Hide Algebra View, Input Bar and coordinate axes (*View* menu).
- Change the labeling setting to *New Points Only* (menu *Options – Labeling*).



Introduction of New Tools

	**Perpendicular Line** **New!** Hint: Click on an already existing line and a point in order to create a perpendicular line through this point.
	**Parallel Line** **New!** Hint: Click on an already existing line and a point in order to create a parallel line through this point.
	**Intersect Two Objects** **New!** Hint: Click on the intersection point of two objects to get this one intersection point. Successively click on both objects to get all intersection points.
	**Polygon** **New!** Hints: Click in the Graphics View or on already existing points in order to create the vertices of a polygon. Connect the last and first vertex to close the polygon! Always connect vertices counterclockwise!

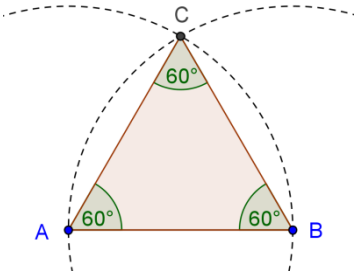
Instructions

1		Segment *AB*
2		Perpendicular line to segment *AB* through point *B*
3		New point *C* on perpendicular line
4		Parallel line to segment *AB* through point *C*
5		Perpendicular line to segment *AB* through point *A*
6		Intersection point *D*
7		Polygon *ABCD* Hint: To close the polygon click on the first vertex again.
8		Save the construction
9		Apply the drag test to check if the construction is correct

Equilateral Triangle Construction

Preparations

- Open new GeoGebra file.
- Hide Algebra View, Input Bar and coordinate axes (*View* menu).
- Change the labeling setting to *New Points Only* (menu *Options – Labeling*).



Introduction of New Tools

	**Circle with Center through Point** **New!** Hint: First click creates center, second click determines radius of the circle.
	**Show / Hide Object** **New!** Hints: Highlight all objects that should be hidden, then switch to another tool in order to apply the visibility changes!
	**Angle** **New!** Hint: Click on the points in counterclockwise direction! GeoGebra always creates angles with mathematically positive orientation (= counterclockwise).

Hints: Don't forget to read the toolbar help if you don't know how to use a tool. Try out all new tools before you start the construction.

Instructions

1		Segment *AB*
2		Circle with center *A* through *B* Hint: Drag points *A* and *B* to check if circle is connected to them.
3		Circle with center *B* through *A*
4		Intersect both circles to get point *C*
5		Polygon *ABC* in counterclockwise direction
6		Hide circles
7		Show interior angles of triangle Hint: Clockwise creation of the polygon gives you the exterior angles!
8		Save the construction
9		Apply the drag test to check if the construction is correct.

Linear Equations

Preparations

- Open new GeoGebra file.
- Show the Algebra View, Input Bar, and coordinate axes (*View* menu).

Introduction of New Tool

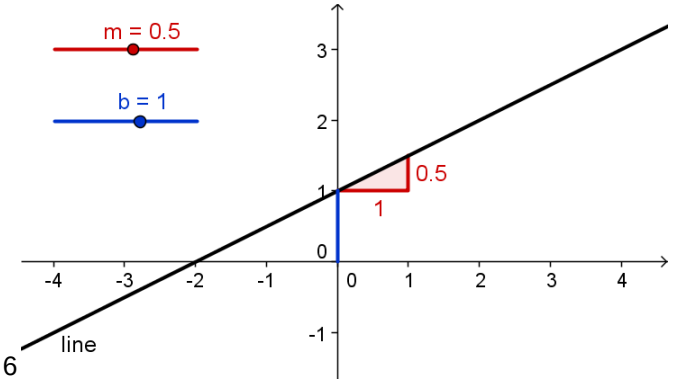
	**Slope** **New!** Hint: Click on an already existing line to create the slope and draw a slope triangle.

Hints: Don't forget to read the toolbar help if you don't know how to use the tool. Try out the new tool before you start the construction.

Instructions 2

1		Delete the line created in activity 1.
2		Create sliders *m* and c using the default settings of sliders.
3		Enter `line: y = m * x + c` Hint: Don't forget to use an asterisk or space to indicate multiplication!
4		Intersection point *A* between the line and the *y*-axis Hint: You may also use the command `Intersect[line, yAxis]`.
5		Point *B* at the origin
6		Segment between points *A* and *B* Hint: You might want to increase the line thickness in order to make the segment visible on top of the *y*-axis.
7		Slope (triangle) of the line
8		Hide unnecessary objects
9		Enhance the appearance of the file using the *Properties Dialog*.

