5. Special GeoGebra Features

5.1. Animation

5.1.1. Automatic Animation

GeoGebra allows you to animate one or several free numbers and/or angles at the same time if they are shown as *sliders* in the *Graphics View*.

If you want to animate a free number or angle in GeoGebra, you need to right click (Mac OS: *Ctrl*-click) on the number or angle and select *Animation On* from the appearing *Context Menu*. In order to stop the animation, you need to un-check *Animation On* in the same *Context Menu*.

Note: After animating a free number or a free angle, an animation button appears in the lower left corner of the *Graphics View*. It allows you to either ▯▯ pause or ▷ continue an animation.

In the *Properties Dialog* on tab *Slider* you can change the behavior of the animation:
On the one hand, you may control the *Speed* of the animation.
Note: A speed of 1 means that the animation takes about 10 seconds to run once through the interval of the slider.
On the other hand, you may change how the animation cycle is repeated:

- <=> *Oscillating*:
  The animation cycle alternates between *Decreasing* and *Increasing*.
- => *Increasing*:
  The slider value is always increasing. After reaching the maximum value of the slider, it jumps back to the minimum value and continues the animation.
- <= *Decreasing*:
  The slider value is always decreasing. After reaching the minimum value of the slider, it jumps back to the maximum value and continues the animation.

Note: While an automatic animation is activated, GeoGebra remains fully functional. This allows you to make changes to your construction while the animation is playing.

5.1.2. Manual Animation

To manually change a number or angle continuously, select the *Move* tool. Then, click on a *free number or angle* and press either the + or – key or the arrow keys on you keyboard. Keeping one of these keys pressed allows you to produce manual animations.

Example: If a point's coordinates depend on a number *k* like in *P = (2 k, k)*, the point will move along a straight line when *k* is changed continuously.

Note: You can adjust the increment of the slider on tab *Slider* of the *Properties Dialog* of this object.

Keyboard Shortcuts:

- *Shift* + *arrow* key gives you a step width of 0.1 units
- *Ctrl* + *arrow* key gives you a step width of 10 units
- *Alt* + *arrow* key gives you a step width of 100 units

Note: A point on a line can also be moved along its line using the + or – key.

5.2. Conditional Visibility

Apart from just showing or hiding certain objects you can also have their visibility status depend on a certain condition. For example, you would like an object to appear on screen if you check a *checkbox* positioned in the *Graphics View* or if a *slider* is changed to a certain value.

Conditionally Show or Hide Existing Objects

You can use the tool *Checkbox to Show / Hide Objects* in order to create a checkbox that controls the visibility of one or more existing objects on screen. Alternatively, you could also create a Boolean variable (e. g., `b = true`) using the *Input Bar* and make it visible as a checkbox in the *Graphics View* by changing its visibility status (e. g., use tool *Show / Hide Object* or use the *Context Menu*). In order to use this Boolean variable as a condition for the visibility of certain objects, you need to follow the steps described below.

Changing the Visibility of Newly Created Objects

In the *Properties Dialog*, you can enter a condition for the visibility of an object on tab *Advanced*.
Note: You can select the logic operators (e. g., ≠, ≥, ∧, ||) from the drop down menu in order to create your conditional statements.

Examples:

- If *a* is a slider, then the conditional statement `a < 2` means that the corresponding object is only shown in the *Graphics View* if the slider's value is less than 2.
- If *b* is a Boolean variable, you can use `b` as a conditional statement. The corresponding object is shown whenever the value of *b* is *true* and is hidden when the value of *b* is *false*.
- If *g* and *h* are two lines and you would like a text to be shown whenever these lines are parallel, then you could use `g || h` as a conditional statement for the text.

Table of Contents for the online GeoGebra book
url: http://www.geogebra.org/book/intro-en/

1. Installation and Introduction of GeoGebra
Activity 1: Installing GeoGebra
Activity 2: Save the Accompanying Files
Introduction: What is GeoGebra and How Does It Work?

