OK Geometry Basic - Part II

Reference for OK Geometry Sketch Editor (v. 19)

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Contents

OK Geometry Sketch Editor is similar in many respects to other dynamic geometry software programmes, but differs in some important aspects. You can get a first impression of Sketch Editor in Section 1. We strongly recommend reading Section 2, which describes important features of this editor. Section 3 and 4 provide details of operations and editor commands that might interest you. Finally, Section 5 contains step-by-step descriptions of various examples, all of which are provided with the source files.

1. Sketch Editor of OK Geometry

Creating and editing constructions in OK Geometry is generally similar to creating and editing them in other dynamic geometry software. OK Geometry allows many operations that are common in dynamic geometry programs (e.g. dragging points, defining macros). However, there are differences due to the specific aims of OK Geometry. Dynamic geometry programs promote, above all, conceptual understanding - thus, only very simple construction commands are available, because students should understand how to work out constructions from basic operations. Furthermore, these programs enable elaborated visual representations for effective explorations and demonstrations. On the other hand, **the aim of OK Geometry is to promote hypothetising, deductive reasoning, and proving**. Consequently, the commands of OK Geometry Sketch Editor allow fast and efficient design of geometric configurations. Besides direct non-trivial constructions (e.g. to construct a circle that touches three given circles) the Sketch Editor also allows implicit constructions and constructions based on optimisation. Such constructions are obtained by imposing additional restrictions or optimisation requirements to an existing construction. For example, in a given construction we may want a triangle in a construction to be equilateral or that its area is minimal. Using specific tools (described in the help file of Ok Geometry Basic) we then analyse the obtained configuration, study its properties, perhaps find how to construct it with compass and ruler, and, possibly, also prove some properties of the designed configuration.

Note that the Sketch Editor is not available in Easy mode of OK Geometry.

1.1. The interface

The Sketch Editor of the OK Geometry is accessed via the Sketch button on the main menu bar. To exit edit mode, click on the Sketch button again or click another button on the main menu bar.

The left part of the interface (the information pane) contains various sections that can be collapsed or expanded (Figure 1). You can expand or collapse each section by clicking the triangular button next to the section title (right click on these buttons for a full expansion). In the **Task section** you can write or edit textual information related to the construction (e.g., description of a construction, formulation of a task, comments). The **Treatment section** contains information to be used in the analysis (outside the Sketch Editor). The section **Transformations & Parameters** contains the lists of transformations and parameters/expressions that are declared in a construction. Finally, the **Help section** contains explanations of the commands used. You can at any time turn the Help section on or off with the **F8** key.

The right part (the visualisation pane) contains the drawing of the current construction. Above the drawing is the **menu line** of the editor. Below the menu line there is a very important (red coloured) **information line**. Keep an eye on it – it tells you what is going on and what is expected of you (additional help on how to use the commands can be found in the **Help section** of the information pane, if the help for commands is activated). On the right of the drawing pane there is a toolbar with buttons for the commands that are frequently used.
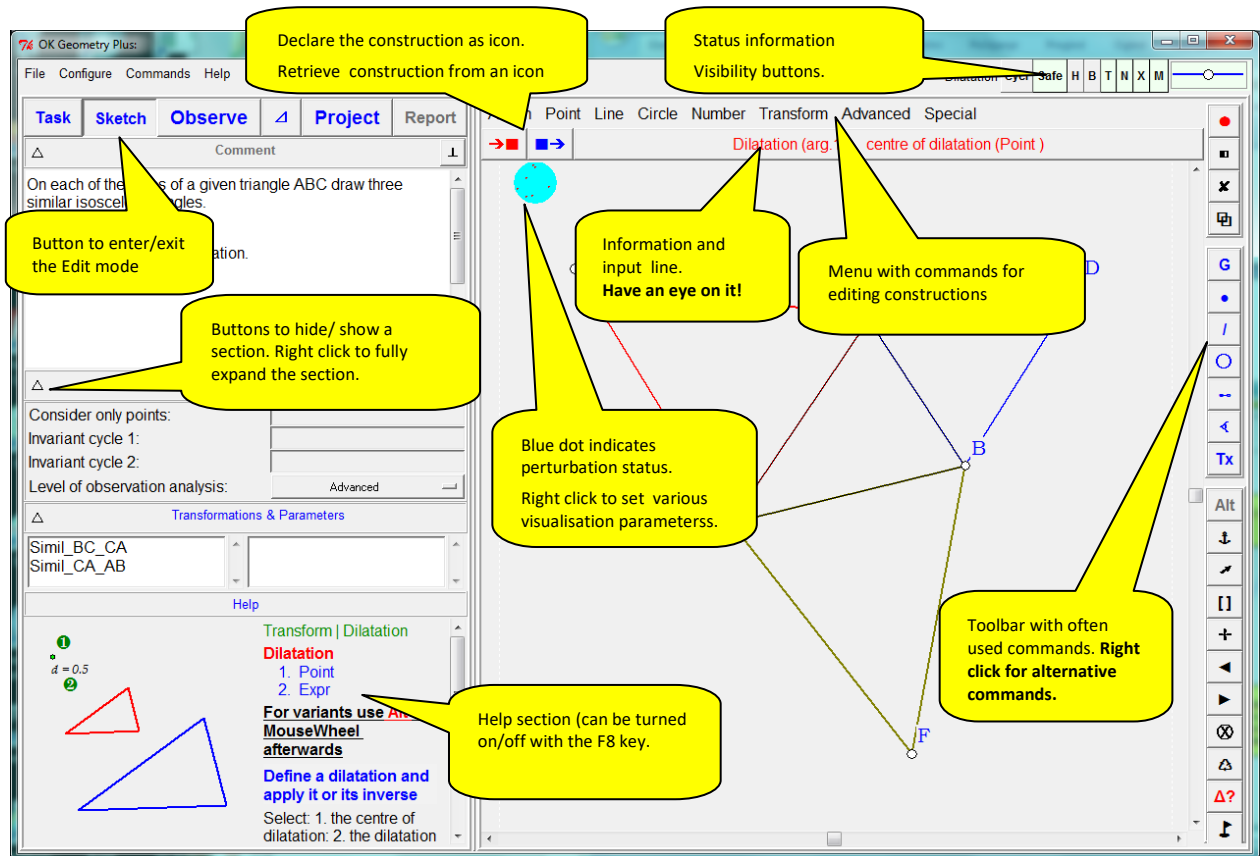
Figure 1

1.2.   A first example

The following example gives you an idea on how to make constructions in OK Geometry. We construct a (dynamic) right triangle with the inscribed circle in it. Furthermore, we shall label the points in which the circle touches the sides of the triangle. Here are the steps to follow.

1. Enter the Edit mode by pressing the **Sketch** button in the main menu bar. The editor's menu appears above the visualisation area. (If the current construction is not empty use the *File|New project* command in the main menu.)
2. To draw a right triangle, select (click) the command *Advanced|Shapes|Right triangle*
3. The line below the menu (the information line) instructs you to pick three points (vertices): First a vertex at an acute angle, then the vertex at the other acute angle, and then the vertex at the right angle. The position of the third vertex is automatically corrected so that the triangle is right.
4. Label the vertices of the triangle. A simple way (but not the quickest) is to click on the *Label vertex* button in the editor's toolbar (click on the button with an underlined letter on it). Then click on the vertices in the desired order. Immediately after a label is set you can change the position of the label with the mouse-wheel.
5. To draw the inscribed circle, select in the editor's menu the command *Circle|Circle 3obj* or, equivalently, right click on the circle button in the editor's toolbar and select the circle with digit 3 inside. This command draws a circle that touches or passes through three given objects (lines, points, circles).
6. Click on each of triangle's three sides. After you pick the first side the whole triangle is emphasised since the triangle was constructed as one object). A circle appears.

7. There are several circles that touch the three baselines of the sides (from inside or outside the triangle). To access them click repeatedly the **Alt** button in the editor's toolbar. Click **Alt** several times (or use the mouse wheel) until you obtain the desired solution.
8. Finally, to draw the points where the circle touches the sides, select the command *Point|Point* or click on the Point button on the editor's toolbar. Click on the three points of touch. These points are automatically labelled.