Task
Write down instructions for your students that guide them through examining the influence of the equation's parameters on the line by using the sliders. These instructions could be provided on paper along with the GeoGebra file.



The Slope Function

Preparations

- Open a new GeoGebra file.
- Show the Algebra View, Input Bar, and coordinate axes.

Introduction of new tool

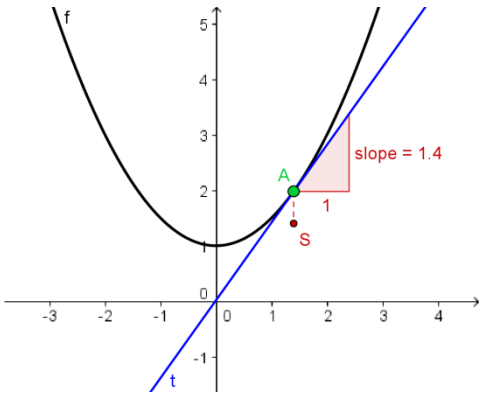
Tangents Hint: Click on a point on a function and then on the function itself.	**New!**

Hints: Don't forget to read the toolbar help if you don't know how to use the tool. Try out the new tool before you start the construction.

Instructions

1		Enter the polynomial `f(x) = x^2/2 + 1`
2	A	Create new point *A* on function *f*. Hint: Move point *A* to check if it is really restricted to the function graph.
3		Create tangent *t* to function *f* through point *A*.
4		Create the slope of tangent *t* using: `slope = Slope[t]`
5		Define point S: `S = (x(A), slope)` Hint: `x(A)` gives you the *x*-coordinate of point *A*.
6		Connect points *A* and *S* using a segment.

Back to School…



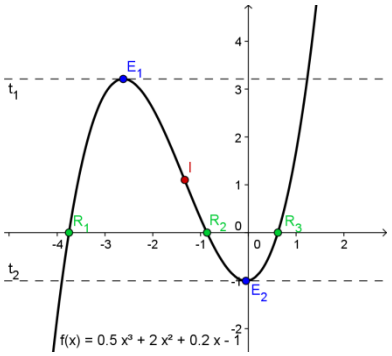
(a) Move point *A* along the function graph and make a conjecture about the shape of its path, which corresponds to the slope function.

(b) Find the equation of the slope function. Turn on the trace of point *S*. Move point *A* to check your conjecture.
Hint: Right click point *S* (MacOS: *Ctrl*-click) and select *Trace On*.

(c) Find the equation of the resulting slope function. Enter the function and move point *A*. If it is correct the trace of point *S* will match the graph.

(d) Change the equation of the initial polynomial *f* to produce a new problem.

Exploring Polynomials



Preparations

- Open a new GeoGebra document.
- Show the Algebra View, Input Bar, and coordinate axes.

Instructions

1		Enter the cubic polynomial `f(x) = 0.5x^3 + 2x^2 + 0.2x - 1`
2		Create the roots of polynomial *f*: `R = Root[ f ]` Hint: If there are more than one roots, GeoGebra will produce indices for their names if you type in `R =` (e.g., R_1, R_2, R_3).
3		Create the extrema of polynomial *f*: `E = Extremum[ f ]`
4		Create tangents to *f* in E_1 and E_2
5		Create the inflection point of polynomial *f*: `I = InflectionPoint[ f ]`

Hint: You might want to change properties of objects (e.g. color of points, style of the tangents, show name and value of the function).

Resizing, Reflecting, and Distorting a Picture

In this activity you will to learn how to resize an inserted picture to a certain size and how to apply transformations to the picture in GeoGebra.

Introduction of New Tool

	**Reflect Object about Line** Hint: Click the object to be reflected and then click the line of reflection.	New!
	**Insert Image** Hint: Click in the Graphics View to insert the picture at this position.	New!

Hints: Don't forget to read the toolbar help if you don't know how to use these tools. Try out the new tools before you start the construction.