2. Drawing versus Geometric Construction
Activity 3: Drawing Geometric Figures and Other Objects
Activity 4: Saving GeoGebra files
Activity 5: Drawings, Constructions, and Drag Test
Activity 6: Rectangle Construction
Activity 7: Equilateral Triangle Construction

3. Practice Block I
Tips and Tricks
Activity I.a: Square Construction
Activity I.b: Regular Hexagon Construction
Activity I.c: Circumscribed Circle of a Triangle
Activity I.d: Visualize the Theorem of Thales

4. Basic Algebraic Input, Commands, and Functions
Tips and Tricks
Activity 8a: Constructing Tangents to a Circle (Part 1)
Activity 8b: Constructing Tangents to a Circle (Part 2)
Activity 9: Exploring Parameters of a Quadratic Polynomial
Activity 10: Using Sliders to Modify Parameters
Activity 11: Library of functions

5. Export of Pictures to the Clipboard
Activity 12a: Exporting Pictures to the Clipboard
Activity 12b: Inserting Pictures into a Text Processing Document

6. Practice block II
Tips and Tricks
Activity II.a: Parameters of a Linear Equation
Activity II.b: Introducing Derivatives – The Slope Function
Activity II.c: Creating a 'Function Domino' Game
Activity II.d: Creating a 'Geometric Figures Memory' Game

7. Inserting Pictures into the Graphics Window
Activity 13: Drawing Tool for Symmetric Figures
Activity 14a: Resizing and Reflecting a Picture
Activity 14b: Distorting a Picture
Activity 14c: Exploring Properties of Reflection

8. Inserting Text into the Graphics Window
Activity 15: Coordinates of Reflected Points
Activity 16: Rotation of a Polygon

9. Practice Block III
Tips and Tricks
Activity III.a: Visualizing a System of Equations
Activity III.b: Translating Pictures
Activity III.c: Constructing a Slope Triangle
Activity III.d: Exploring the Louvre Pyramid

10. Creating Static Instructional Materials
Activity 17a: Saving Pictures as Files
Activity 17b: Inserting Pictures into MS Word

11. Creating Dynamic Worksheets
Introduction: The GeoGebraWiki and User Forum
Activity 18a: Creating Dynamic Worksheets
Activity 18b: Enhancing Dynamic Worksheets
Activity 18c: Providing Dynamic Worksheets to Students

12. Practice Block IV
Tips and Tricks
Activity IV.a: Area Relations of Similar Geometric Figures
Activity IV.b: Visualizing the Angle Sum in a Triangle
Activity IV.c: Visualizing Integer Addition on the Number Line
Activity IV.d: Creating a 'Tangram' Puzzle

Tips and Tricks

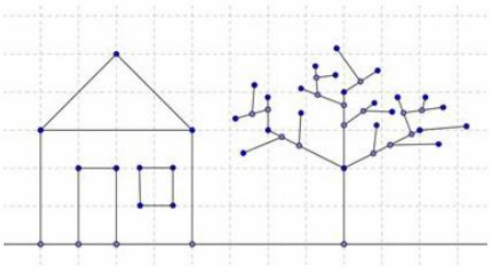
- Summarize the properties of the geometric figure you want to create.
- Try to find out which GeoGebra tools can be used in order to construct the figure using some of these properties (e.g. right angle – tool *Perpendicular line*).
- Make sure, you know how to use each tool before you begin the construction. If you don't know how to operate a certain tool, activate it and read the toolbar help.
- For each of these activities, open a new GeoGebra file, hide the algebra window, input field, and the coordinate axes.
- You might want to save your files before you start a new activity.
- Don't forget about the *Undo* and *Redo* buttons in case you make a mistake.
- Frequently use the *Move* tool in order to check your construction (e.g. are objects really connected, did you create any unnecessary objects).
- If you have questions, please ask a colleague before you address the presenter or assistant(s).

from the page http://www.geogebra.org/book/intro-en/

Activity 3: Drawing Geometric Figures and Other Objects

Preparations

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



Drawing pictures with GeoGebra

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

New point	New!
Move	New!
Line through two points	New!
Segment between two points	New!
Delete object	New!
Undo / Redo buttons	New!
Move drawing pad	New!
Zoom in / Zoom out	New!