The construction is complete and ready to be analysed (Figure 2) – simply click on the main menu button **Observe**. Among other properties, the analysis will point to the fact that the lines AD, BE, and CF meet at the same point (a well know fact to anybody who has heard of Gergonne point).
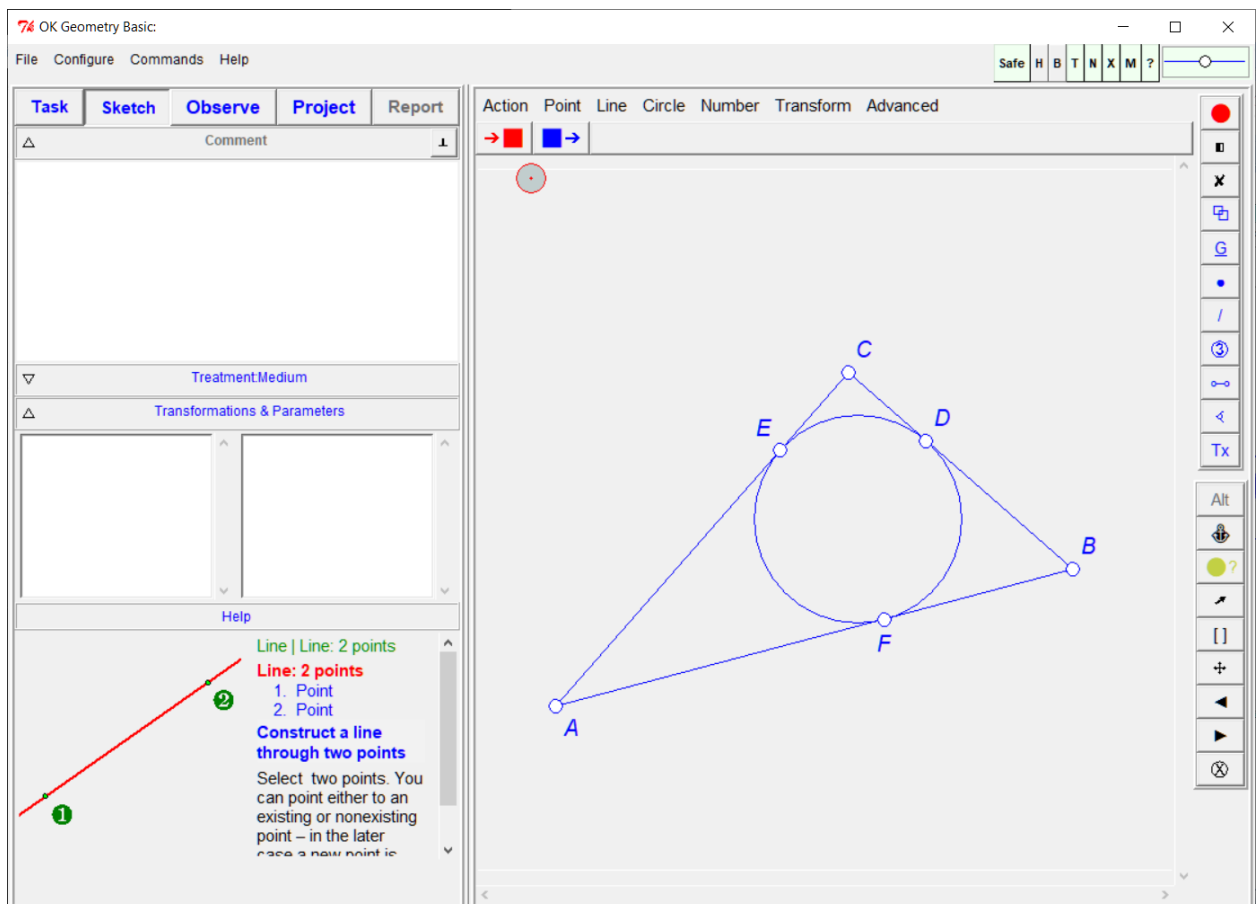
Figure 2

2. General guidelines

Most commands of the OK Geometry Sketch Editor are simple to use and there is no reason to study them in detail on the first reading. However, *we strongly recommend that you read the following general guidelines for specific features of the OK Geometry Sketch Editor.*

With the editor you can edit points, lines, line segments, polylines (polygon lines), circles, arcs, conics, transformations, and numerical parameters. Polylines are chains of line segments. Segments are therefore a special case of polylines. Note that OK Geometry does not work with rays and vectors.

2.1.   How to find command

To enable fast and efficient construction, the OK Geometry Sketch Editor contains many commands. The commands can be accessed via the toolbox in the right part of the editing pane (note that more buttons can be accessed by right-clicking on buttons, see Section 3), or via commands in the menu line. Although the commands and the positions of the commands in the menu follow a logical order, it can be difficult for a beginner to find them and use them. To overcome this, you can use the ***Glossary command*** help in the Help menu or press the ***F1 key*** on the keyboard. We will explain this with an example. Suppose you want to obtain a line that is tangent to two given circles. In the *Glossary command* prompt write an approximate name or word that refers to the command, for example *tangent*. In the form that appears, under the section *Commands* you will find a list of commands that refer to your prompt. A click on each of the commands gives you (Figure 3)

- the position of the command in the menu,
- the parameters required by the command,
- important notes regarding the use of ***Alt*** and ***Anchor*** modifiers (see Sections 2.5 and 2.7),
- a description of the command,
- a pictorial explanation (click on the >>> sign for more illustrations).

In our case, we find that the right command is *Line: 2 objects*. A **right cli**ck on the Description part activates the command (when Sketch mode).
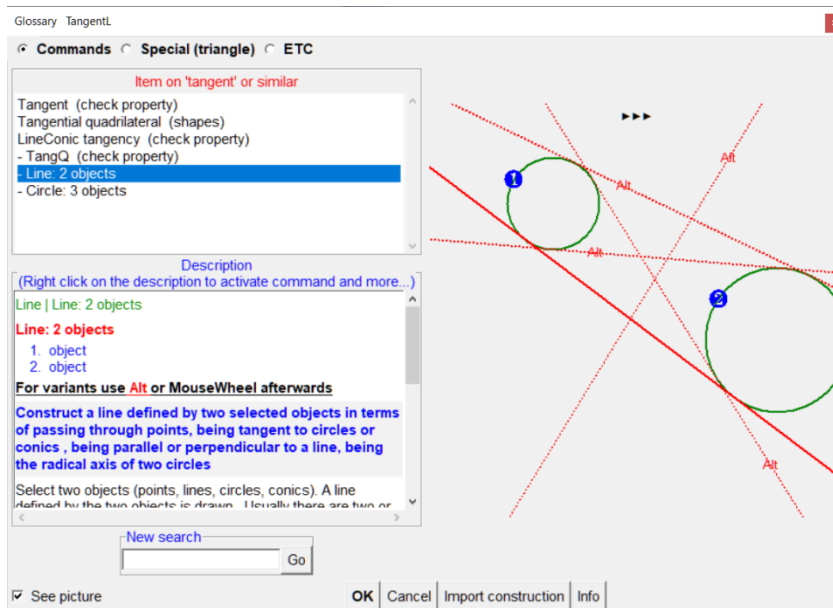
Figure 3

2.2.   The blue dot

The blue dot in the upper left part indicates whether the construction is displayed in *exact* or *perturbed* mode. It also enables switching between the two modes and a quick way of setting some drawing parameters.

		Displayed construction	Left click on blue dot	Right click on blue dot
Perturbed mode		One of the **perturbed** variants of the original construction.	Switch between exact and perturbed mode	A shortcut for **configuring** frequently used **sketch related parameters** (e.g. mode of filling areas, font of point labels). You can also set the **level of the displayed help** for the construction commands.
Exact mode		The original construction (e.g. as imported from a system).		

Note. Internally, all observations are made in the perturbed mode. On the other side, all exports of constructions are made in the exact mode, irrespective of the status of the blue dot.

Note. Some constructions cannot be displayed in exact mode.

 In general, it is rather irrelevant which mode is active. In the *exact mode* you see horizontal and vertical lines as horizontal and vertical. Furthermore, in the exact mode there is a mechanism that makes it easy to construct visually horizontal and vertical lines (though they need not be horizontal or vertical by construction). On the other hand, in the perturbed mode the position of all free points often changes slightly.

2.3. Command first, then parameters

Actions of the Sketch Editor are executed by **first** activating the appropriate command and **then** pointing to the involved objects or entering the data. The active command (together with required actions) is displayed in the information line just below the editor menu. It is a good practice to constantly check the information line, especially when you learn to use the program. Most commands remain active until either another command is activated or **Escape** key is pressed. For example: To draw some points first activate the command *Point|Point* and then click on the desired positions of one or more points. Similarly, to drag a point it is necessary to first click on the command *Action|Drag Point* and then drag one or more points.

The execution of a command can be cancelled at any time by pressing the **Escape key** (Esc).

2.4. Only labelled points count

The label of a point consists of a single letter optionally followed by a numeral and/or apostrophes, for example: A, A2, A', k3, u1''. Labels consisting of more than one character are also allowed, but must be written in brackets where necessary, e.g. (AE) for AE. Label only points that are potentially relevant for the analysis. Labels are case sensitive. The characters x,y,z are not allowed as labels.

Note. Other objects (lines, circles, etc.) can also be labelled – either by writing the name immediately after the object is created or later using the text command (seeAction|Mark|Text command). However, when *analysing the construction, only labels of points are taken into account*, all other labels are ignored

Note. If a command results in a construction of a single point, this point is usually labelled automatically. It is possible to write the label of an object immediately after it is constructed. The position of the label can be changed using the mouse wheel or the Anchor command. Of course, the label and the position of the label can also be changed later with appropriate commands.

2.5. Alternative solutions

Use the **Alt** button on the editor's toolbar[1] (possibly together with the mouse wheel) for alternative results of construction operations that give rise to two or more solutions. In such cases a red **Alt** button appears on the editor's toolbar. Only one solution is displayed at time. By pressing the **Alt** button repeatedly, you can access to alternative solutions. Note that some alternatives may be 'empty' or duplicated. For example, the task of constructing a circle that is tangent to three given circles usually has several solutions. Only one solution is drawn at a time. By repeatedly pressing the **Alt** button the desired solution is obtained. For convenience, Alt button executes also analogies of some commands (e.g. parallel/perpendicular line). Figure 4 shows a simple example (line tangent to two circles) with several possible solutions including the radical axis. Using the **Alt button** it is possible to choose the desired solution.