Instructions for Reflecting and Resizing a picture

1		Insert a picture into the left part of the Graphics View.
2		Point *A* at the lower left corner of the picture
3		Set point *A* as the FIRST corner point of your picture. Hint: Open the *Properties Dialog* and select the picture in the list of objects. Click on tab 'Position' and select point *A* from the drop-down list next to *Corner 1*.
4		Point `B = A + (3, 0)`
5		Set point *B* as the SECOND corner point of the picture. Hint: You just changed the width of the picture to 3 cm.
6		Line through two points in the middle of the Graphics View.
7		Reflect the picture at the line Hint: You might want to reduce the filling of the image in order to be able to better distinguish it from the original (*Properties Dialog*).

Back to School…

(a) Move point *A* with the mouse. How does this affect the picture?

(b) Move the picture with the mouse and observe how this affects its image.

(c) Move the line of reflection by dragging the two points with the mouse. How does this affect the image?

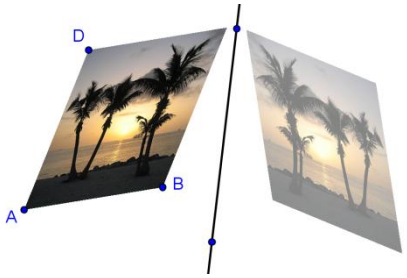
Instructions for Distorting a Picture

1		Open the figure you created in the previous activity.
2		Delete point *B* to restore the picture's original size
3		Create a new point *B* at the lower right corner of the original picture.
4		Set the new point *B* as the second corner point of your picture. Hint: You can now resize the image by moving point *B*.
5		Create a new point *D* at the upper left corner of the original picture. Hint: GeoGebra offers a 'fast-renaming' option. Activate *Move* mode and select the object. When you start typing the new name GeoGebra opens the *Rename* dialog window.
6		Set the new point *D* as the FOURTH corner point of your picture

Back to School…

(a) How does moving point *D* affect the picture and its image?

(b) Which geometric shape do the picture and the image form at any time?

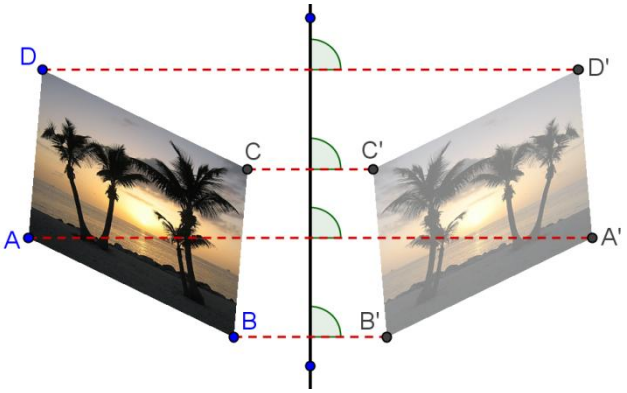


Exploring Properties of Reflection

In this activity you will create a dynamic figure that allows your students to explore the properties of reflection.

Preparations

You will now modify the construction created in the previous activity. If you want to keep the original as well you need to save your file.



Instructions

1		Open the file you created in the previous activity which contains the distorted picture of the palm trees and its reflection at a line.
2		Segment between points *A* and *B*
3		Segment between points *A* and *D*
4		Parallel line to segment *AB* through point *D*
5		Parallel line to segment *AD* through point *B*
6		Intersect the two lines to get intersection point *C*
7		Hide unnecessary objects
8		Reflect all four corner points *A*, *B*, *C*, and *D* at the line to get their images *A'*, *B'*, *C'*, and *D'*.
9		Connect corresponding points with segments (e.g. points *A* and *A'*)
10		Create angles between the line of reflection and the segments

Back to School…

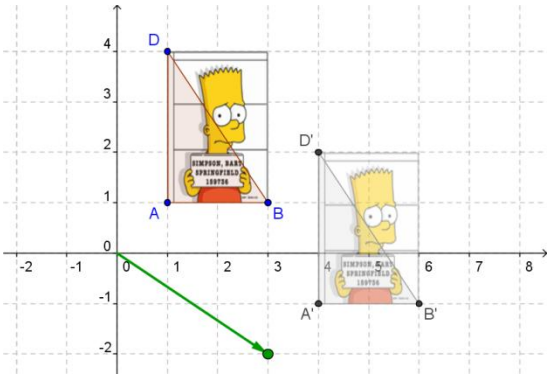
(a) Move the corner points *A*, *B*, *C*, and *D* of the original picture. Are you able to drag all these points with the mouse? If no, which one can't be dragged and why?