What to practice

- How to select an already existing object.
  Hint: When the pointer hovers above an object, it highlights and the pointer changes its shape from a cross to an arrow. Clicking selects the corresponding object.
- How to create a point that lies on and object.
  Hint: The point is displayed in a light blue color. Always check if the point really lies on the object by dragging it with the mouse.
- How to correct mistakes step-by-step using the *Undo* and *Redo* buttons.

Tip: Several tools allow the creation of points “on the fly”. Therefore, no existing objects are required in order to use the tool.

Example: The tool *Segment between two points* can be applied to two already existing points or to the empty drawing pad. By clicking on the drawing pad the corresponding points are created and a segment is drawn in between them.

Activity 5: Drawings, Constructions, and Drag Test

Open the dynamic worksheet A05_Drawing_Construction_Squares.html

from the page http://www.geogebra.org/book/intro-en/

The dynamic figure shows several squares constructed in different ways.

- Examine the squares by dragging ALL their vertices with the mouse.
- Find out which of the quadrilaterals are real squares and which ones just happen to look like squares.
- Try to come up with a conjecture about how each square was created.
- Write down your conjectures on paper.

Discussion

- What is the difference between a drawing and a construction?
- What is the “drag test” and why is it important?
- Why is it important to construct figures instead of just drawing them in interactive geometry software?
- What do we have to know about the geometric figure before we are able to construct it using dynamic mathematics software?

Activity 6: Rectangle Construction

from the page http://www.geogebra.org/book/intro-en/

Preparations

- Summarize the properties of a rectangle before you start the construction.
  Hint: If you don't know the construction steps necessary for a rectangle you might want to open the file *A06 Rectangle Construction.ggb*. Use the buttons of the navigation bar in order to replay the construction process.

- Open new GeoGebra file.
- Hide algebra window, input field and coordinate axes (*View* menu).
- Change the labeling setting to *New points only* (menu *Options – Labeling*).

Introduction of new tools

- *Perpendicular line* and *Parallel line tools*
  Hint: Click on an already existing line and a point in order to create a perpendicular line / parallel line through this point.
- *Intersect two objects* tool
  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* tool
  Hints: Click on the drawing pad or 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!

Hint: Don't forget to read the toolbar help if you don't know how to use a tool.

Hint: Try out all new tools before you start the construction.

Activity 7: Equilateral Triangle Construction

from the page http://www.geogebra.org/book/intro-en/

Preparations

- Summarize the properties of an equilateral triangle before you start the construction.
  Hint: If you don't know the construction steps necessary for an equilateral triangle you might want to have a look at the following file:
  A07_Equilateral_Triangle_Construction.ggb. Use the buttons of the navigation bar in order to replay the construction process.

- Open new GeoGebra file.
- Hide algebra window, input field 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* tool
  Hint: First click creates center, second click determines radius of the circle.
- *Show / hide object* tool
  Hints: Highlight all objects that should be hidden, then switch to another tool in order to apply the visibility changes!
- *Angle* tool
  Hint: Click on the points in counterclockwise direction! GeoGebra always creates angles with mathematically positive orientation.

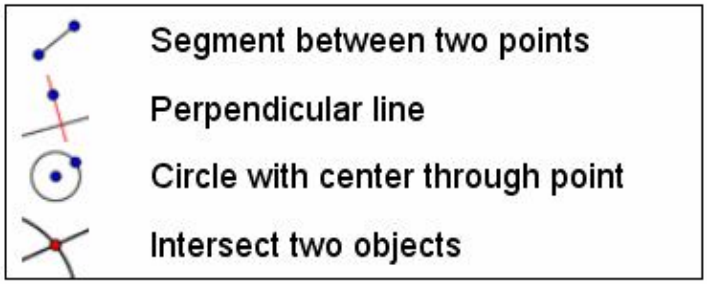
Hint: Don't forget to read the toolbar help if you don't know how to use a tool.