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[1] Do not confuse the **Alt button** with the **Alt key** on the keyboard.
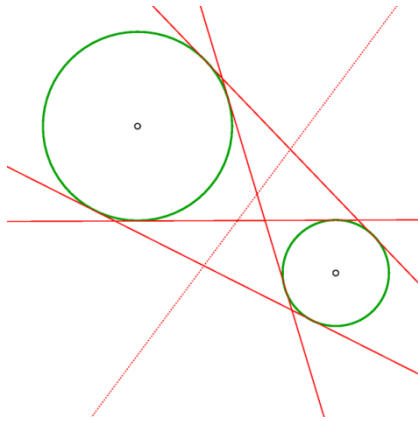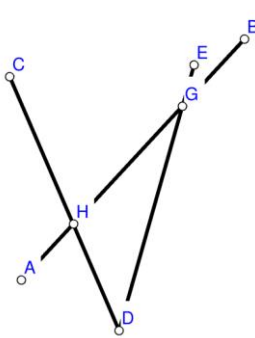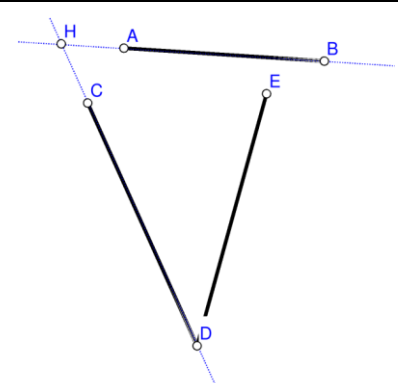
Figure 4

2.6. Safe points

Safe points is a feature that determines the behaviour of a point located on an object, such as a line segment, a segment of a polyline, a circular arc. Safe points feature can be enabled ON or OFF. If Safe points is set to ON, line and arc segments in a construction of a point are treated as the corresponding base objects. For example, a free point on a line segment is treated as a point on the baseline of the line segment, so that the point can be dragged along the line outside the line-segment. The intersection point of two line segments, constructed as intersection under Safe points ON, is constructed as the intersection of the corresponding baselines. We illustrate this feature with two examples (Figure 5).

Construction of points	Behaviour of the construction
G was defined as the intersection of segments with Safe points OFF. H was defined as the intersection of segments with Safe points ON.	When A is dragged so that the segment AB does not intersect the polyline CDE, the point G 'disappears'. Since H was constructed with Safe points ON, H is positioned at the intersection of the corresponding baselines of the segments AB and CD. (*Note. The dotted lines are displayed here only for evidence.*)

G was defined as a point on the polyline ABCA with Safe points OFF. H was defined as a point on the polyline ABCA with Safe points ON.	As G is dragged around, it remains on the polyline, since it was constructed under Safe point OFF. The point H was constructed under Safe points ON, thus it was positioned on the line AB. When dragged H remains on the line AB. (*Note. The dotted line is displayed here only for evidence.*)

Figure 5

Whether a point is constructed with Safe points ON or OFF depends on the type of intersection or linking you need. The ON option is more robust in that the intersection of two line segments always exists (unless the segments are parallel).

2.7.   The anchor command

The **Anchor** command and the corresponding ⚓ button in the Sketch Editor's toolbar change the visual aspect of various objects.

For example, the label of a point is placed by default above to the right of the constructed point (Figure 6). To change the position of the label with respect to the point, use repeatedly the **Anchor** command on the point (or its label). A faster way for repeating is to scroll the mouse-wheel.

Figure 6

Another important example is the visualisation of angles (Figure 7). A pair of intersecting lines (or 3 points) gives rise to several angles. To choose between them you can use the Anchor command repeatedly at any time, possibly followed by mouse scrolls.
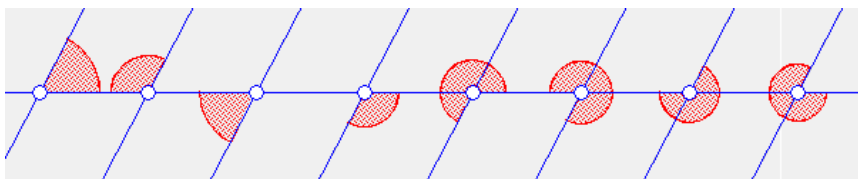
Figure 7

For a comprehensive overview of object visualisation, see Section 6.

The following table presents the effects of the Anchor command on the visual representation of geometric objects.

Object	Effect
Point (label)	Changes the position of the label with respect to the point.
Angle	Sets a different angle with the same base-lines as the original.
Arrowed segment	Changes the position and size of the arrows.
Text/Marker	Changes the position of the text/marker with respect to the reference point of the text.
Line	Changes the representation of the line: it can extend over the entire displayed area or only over the displayed points on the line.
Line segment	Changes the representation of the segment: it can extend between the edge points of the segment or somehow over its edge points.
Arc	Changes the representation of the arc: it can extend between its edge points or somehow over its edge points.
Congruence sign on segment or arc	Changes the number of bars on the congruence sign.
Filled polyline, circle	In case of solid fill, changes the fill level of the polygon or disk, and thus sets order of superposition of the filled objects.

2.8.   Geometric transformations and numeric parameters

Geometric transformations and numeric parameters are considered as explicit objects. For example, you can define a rotation around a point to be an object by itself. You can apply this transformation to any object at any time.

The used numeric parameters and transformations are shown on the left of the display. Numeric parameters can be assigned a desired value or can be the result of a measurement. Numeric parameters can be 'dragged'. In expressions you can refer to a parameter named 'mypar' as [mypar].

2.9.   Commands on polylines
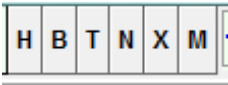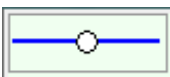
Commands that apply to line segments have, when applied to a polyline, two or three variants. Such commands can be applied to one segment of the polyline, to each segment of the polyline, or with respect to the entire polyline. For example: The command Midpoint when applied to a polyline has three versions:
- you can create the midpoint of the segment you pointed to,
- you can create the set of midpoints of each segment of a polyline,
- you can create the midpoint of the entire polyline (i.e. at the point that splits the polyline into two parts of equal length).

3. Toolboxes
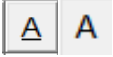
3.1.   Visibility and current style information

On the upper right of the Editor window there is a small toolbox with visibility indicators (switches) and for setting the style (colour, widths, shape of lines/points, etc.) of the drawn objects.

Button	Command
Cycl	**Cyclic mode ON/OFF switch and indicator** (*Only in Plus mode*). If the cyclic mode is ON, the program executes cyclic constructions on triangles. (See OK Geometry Plus documentation for details.)
Safe	**Safe point button ON/OFF switch and indicator.** See Section 2.6.
H B T N X M	**Visibility ON/OFF switches and indicators.** (See OK Geometry Basic reference.)
	When the **H** button is active, the hidden objects are displayed as if they were not hidden, otherwise they are displayed with a thin red dotted line.
	When the **B** button is active, the bleached objects are displayed as if they were not bleached.
	When the **T** button is active, the texts in the drawing are visible. Note that this does not affect the visibility of points' labels.
	When the **N** button is active, the transparent objects are visible (coloured in yellow), otherwise they are not displayed.
	When the **X** button is active, the auxiliary lines (related to angles) are visible, otherwise they are not.
	When the **M** button is active, the markers are visible, otherwise they are not visible.
	When the **?** button is active, the unknown objects of a construction are highlighted. (See section Advanced observation in OK Geometry Plus reference.)
(style indicator)	The rightmost indicator shows the style of the new objects to be created in Sketch Editor.
	To change the style of new objects, click on this indicator and set the styles on the form that appears.

3.2.   Sketch Editor toolbox

The editor's tool bar contains the frequently used commands. If two or more buttons are shown together on the table below, use the right button to select among them.

Button	Command
●	**Restyle objects**. Changes the style (i.e. colour, width or size, shape) of displayed objects. Clicking this button brings up the form for setting styles; then click one by one the objects to be restyled.
▯	**Hide/Show hidden objects.** If activated, the hidden objects are displayed in red. A click on an object changes its status from hidden to visible and vice-versa.
✗	**Delete objects.**
▣ ▣ ★ ☆ ✳	**Scenes (blue).** The Scenes command is used to declare or manage the scenes of a construction. The scenes share a common (ground) construction. For each scene it is possible to declare independently the emphasis, bleach, and transparency status of particular objects. The **Scenes** command displays a form that allows the setting of scenes on the current (ground) construction.
	Scenes (green). A simple way for displaying the scenes of the current construction.
	Toggle the emphasis status. Toggles the emphasis status of objects on the ground construction.
	Toggle the bleach status. Toggles the bleach status of objects on the ground construction.
	Toggle the transparency status. Toggles the transparency status of objects on the ground construction.
Gen	**Manage generic construction.** Generic constructions are described in the OK Geometry Plus reference documentation. The button is present also in the Basic mode. It turns red when the current construction is a generic construction, so that you can manage the examples in it even if you work in the Basic mode. For more information, see the Generic constructions section in the OK Geometry Plus reference manual.
A A	**Label a point.**
	Auto label indicated points. Labels a point with the letter that is on displayed on the button. If the point is already labelled, the label is deleted. To set the label on the button, press the **Alt+S** key.