(b) Move the line of reflection. What do you notice about the angles between the segments connecting the corresponding corner points and the line of reflection?

Translating Pictures

Preparations

- Make sure you have the picture *03_Bart.png* saved on your computer.
- Open a new GeoGebra file.
- Show the Algebra View, Input Bar, coordinate axes, and grid (*View* menu).
- In the *Options* menu set the point capturing to *On (Grid)*.



Introduction of New Tools

	**Vector between Two Points** **New!** Hint: First click determines the starting point and second click sets the vector's endpoint.
	**Translate Object by Vector** **New!** Hint: Click the object to be translated and then click the translation vector.

Hints: Don't forget to read the toolbar help if you don't know how to use these tools. Try out the new tools before you start the construction.

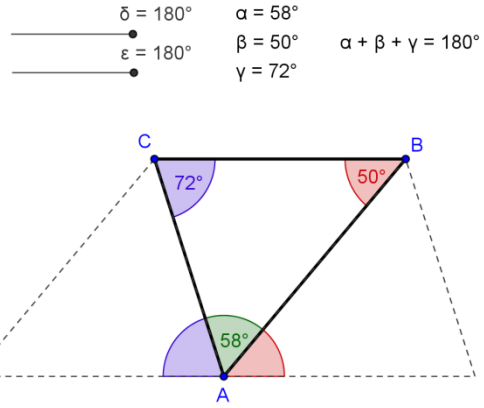
Instructions

1		Insert picture *03_Bart.png* into the first quadrant.
2		Points `A = (1, 1)`, `B = (3, 1)`, and `D = (1, 4)`
3		Set point *A* as the FIRST, *B* as the SECOND, and *D* as the FOURTH corner point of the picture. Hint: *Properties dialog* – tab *Position*
4		Triangle *ABD*
5		Points `O = (0, 0)` and `P = (3, -2)`
6		Vector `u = Vector[O, P]` Hint: You could also use tool *Vector between two points*.
7		Translate the picture by vector *u*. Hint: You might want to reduce the filling of the image.
8		Translate the three corner points *A*, *B*, and *D* by vector *u*.
9		Triangle *A'B'D'*
10		Hide point *O* so it can't be moved accidentally.
11		Change the color and size of objects to enhance your construction.

Visualizing the Angle Sum in a Triangle

Preparations

- Open a new GeoGebra file.
- Hide the Algebra View and coordinate axes (*View* menu).
- Show the Input Bar (*View* menu).
- Set the number of decimal places to 0 (menu *Options* – *Decimal places*).



Introduction of new tool

Midpoint or Center **New!**
Hint: Either click on two points or on a segment to create the midpoint. Click on a circle in order to show its center point.

Hints: Don't forget to read the toolbar help if you don't know how to use a tool. Try out new tools before you start the construction.

Instructions

1		Triangle *ABC* with counter clockwise orientation
2		Angles *α*, *β*, and *γ* of triangle *ABC*.
3	a = 2	Slider for angle *δ* with interval 0˚ to 180˚ and increment 10˚
4	a = 2	Slider for angle *ε* with interval 0˚ to 180˚ and increment 10˚
5		Midpoint *D* of segment *AC* and midpoint *E* of segment *AB*
6		Rotate the triangle around point *D* by angle *δ* (setting *clockwise*).
7		Rotate the triangle around point *E* by angle *ε* (setting *counterclockwise*).
8		Move both sliders *δ* and *ε* to show 180˚.
9		Create angle *ζ* using the points *A'C'B'*
10		Create angle *η* using the points $C'_1B'_1A'_1$
11		Enhance your construction using the *Properties Dialog*. Hint: Congruent angles should have the same color.
12	ABC	Create dynamic text displaying the interior angles and their values (e.g. "*α* = " + *α*).

13		Calculate the angle sum by entering `sum = α + β + γ` into the Input Bar and hitting the *Enter*-key.
14	ABC	Insert the angle sum as a dynamic text: `"α + β + γ = " + sum`
15		Match colors of corresponding angles and text. Fix text that is not supposed to be moved.