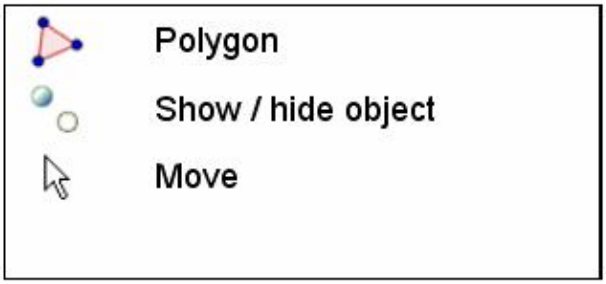
Hint: Try out all new tools before you start the construction.

Activity I.a: Square Construction

Classification: Basic task

In this activity you are going to use the following tools. Make sure you know how to use each tool before you begin with the actual construction of the square:

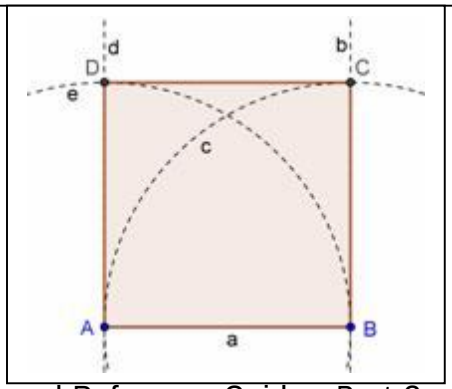




1. Hint: You might want to have a look at the file A_1a_Square_Construction.html if you are not sure about the construction process.

Construction process

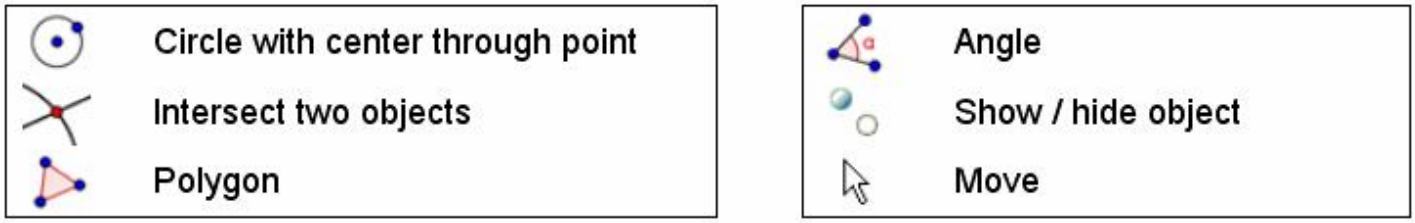
2. Draw segment a = AB between points A and B
3. Construct perpendicular line b to segment AB through point B
4. Construct circle c with center B through point A
5. Intersect circle c with perpendicular line b to get intersection point C
6. Construct perpendicular line d to segment AB through point A
7. Construct circle e with center A through point B
8. Intersect perpendicular line d with circle e to get intersection point D
9. Create polygon ABCD.
   Hint: Don't forget to close the polygon by clicking on point A after selecting point D.
10. Hide circles and perpendicular lines
11. Perform the drag test to check if your construction is correct



Activity I.b: Regular Hexagon Construction

Classification: Basic task

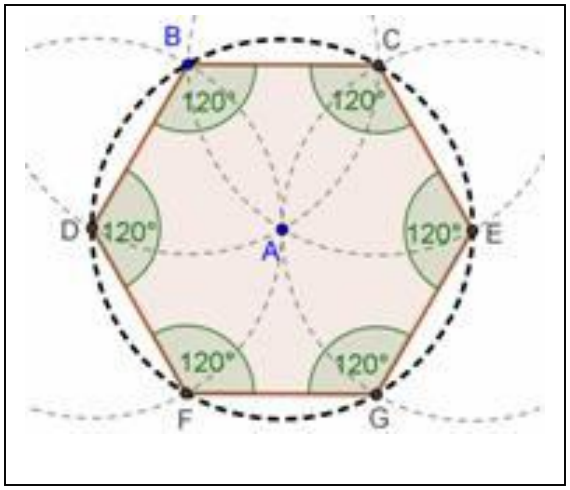
In this activity you are going to use the following tools. Make sure you know how to use each tool before you begin with the actual construction of the hexagon:



Hint: You might want to have a look at the file *A_1b_Hexagon_Construction.html* if you are not sure about the construction process.