• | •× | •½	**Point.** Declares a free point, a free point on an object or an intersection point (depending on the indicated position).
	Intersection of two objects. Declares a point as an intersection of two objects.
	Midpoint of segment, centre of circle. Declares a point as the midpoint of a segment or the centre of a circle.
/ | %	**Line through 2 points.** Use the **Anchor** command to change the mode of representing a line. See Section 6 for details.
	Line by 2 objects. Depending on the objects, the constructed line passes through point(s), is tangent to circle(s), is parallel or perpendicular to a given line, can be the line bisector or the radical axis of two circles. Use the **Alt** button to select alternatives. Use the **Anchor** command to change the mode of representing a line. See Section 6 for details.
○ | ③ | ② | ① | ○	**Circle with given centre and a point on the circumference.**
	Circle by 3 objects. Constructs a circle touching three given objects (points, lines, circles). Use the **Alt** button to select among alternatives.
	Circle by radius and 2 objects. Construct a circle with a given radius and touching two objects (points, lines, circles). Use the **Alt** button to select among alternatives.
	Circle with given centre and an object. Constructs a circle, with a given centre and touching a given object. Use the **Alt** button to select among alternatives.
	Compass. Constructs a circle, with a given radius (a line segment or the radius of a given circle) and a given centre.
•• | ⊣ | Λ	**Line segment.** Use the **Anchor** command to change the mode of representing a line. See Section 6 for details.
	Perpendicular segment. Constructs a perpendicular connection from a point to an object. Use the **Anchor** command to change the mode of representing a line. See Section 6 for details.
	Polyline. Constructs a polyline (a chained sequence of segments).

◁ ‖ ▓ →	**Angle.** Constructs an angle, given three points (ray, vertex, ray) or two baselines. Angles are positively oriented. Use the **Anchor** command to select among angles with the same baselines. See Section 6 for details.
	Congruence. Puts/clears a congruence mark (with 1,2,3,4 or 0 lines) on an object. Use the **Anchor** command to change the type of congruence mark. See Section 6 for details.
	Mark area. Toggles on/off the fill state of the polygon or circle. To select the fill (or border) colour, use the command **Restyle object.** Use the **Anchor** command to set the fill level of the area (in case the solid fill is used). See Section 6 for details.
	Mark arrow. Adds an arrow to the displayed line segment. Use the **Anchor** command to change the position and size of the arrow. See Section 6 for details.
Tx ①	**Text.** Places a text on the plane. Texts can be attached to objects. Texts are not geometric object but in many respects they behave as labelled points. Use the **Anchor** command to change the position or the text wrt. its reference point. Section 6 for details.
	Marker. Place a marker on the plane. Markers consist simple marks with an optional information in a balloon. Markers are not geometric object but in many respects they behave as labelled points. Use the **Anchor** command to change the position or the mark wrt. its reference point.
Alt	**Alternative results.** Selects among alternatives. If pressed (repeatedly), displays alternative results of certain commands. The same effect is achieved by scrolling the **mouse wheel**. Alternatives refer to different solutions or to analogous commands (e.g. parallel and perpendicular lines). See Section 2.5.

⚓	**Anchor.** Changes a visual aspect of objects. The button can be pressed repeatedly. The same effect is achieved by scrolling the **mouse wheel**. Changes the position of the *label of a labelled point*. Changes the *selection of angle* between intersecting lines. Changes the *extensions* in represented lines, lines segments, arcs. Changes the *direction of arrow* on an arrowed segment. Changes the *congruence sign* on a segment or arc. Changes the *position of a text* wrt. its reference point. Changes *fill level of a polygon or circle* (in case of solid fill).
●?	**Mark/unmark object as unknown.** This button is visible in the OK Geometry Plus only. For more information, see the Advanced query section in the OK Geometry Plus reference manual.
↗	**Drag.** Drags a point or a numeric parameter.
[ ]	**Zoom fit**. Press repeatedly for various zooming options: view all objects; view all displayed points; view all labelled points; view user (saved) view.
✛	**Pan.** Moves the whole configuration.
◄	**Undo.** Undoes the last command. Can be pressed repeatedly.
►	**Redo.** Redoes the last undo command. Can be pressed repeatedly.
⊗	**Redefine object.** Pick the object to be redefined and the set the new construction of the object.
△	**Set cyclic objects**. This button is visible in the OK Geometry Plus only. It declares 3 objects as cyclic with respect to the reference triangle.
Δ?	**Analyse object in the reference triangle.** This button is visible in the OK Geometry Plus only. For more information, see the Triangle analysis section in the OK Geometry Plus reference manual.

Some examples of geometric constructions are described in detail in Section 5. All commands are explained in detail in Section 4.

4. Description of the menu commands

The commands of the Sketch Editor are grouped in columns. Note that some columns and some commands in columns are present in Plus mode only. These commands are explained in the OK Geometry Plus reference manual.

4.1.   Sketch Editor: menu organisation

Action commands	Commands for manipulating geometric objects: drag points or parameters, label vertices, hide and delete objects, undo commands, zooming.
Point commands	Commands for placing and constructing points and sets of points.
Line commands	Commands for constructing lines, line segments, and polylines. Note that OK Geometry does not explicitly use rays and vectors.
Circle commands	Commands for constructing circles, circular arcs, and conics.
Number commands	Commands for numerical operations: measure geometric quantities, declare numeric parameters, calculate expressions, compose conditions.
Transformation commands	Commands for defining transformations and commands for applying transformations to objects. A transformation is treated as an explicit object. Once defined, it can be applied later to various objects.
Advanced commands	Commands for complex operations: construct frequently used shapes, create a locus of point, checking conditions, implicit constructions, optimisation based constructions.
(Special commands)	Commands from this group are available in Plus mode only. The group includes a set of commands related to triangle geometry. For more information, see the OK Geometry Plus reference manual.
(Generic constructions)	Commands from this group are available in Plus mode only. The group includes a set of commands for creating and managing generic constructions. For more information, see the OK Geometry Plus reference manual.
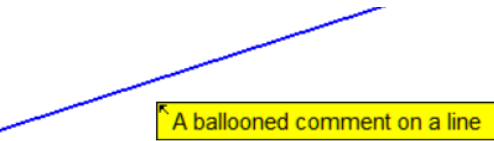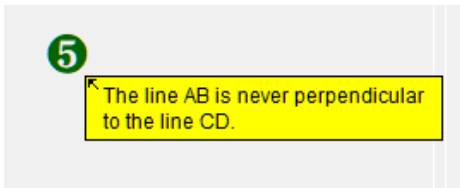
4.2. Action commands
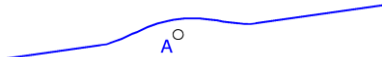
Command	Purpose	Comments
New project	Clear the current project and the current construction.	
New construction	Clear the current construction.	**Note**. The project (i.e. all icons) remains unchanged.
Drag point/parameter	Drag free points Dynamically change the value of a parameter	Only free (non-constructed) points can be dragged. **Note.** A long (continuous) click on a free point automatically calls the dragging command. It is possible to 'drag' numeric parameters that were declared as numbers (and not obtained as expressions or as measurements). To change the value of a parameter, activate the drag command and then click a numeric parameter. In the form that appears set the minimal, maximal value of the parameter as well as the incremental step. Then click on **Apply interval**. Use the slider to change the value of the parameter.
Hide	Hide objects	Click on the object you want to hide. Hidden objects are taken into account in the construction, but they are not visible and they are not observed. To unhide objects, use the command *Action|Show hidden*. Note that it is not possible to hide parameters and transformations.
Show hidden	Show hidden objects and hide objects	When active, all objects (displayed and hidden) are shown. The hidden ones are coloured red. Clicking on objects changes their status from hidden to displayed and vice versa.
Delete	Delete an object together with all objects that depend on it	

Redefine object	Redefine an object and modify it accordingly the depending objects.	Pick the object to be redefined. Then define a new object in place of the redefined one.
		Example. Suppose you draw a line AB. After several construction steps involving the line AB you find out that AC should be used instead of AB. To correct the situation, redefine the line:
		- Select the command Redefine object
		- Click on the line AB. The line turns blue and dotted.
		- Select the command Line 2pts
		- Click on the points A and C. The situation is corrected.
Visually align 2 points	Visually align two points horizontally or vertically.	The command aligns two selected points horizontally or vertically, whichever is closer. The perfect alignment is visible only in the exact (non-perturbated) view and in exported/printed images.
		The command causes a switch to the exact view.
Anchor label/angle/text/line	Change the position of label/text/marker wrt. its reference point	The Anchor button can be pressed repeatedly (the same effect is obtained by scrolling the **mouse wheel**).
	Change an angle with one with the same baselines	Anchor changes the position of the *label of a labelled point*. Note that labels can also be 'dragged' by a continuous click.
	Change congruence mark	Anchor changes the *selection of the angle* between intersecting lines (there are 8 choices).
	Change arrows on a segment	Anchor changes the *size and direction of arrow* on an arrowed segment.
	Change the fill level of an area	Anchor changes the *position of a text* wrt. its reference point.
	Change the way of representing a line, a segment, an arc	Anchor changes the *fill level of a region* – this makes sense only when a solid fill is used and the filled regions overlap.
		Anchor changes the extensions of the represented line: a line can be drawn up to the represented world or it can extend a bit over the visible points on the line. You can set the size of the extension in the *Configure|General options|Sketch|Extension of lines*.
		See Section 6 for more information on Anchor command.

Labels|Auto label	Auto label selected points Unlabel points	The point you click on is labelled with the first available label (as shown in the editor's toolbar). If the selected point is already labelled, then the label is deleted. To change the starting label, press the **Alt-S** or use the command *Actions|Labels|Label* vertex.
Labels|Label vertex	Label selected points with specified labels	Click on the point you want to label. Then write the desired label of the point. The label should comply with the format of labels (see General guidelines).
Labels|Clear label	Delete the label of selected points.	Click on the point to be unlabelled.
Labels|Set next label	Set new label for auto-labelling	The command initiates the starting label for the command *Labels|Auto label.* Alternatively, you can use the **Alt+S** key**.**
Labels|Label all	Auto label all displayed points	All displayed unlabelled points are labelled with the first available label in the same order as they were defined.
Labels|Clear all labels	Clear all labels	The labels of all points are deleted.
Mark|Mark angle	Mark an angle	To mark an angle, select: 1. a point on the ray; 2. the vertex of the angle; 3. a point on the other ray. Alternatively, select: 1. one of the baselines; 2. the other baseline of the angle. A positively oriented angle is marked. **Note.** Use the **Anchor** command (or scroll the mouse wheel) to mark other angles with the same baselines. See Section 6 for more details. **Note.** The radius and the type of the arc denoting the angle are set automatically. To modify the radius and the type of angle mark, right click on the blue dot or use the command *Configuration|General options|Sketch.* **Note.** The angle marks can be limited to angles less than 90, 180 or 360 degrees. To set this right click on the blue dot or use the command *Configuration|General options|Sketch.*

Mark|Mark area	Mark or unmark the interior of a polygon	The command toggles the fill state of a polygon or circle. **Note.** There are several ways of hatching (filling) the area. To select the type and density of hatch, right click on the blue dot or use the command *Configuration|General options|Sketch.* **Note.** Polylines need not be closed in order to be (area) filled. **Note. The command *Restyle object* provides a better way to colour the interior and border of a circle or polygon.**
(Mark|Toggle Unknown status)	**The command is available in the Plus mode only.**	The command toggles the Unknown status of objects. The command appears in OK Geometry Plus only. This command is used to mark objects that are considered as Unknown (non-given). Object marked as Unknown are coloured in pale-green. Such objects are not considered in the query, unless they are the object of query. A typical use of this function is the study of construction problems. In a construction we can query how can an Unknown object be obtained from known objects. For more information, see the Advanced query section in the OK Geometry Plus reference manual.
(Clear all Unknown)	**The command is available in the Plus mode only.**	The command clears the Unknown flag for all objects. The command appears in OK Geometry Plus only. For more information, see the Advanced query section in the OK Geometry Plus reference manual.
Mark|Mark arrow	Mark one or two arrows on a line segment	The command marks/unmarks one or more arrows a line segment. **Note.** Apply the **Anchor** command repeatedly (or scroll the **mouse wheel**) for various alternatives of placing arrows. See Section 6 for more information. **Note.** Adding arrows affects a line segment only visually, not functionally (i.e., arrowed segment does not function as a vector).

Mark|Mark congruence	Mark a line segment or angle with a congruence sign	The command places a congruence sign on a line segment or an angle. Apply repeatedly (or scroll the **mouse wheel**) to select among different congruence marks. **Note.** You can also use the **Anchor** command to change the type of congruence sign. See Section 6 for more information.
Mark|Marker	Create ballooned comments to displayed objects	**A click on a displayed object** allows you to create a comment that object. The comment is shown in a balloon only when the mouse pointer is on the object. Comments to the object are also shown in the *Commands|Construction steps* command. A ballooned comment on a line
	Place a marker with a ballooned comment	**A click on an 'empty space'** creates a marker. Markers are encircled numbers 1-10 or predefined symbols like !, ?, * with optional comments in balloons. Comments appear only when the mouse is on the marker. ❺ The line AB is never perpendicular to the line CD.

Mark|Detour point	Make an object to visually avoid a given point	The detour visually emphasises the fact that a point does not lay by definition on an object. Detour can be useful when presenting hypothetical situations ("Assume that the line does not pass through A ...") or facts to be yet proved ("We do not know yet if the line passes through A, we need to prove this."). In order to detour an object away from a point: 1. pick the object; 2. pick the point to be avoided, 3. enter the radius of the detour circle. **Note.** You can use the **Alt** command to change the side of the detour. **Note.** The radius of the detour can be set in *Configuration|General options|Sketch.*
Mark|Detour segment	Make an object visually avoid a given point along a segment	The detour only visually modifies a displayed line or circle along a segment. This command serves the same function as Detour point, only the presentation is a bit different. Detour can be useful when presenting hypothetical situations ("Assume that the line does not pass through A ...") or facts to be yet proved ("We do not know yet if the line passes through A, we need to prove this."). In order to detour an object along a segment: 1. pick the object; 2. pick the beginning of the detour; 3. pick the end of the detour, 4. enter the magnitude of the detour. The picked points become hidden. **Note.** Use the **Alt** command to change the side of the detour.
Mark|Text	Place a simple text in the construction	The command is used to place simple text in the dynamic construction or to modify a previously included text. The text can spread over several lines. **Note.** It is not granted that non-standard characters are correctly exported/printed. **Note.** To insert a dynamic value of a parameter, put the parameter name in brackets. For example: if Length_DA is the name of a parameter, you can insert a text like "Length of DA is [Length_DA]". **Note.** You can also use the **Anchor** command to change the position of the text wrt. its reference point.

Background	Set the background of the construction	The background can only be a self-standing imported image. If geometric objects are added on the background image, be sure to use the exact (non-perturbed) mode for displaying objects.
Background|Background from file	Import background from an image file	The background can only be a self-standing imported image to be displayed. If geometric objects are added on the background image, be sure to use the exact (non-perturbed) mode for displaying objects.
Background|Background from clipboard	Import background from the image in the clipboard	The background can only be a self-standing imported image to be displayed. If geometric objects are added on the background image, be sure to use the exact (non-perturbed) mode for displaying objects.
Background|Clear background	Clear the background	
Scenes...	Manage the scenes of the current construction	The command displays a self-explaining form, with which emphasise/bleach/transparency attributes of objects can be defined for each scene of the current construction. See the section Scenes in OK Geometry Basic reference.
Emphasise|Toggle bleach	Toggle the bleach status of objects	A bleached object is less visible (fainted). **Note.** The bleaching level can be set with **Alt+Mouse-wheel** or with the occasionally shown slider. **Note.** This command affects only the ground scene. Use the *Scenes...* command to manage other scenes of the construction.
Emphasise|All bleach	Bleach all objects	A bleached object is less visible (fainted). **Note.** The bleaching level can be set with **Alt+Mouse-wheel** or with the occasionally shown slider. **Note.** This command affects only the ground scene. Use the *Scenes...* command to manage other scenes of the construction.
Emphasise|Unmark all bleach	Un-bleach all objects	A bleached object is less visible (fainted). **Note.** The bleaching level can be set with **Alt+Mouse-wheel** or with the occasionally shown slider. **Note.** This command affects only the ground scene. Use the *Scenes...* command to manage other scenes of the construction.

Emphasise|Toggle emphasis	Toggle the emphasis status of object	An emphasised object is highlighted in a controlled way. **Note.** The emphasis level can be set with **Shift+Mouse-wheel** or with the occasionally shown slider. **Note.** This command affects only the ground scene. Use the *Scenes...* command to manage other scenes of the construction.
Emphasise|Unmark all emphasis	Clear emphasis attribute of objects	An emphasised object is highlighted in a controlled way. **Note.** The emphasis level can be set with **Shift+Mouse-wheel** or with the occasionally shown slider. **Note.** This command affects only the ground scene. Use the *Scenes...* command to manage other scenes of the construction.
Emphasise|Toggle transparent	Toggle the transparency status of object	A transparent object is not visible, but is taken into account in the construction and also in the observation. The Sketch Editor shows transparent objects either coloured yellow or transparent. **Note.** This command affects only the ground scene. Use the *Scenes...* command to manage other scenes of the construction.
Emphasise|Unmark all transparent	Declare all objects as non-transparent	A transparent object is not visible, but is taken into account in the construction and also in the observation. The Sketch Editor shows transparent objects either coloured yellow or transparent. **Note.** This command affects only the ground scene. Use the *Scenes...* command to manage other scenes of the construction.
Emphasise|Make everything transparent	Declare all objects as transparent	A transparent object is not visible, but is taken into account in the construction and also in the observation. The Sketch Editor shows transparent objects either coloured yellow or transparent. **Note.** The command affects only the ground scene. Use Scenes... command to modify other scenes of the construction.