Construction process

1. Draw a circle with center A through point B
2. Construct another circle with center B through point A
3. Intersect the two circles in order to get the vertices C and D.
4. Construct a new circle with center C through point A.
5. Intersect the new circle with the first one in order to get vertex E.
6. Construct a new circle with center D through point A.
7. Intersect the new circle with the first one in order to get vertex F.
8. Construct a new circle with center E through point A.
9. Intersect the new circle with the first one in order to get vertex G.
10. Draw hexagon FGECBD.
11. Create the angles of the hexagon.
12. Perform the drag test to check if your construction is correct.



Activity 9: Exploring Parameters of a Quadratic Polynomial

Back to school...

In this activity you will explore the impact of parameters on a quadratic polynomial. You will experience how GeoGebra could be integrated into a 'traditional' teaching environment and used for active, student-centered learning.

Follow the instructions on the paper worksheet and write down your results and observations while working with GeoGebra. Your notes will help you during the following discussion of this activity.

Exploring Parameters of a Quadratic Polynomial

1. Open a **new GeoGebra file**

2. **Type** in `f(x) = x^2` and hit the *Enter* key. Which **shape** does the function graph have? Write down your answer on paper.

3. In *Move* mode, highlight the polynomial in the algebra window and use the ↑ **up and ↓ down arrow keys**.
   a. How does this **impact the graph** of the polynomial? Write down your observations.
   b. How does this **impact the equation** of the polynomial? Write down your observations.

4. Again, in *Move* mode, highlight the function in the algebra window and use the ← **left and → right arrow keys**.
   a. How does this **impact the graph** of the polynomial? Write down your observations.
   b. How does this **impact the equation** of the polynomial? Write down your observations.

5. In *Move* mode, double click the equation of the polynomial. Use the keyboard to **change the equation** to `f(x) = 3 x^2`.
   Hint: Use an asterisk * or space in order to enter a multiplication.
   a. **Describe** how the function graph changes.
   b. **Repeat changing the equation** by typing in different values for the parameter (e.g. 0.5, -2, -0.8, 3). **Write down** your observations

Discussion

Did any problems or difficulties concerning the use of GeoGebra occur?
How can a setting like this (GeoGebra in combination with instructions on paper) be integrated into a 'traditional' teaching environment?
Do you think it is possible, to give such an activity as a homework problem to your students?
In which way could the dynamic exploration of parameters of a polynomial possibly affect your students' learning?
Do you have ideas for other mathematical topics that could be taught in similar learning environment (paper worksheets in combination with computers)?

Activity 10: Using Sliders to Modify Parameters

Let's try out a more dynamic way of exploring the impact of a parameter on a polynomial f(x) = a x^2 by using sliders to modify the parameter values.

Preparation

Open a new GeoGebra file
Show the algebra window, input field, and coordinate axes (*View* menu)

Construction process

1	`a = 1`	Create the variable a
2	`f(x) = a * x^2`	Enter the quadratic polynomial *f*
		Hint: Don't forget to enter an asterisk * or space between `a` and `x^2`.

Representing a number as a slider

To display number as a slider in the graphics window you need to right click (MacOS: *Ctrl*-click) the variable in the algebra window and select *Show object*.

Enhancing the construction

Let's create another slider b that controls the constant in the polynomial's equation f(x) = a x^2 + b.

5		Create a slider *b* using the *Slider* tool
		Hint: Activate the tool and click on the drawing pad. Use the default settings and click Apply.
6	`f(x) = a * x^2 + b`	Enter the polynomial f
		Hint: GeoGebra will overwrite the old function f with the new definition.

Tasks

Change the parameter value *a* by moving the point on the slider with the mouse. How does this influence the graph of the polynomial?

What happens to the graph when the parameter value is (a) greater than 1, (b) between 0 and 1, or (c) negative? Write down your observations.