Restyle objects	Set the visual appearance of picked objects.	In the form that appears, select the width, colour, and shape of line/point. It is possible to change only some attributes and leave others unchanged.
		In the form, set the appearance parameters; then click on the objects you want to apply the appearance parameters.
		For polygons you can specify whether the selected colour refers to the border line or to the filled interior. There are several ways of hatching (filling) the area. To select the type and density of hatch, right click on the blue dot or use the command *Configuration|General options|Sketch.*
		The **More** command allows efficient ways of simultaneously restyle several objects. It is possible to restyle at once all objects of a given colour, or all objects of a given type and pattern, etc.
Undo command	Undo the last command	The command can be repeated several times.
Redo command	Undo the last undo command	The command can be repeated several times.
Zoom|Zoom in [Ctrl+Plus]	Zoom in with respect to the centre of the displayed area	**Note.** To achieve a similar effect, use **Ctrl+Mouse-wheel.**
Zoom|Zoom out [Ctrl+Minus]	Zoom out with respect to the centre of the displayed area	**Note.** To achieve a similar effect, use **Ctrl+Mouse-wheel**.
Zoom|Pan view	Drag the view area to the desired position	**Note.** To achieve a similar effect, use a long (continuous) click on an empty space in the construction.
Zoom|Zoom view	Mark the region to be zoomed-in	Define (by dragging) the rectangle, which becomes the new view area.
Zoom|Zoom save [Ctrl+End]	Save the current view	The saved view can be accessed by repeatedly pressing the [] button in the Sketch Editor tool box.
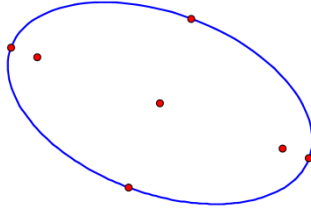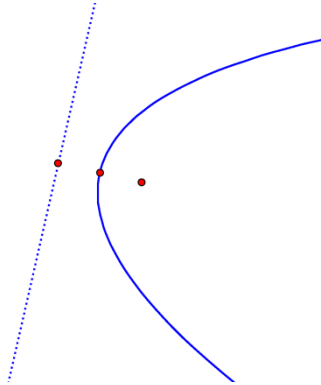
Zoom|Fit points/objects *[Ctrl+Home]*	Zoom to various ways of showing all points/objects	Sets the viewed area so that all visible points are displayed. If repeated, then the viewed area contains in turn: 1. all labelled points; 2. all visible points; 3. all visible objects; 4. the user-saved view area.
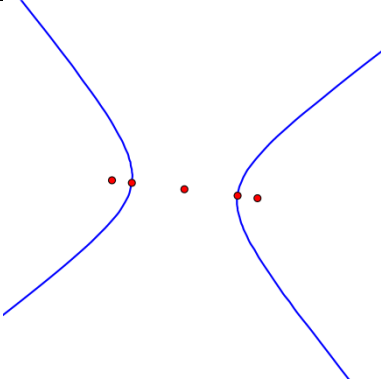
4.3.   Point commands

Command	Purpose	Comments
Point	Draw a point

Draw a point on an object

Draw an intersection point | A click on an 'empty' region creates a 'free' point.

A click on an object (e.g., a line, a circle) creates a 'free' point that is attached to this object (if **Safe points** is OFF) or to the corresponding base object (if **Safe points** is ON). (See the **Safe points** command.)

A click o the intersection of two objects creates the intersection point. (See also *Intersections* for the set of all intersection points of two objects.) |
| *Point on object* | Draw a point that is attached to an object | A click on an object (e.g., a line, a circle) creates a 'free' point that is attached to this object (if **Safe points** is OFF) or to the corresponding base object (if **Safe points** is ON). (See the **Safe points** command.) |
| *Intersection* | Construct a point as an intersection of two objects | Click on two objects, one after the other. The command creates the intersection point that is closest to the (first) clicked position.

Note. If one of the objects is a conic, the other object must be a line. |
| *PointXY* | Create a point with given fixed coordinates | Enter the coordinates of a point. Such a point cannot be dragged. It is considered a fixed point also in the observation analysis. |

Safe points	Toggle the Safe modality of treating line segments and arcs. (See 2.6.)	The status of the **Safe points** is shown by the **Safe** indicator in the upper right part of the display. Clicking on the indicator changes the status of **Safe points**. The **Safe points** mode affects intersection and dragging operations. If **Safe points** is OFF then intersections and dragging operations work as intuitively expected. If **Safe points** is ON then line segments, segments of polylines, and circular arcs are interpreted as base-lines or base-circles. This option is more robust and therefore should be preferred. *Example. If a point is created as the intersection of two segments (with Safe intersection ON), then the point is defined as the intersection of the corresponding base-lines. Such intersection point exists even if the two segments (when dragged) do not intersect each other.* *Example. If a point is linked to a line segment (with Safe intersection ON), the point can be dragged along the base-line of the segment.*
Midpoint	Construct the midpoint between two points Construct the midpoint of a line segment or an arc Construct the point at halfway along a polyline Construct the midpoints of all segment of a polyline (See 2.9)	Pick two points or a segment, or an arc or a polyline.

Divide ratio	Construct the point along an arc, a segment or a polyline that divides it in length in a given ratio Construct points on a polyline that divide each of its segment in a given ratio (See 2.9)	Pick two points or a segment, or an arc or a polyline. Then enter the desired ratio. The ratio *a/b* or *a:b* divides a segment in ratio *a:b*. For example, if the segment AB is divided in a ratio 1:2, the point C is created, which lies at 1/3 of the distance from A to B.
Centre of circle	Construct the centre of a circle or circular arc	
Nearest point	Construct the point on a given object that is closest to a given point (See 2.9)	Pick: 1. an object (line, line segment, polyline, arc); 2. a point. The command constructs a point on the object (1) that is closest to the point (2). **Note.** If the selected object (1) is a polyline, then you can obtain the nearest point on the shown segment, on each segment, or on the entire polyline.
At length	Construct a point on the object at a given arc length (See 2.9)	Select: 1. an object (line segment, polyline, arc); 2. a positive number. The command constructs a point on object (1), so that the arc length from the beginning of the object to the constructed point is equal to (2). **Note** If the selected object (1) is a polyline, then you can obtain points at a given length on the shown segment, on each segment, or on the entire polyline.
Triangle 4 centres	Construct the 4 classical triangle centres	In the form that appears, select the type of triangle centre. Then, either pick a triangle (as a polyline) or its three vertices.
Harmonic conjugate	Construct the harmonic conjugate of a point with respect to the reference points.	Select: 1. the two reference points; 2. the point to be harmonically conjugated. **Note.** If the point to be conjugated is not collinear with the reference points, it is replaced with its projection onto the line through the reference points.

Vertices	Create the set of vertices of a polyline	Some commands create a polyline with no marked vertices on it. Use this command to obtain all vertices of such polylines.
Conic points	Construct the characteristic points of a conic.	Pick a conic or 5 points on the considered conic. The command constructs a set of points. The number and the meaning of the constructed points depends on the type of the considered conic.

If the conic is an ellipse then 7 points are constructed: the centre, the two focuses and the endpoints of both axes.

If the conic is a parabola then 3 points are generated: the focus, the intersection of the axis with the parabola and the intersection of the axis with the directrix.

If the conic is a hyperbola then 5 points are generated: the focuses, the centre and the two intersections of the hyperbola with the axis.
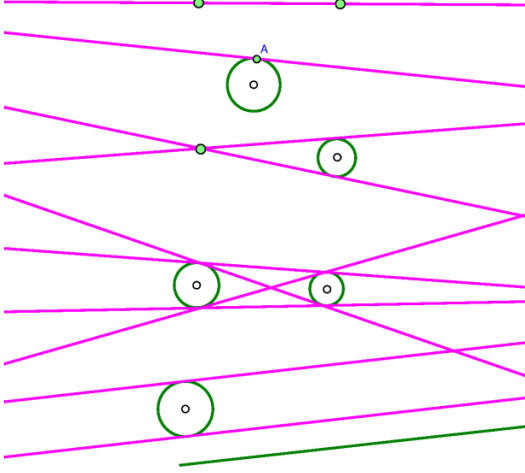
Intersections/ Intersections	Construct the set of **all** intersection points of two objects	Select two objects (circles, lines, arcs, polylines, conic). The command constructs the set of all intersection points of the two objects. **Note.** If one of the objects is a conic, the other one should be a line.
Intersections/ Nearest intersection	Construct the intersection point of two objects that is closest to a given point	Select: 1. two objects (circles, lines, arcs, polylines, conic); 2. a point. **Note.** If one of the objects is a conic, the other one should be a line.
Intersections/ Farthest intersection	Construct the intersection point of two objects that is furthest away from a given point	Select: 1. two objects (circles, lines, arcs, polylines, conic); 2. a point. **Note.** If one of the objects is a conic, the other one should be a line.
Grids/Uniform divide	Construct a pattern of equally spaced points along an object or between two points (See 2.9)	Select: 1. two points or a line segment, arc, or polyline; 2. the number of segments (not points!) to be generated. If the selected object (1) is a polyline, then the number of segments between points refers to either along the entire the polyline, along each segment of a polyline or along just one segment of the polyline.
Grids/Rectangular grid	Construct a grid of points in the form of a parallelogram	Select: 1. the lower left corner of the grid; 2. the lower right corner of the grid; 3. the upper left corner of the grid; 4. the number of points in the horizontal direction; 5. the number of points in the vertical direction.

Grids|Circular grid	Construct a grid of points in the form of a circular segment	Enter: 1. the centre of the circle; 2. one corner of the grid; 3. the opposite corner of the grid; 4. the number of points in radial direction; 5. the number of point in angular direction.

4.4.   Line commands
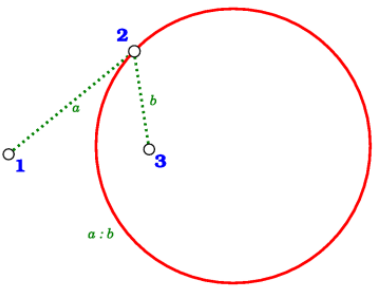
Command	Purpose	Comments
Line: 2 points	Construct a line through two points	Select two points. You can either point to an existing or to a non-existing point – in the latter case a new point is implicitly defined. Use the **Anchor** command to change the mode of representing a line. See Section 6 for details.
Line: point + angle	Construct a line with a fixed inclination	
Segment	Construct a line segment given its endpoints	Select the two edge points of a line segment to be constructed. You can either point to an existing point or to a non-existing point – in the latter case a new point is implicitly defined. Use the **Anchor** command to change the mode of representing a line segment. See Section 6 for details.
Perpendicular segment	Construct a perpendicular segment to a line or to a circle from a point Create a segment of a specified length	Select a point, then an object (line, segment or circle). A perpendicular segment to the object from the selected point is constructed. If you select a point and enter an expression, then a segment of the specified length is created. Use the **Anchor** command to change the mode of representing a line segment. See Section 6 for details.

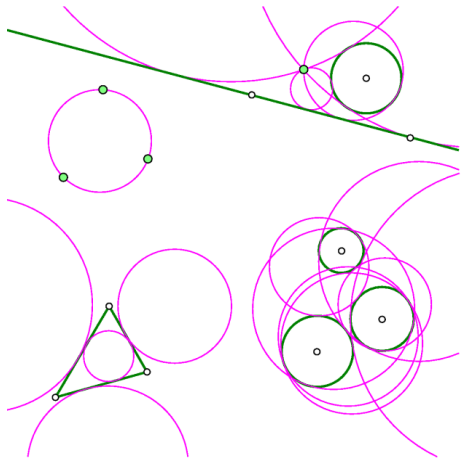|		
Polyline	Construct a polygonal line given its vertices	Click successively to the vertices of the polygonal line. You can either point to existing points or to non-existing points – in the latter case, new points are implicitly defined.
		To draw another polygonal line, click on the Polyline command again.
		To draw a closed polygon, simply end at the starting vertex. There is no indication whether a polyline is closed or whether it should be interpreted as a polygonal region.
		Note. The construction tends to avoid self-intersections. In particular, the **quadrilaterals** are automatically modified to avoid self-intersections of segments.
		Note. If the **Safe points** is ON, the displayed segments of polyline behave as a lines in some situations.
Parallel line	Construct a line that is parallel to a given line and passing through a given point	Pick a line and a point or vice versa.
		Note. To obtain a perpendicular line, press the **Alt** button in editor's toolbar (or scroll the mouse-wheel).
Perpendicular line	Construct a line that is perpendicular to a given line and passing through a given point	Pick a line and a point or vice versa.
		Note. To obtain a parallel line, click on the **Alt** button in editor's toolbar (or scroll the mouse-wheel).
Bisector	Construct the bisector of a line segment	Pick the endpoints of a segment or pick a line segment.
Angle bisector	Construct the angle bisector See 2.5.	Select two lines. The bisector of the resulting angle is displayed. To obtain the alternative solution, click on the *Alt* button in the editor's toolbar (or scroll the mouse-wheel).
		Or, pick three points: 1. a point on a ray; 2. the vertex of the angle; 3. a point on the second ray.
Line: 2 objects	Construct a line defined by two selected objects in terms of passing through points, being tangent to circles or conics , being parallel or perpendicular to a line, being the radical	Select two objects (points, lines, circles, conics). A line defined by the two objects is drawn. Usually there are two or more alternative solutions. To obtain them, click on the *Alt* button in editor's toolbar or scroll the mouse wheel.
		Note. This command comprises most of the line commands. The resulting line is defined by two objects

axis of two circles	and the relations 'passing through', 'parallel with', 'tangential to', 'radical axis'.
	With this command and the mouse wheel you can, for example, construct:
	a line through 2 points;
	a line tangent to 2 circles;
	a line parallel or perpendicular to a given line and touching a given circle;
	the radical axis of two circles;
	a line passing through a point and touching a conic.

4.5.   Circle commands

Command	Meaning	Comments
Circle: centre + point	Construct a circle given its centre and a point on its circumference.	Point to: 1. the centre of the circle; 2. a point on the circumference.
		You can either point to existing points or non-existing points – in the later case, new points are implicitly defined.
Circle: centre + radius	Construct a circle given its centre and the numerical value of the radius.	Set: 1. the centre of the circle; 2. the numeric value of the radius of the circle (either by writing the value on the information line, by selecting a previously defined parameter, or by clicking a circle).

Compass	Construct a circle given its radius (as the length of a line segment or the radius of another circle) and its centre.	Set: 1. the radius of a circle by pointing to a line segment, to the endpoints of a line segment or to a circle; 2. the centre of the circle to be constructed.
Apollonius circle	Given two points, construct the locus of points X with a given ratio of the distances from X to the two given points.	Pick: 1. the first point; 2. a point on the Apollonius circle (to be constructed); 3. the second point. Each point X on the resulting Apollonius circle has the property that the ratio of the distances from X to (1) and from X to (3) is equal to the ratio of the distances from (2) to (1) and from (2) to (3).
Circle: centre + object	Construct a circle, given its centre and an object (circle, line or point) that touches the circle. See 2.5	Select: 1. the centre of the circle, 2. the object touching the circle. The object can be a circle, a line or a point. **Note.** Usually there are more alternative solutions. To get them, click on the *Alt* button in editor's toolbar or use the mouse-wheel.
Circle: radius + 2 objects	Construct a circle with a given radius and two objects (circles, lines or points) that touch the circle. See 2.5.	Set: 1. the first touching object; 2. the second touching object; 3. the radius of the circle (either by entering the numerical value or by pointing to a circle). **Note.** Usually there are more alternative solutions. To get them, click on the *Alt* button in editor's toolbar or use the mouse-wheel.
Circle: central angle + 2 objects	Construct a circle that 'touches' two given objects (circles, lines or points) so that the circle radii to the touch-points form a given	Set: 1. the first touching object; 2. the second touching object; 3. the angle (in degrees) between the radii to the touch-points. **Note.** Usually there are more alternative solutions. To get them, click on the *Alt* button in editor's toolbar or

	angle.	use the mouse-wheel.
Circle: 3 objects	Construct a circle defined by three given objects (circles, lines or points) in terms of passing through points or being tangent to circles or lines See 2.5	Pick the three objects (points, lines, circles) that the circle is supposed to touch. **Note.** Usually there are more alternative solutions. To get them, click on the *Alt* button in editor's toolbar or use the mouse-wheel. With this command you can, for example: draw a circle that touches two lines and passes through a given point; circumscribe a circle to a triangle (point to three vertices); inscribe a circle to a triangle (point to three sides), draw a circle that touches three given circles; and so on …
Semicircle	Construct a semicircle given its endpoints.	Pick: 1. the first endpoint of the semicircle; 2. the remaining endpoint of the semicircle. **Note.** To obtain the alternative solution, press the **Alt** button in editor's toolbar (or scroll the mouse-wheel). Use the **Anchor** command to change the mode of representing the semicircle. See Section 6 for details.
Arc 3 pts	Construct a circular arc given its endpoints and a point inside the arc	Pick: 1. an endpoint of the arc; 2. a point inside the arc; 3. the other endpoint of the arc. Use the **Anchor** command to change the mode of representing an arc. See Section 6 for details.
Arc centre	Construct a circular arc given its centre and two endpoints	Pick: 1. the centre of the arc; 2. the first endpoint of the arc (considering the positive orientation of the arc); 3. the approximate second endpoint of the arc (considering the positive orientation of the arc).

		Use the **Anchor** command to change the mode of representing a line segment. See Section 6 for details.
Indicate arc	Construct an arc indicating a circle	Pick: 1. the centre of the arc; 2.the approximate centre of the indicated arc. This command is useful for illustrating constructions with a compass.
Conic 5 points	Draw a conic given 5 points on it.	Pick 5 points on the conic to be constructed. **Note.** Other constructions of conics are available in menu *Advanced|Shapes|Other*.
(Cubic 9 points)	Draw a cubic given 9 points on it. (Only in Plus mode)	Pick 9 points on the cubic to be constructed. **Note.** Other constructions of cubics are available in menu *Special Triangle derived objects,* in *Special|TrianglePoint derived objects,* and in *Special|Various constructions*

4.6.   Number commands

Command	Purpose	Comments
Distance to object	Find the distance from a point to an object (another point, a line, a circle)	Set: 1. The point from which the distance is measured; 2. The object to which the distance is measured (can be a point, a line or a circle); 3. The name of the parameter with the measured value.
Radius of circle	Find the radius of a circle or circular arc	Pick a circle or arc and declare the name of the parameter.

Angle size	Find the size of an angle	First option: 1. Pick a point on the angle's ray; 2. Pick the angle vertex; 3. Pick a point on the other angle's ray; 4. Enter the name of the parameter with the size of the angle.
		Second option: 1. Pick a base line of a ray; 2. Pick the base line of the other ray; 3. Enter the name of the parameter that will contain the size of the angle between base lines.
		Note. The angles are always expressed in degrees.
		Note. The measured size of the angle can be positive or negative, depending on the orientation of the angle.
		Note. The measured angle between baselines is always smaller or equal to the right angle.
Length, perimeter	Find the perimeter of a circle Find the length of a line segment or circular arc Find the length of a polyline Find the length of a segment of a polyline	Point to a circle, a line segment or a polyline. If you select a polyline, you need to specify, whether the length refers to the pointed segment or to the entire polyline. Then enter the name of the parameter with the length/perimeter.
Area	Find the area of a given circle Find the area enclosed in a polyline	Select a circle or a polyline. Then write the name of the parameter with the measured area. **Note.** The polyline should be closed and without self-intersections, otherwise the resulting area is not valid.
Ratio of segments	Find the ratio of the lengths of two line segments	Either select two existing line segments (they can be part of a polyline) or pick the 4 endpoints of the two line segments. Then write the name of the parameter with the ratio of the lengths of the segments.

| (Winding number) | Find the winding number of a closed polyline with respect to a point

Find the position of a triangle centre with respect to the triangle

Find the orientation of a triangle

(**Available only in Plus mode**) | First option: 1. enter a closed polyline; 2. a point.

The command calculates the winding number of the point with respect to the **closed polyline**.

Second option: 1. Enter a triangle as a closed polyline; 2. an integer.

The command returns the winding number of the triangle with respect to the ETC triangle centre (second argument).

Note. Let *p* be a **simple closed polyline** and P a point. The winding number of *p* with respect to P achieves the following values:

- 1, if *p* is positively oriented and P is in the interior region bounded by *p*;
- -1. if *p* is negatively oriented and P is in the interior region bounded by *p*;
- 0. if P is in the exterior region bounded by *p*;
- 0.5 or -0.5, if P is on the polyline *p*.

Note. If the polyline is not closed, the result is meaningless.

Note. A simple way to determine the orientation of a triangle is to obtain its winding number with respect to its ETC centre 1 (incentre) or 2 (centroid). The result 1 means positive orientation while -1 means negative orientation. |

Value, Expression	Calculate the numerical value or the value of an arithmetic expression	Note the input field that appears in the information line and the OK button next to it. Enter the value of the parameter and then the name of the parameter.
		If the entry value of the parameter is a number, then the parameter can be dynamically changed (see the command *Action|Drag Parameter*).
		The entry value of the parameter can be as well an arithmetic expression, perhaps containing mathematical functions and previously defined parameters. Such parameters cannot be 'dragged'.
		To insert the value of a parameter in the expression, simply click on the parameter in the Transformations & Parameters section (on the left pane). Note that the names of the parameters are written in brackets.
		The expressions should follow the usual syntax rules. Expressions can contain mathematical functions (see the list below). For the power sign use either ^ or **.
		Here are some examples:
		2.785 (a numeric parameter that can be 'dragged')
		1/(6.3 +2,2^2) (an arithmetic expression)
		sqrt(sin(60)+cos(30)) (expression with functions; use degrees)
		[par1]/(2+[par3]) (an expression with previously defined parameters)
Compose conditions	Compose conditions	There are several commands for defining geometric conditions (e.g. whether three points are collinear), see the command Check property *in section 4.8*. With this command you can compose previously defined geometric conditions. The only two allowed operations in the logical expression are logical conjunction (and) and logical disjunction (or).
		Conditions are composed in the field that appears on the information line. To insert a previously set condition, simply click on the condition in the Parameters section. As mentioned, the expression can contain only: conditions, and, or, parentheses.

(Triangle expression)	Calculate triangle related numerical expression (only in Plus mode)	You can use in the expression the well-known triangle-related parameters, e.g. triangle sides, triangle angles, Brocard angles, Conway parameters, etc.
		To calculate a triangle related expression: 1. pick the vertices of the triangle (in expression they are referred to as vertices A, B, C) or click a polyline that defines a triangle; 2. write an expression in the form that appears; 3. write the name of the created parameter.
		Note. Angles are in degrees.

Here is a list of the functions that can be used in numeric expressions:

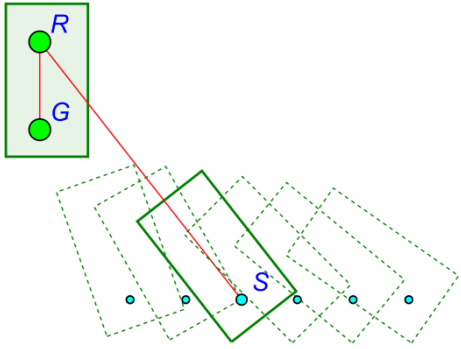|				
ABS(x)	absolute value of x		HYPOT(x,y)	length of hypotenuse in right triangle with sides x and y
ACOS(x)	arcus cosines of x (degrees)		IFIX(x)	integer part of x
			LCM(x,y)	least common multiple of x and y
ASIN(x)	arcus sinus of x, in degrees		LOG(x)	natural logarithm of x
ATAN(y,x)	arcus tangens of y/x, in degrees		MAX(x,y)	the biggest of x and y
ATANG(x)	arcus tangens of x, in degrees		MIN(x,y)	the smallest of x and y
CEIL(x)	smallest integer that is bigger or equal to x		PI	the constant pi
			RAD(x)	x degrees expressed in radians
COS(x)	cosine of x (degrees)		RAND(x,y)	a random number between x and y
DEG(x)	express radians in degrees			
EXP(x)	exponent function		REM(x,y)	remainder of x when divided by y
FLOOR(x)	largest integer that is smaller or equal to x		RND	random number between 0 and 1
			SIGN(x)	sign of x, can be -1, 0 or 1
FROUND(x)	round x to the nearest integer		SIN(x)	sine of x (degrees)
GCD(x,y)	greatest common divisor of x and y		SQRT(x)	square root of x
			TAN(x)	tangens of x (degrees)

4.7. Transformations commands

Transformations in OK Geometry are treated as explicit objects. You can apply a transformation immediately after its definition or later.
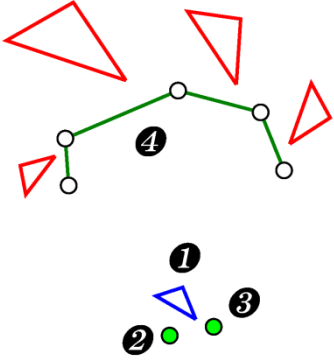
Suppose you want to define a translation that moves a given point A to a given point B. After you select the command *Transformation|Translation* you are asked to pick the point A and the point B. A transformation called Tran_AB is created and can be immediately applied to an object. You can refer to and apply the transformation later using the command *Transform|Transform object*.

The transformation is 'visible' in Transformation & Parameters list. A right click on a transformation in the list reveals possible actions with that transformation. Most actions are self-explanatory, so we mention only two of them. *Transform object* transforms accordingly the object you click on. *Transform object+* transforms successively the objects as you click on them.

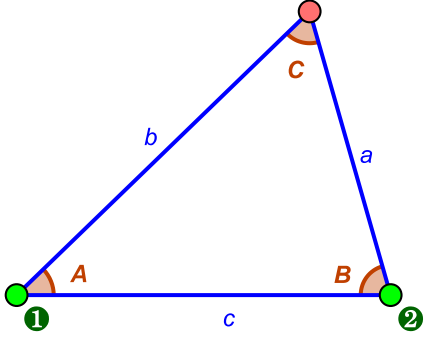| Command	Purpose	Comments
Translation	Define a translation and apply the translation or its inverse Define a glide translation and apply the translation or its inverse	First select a point (origin) and the point where you want the origin to be translated to. **Note.** Press the **Alt** button at this point if you want to declare a glide translation. Then pick the object you want to apply to the (glide) translation. **Note.** Press the **Alt** button at this point to apply the inverse transformation.
Reflection	Define a reflection symmetry (wrt. a line) and apply it	Pick a line or two points on the line of reflection. Then pick the object to be reflected wrt. the line.
Rotation symmetry	Define a rotation symmetry and apply it	Pick the centre of rotation symmetry. Then pick the object to be transformed.
Rotation	Declare a rotation around a given point and apply it or its inverse to an object	Select: 1. the centre of rotation; 2. the angle of rotation; 3. the object to be transformed. **Note.** Press the **Alt** button at this point to apply the inverse transformation. **Note.** The rotation angle is oriented and should be given in degrees. It can be an arithmetic expression containing previously defined parameters.
Dilatation	Define a dilatation and apply it or its inverse to an object	Select: 1. the centre of dilatation; 2. the dilatation factor; 3. the object to be transformed. **Note.** Press the **Alt** button at this point to apply the inverse transformation. **Note.** The dilatation factor can be an arithmetic expression containing previously defined parameters.

Similarity	Declare a similarity transformation and apply the transformation or its inverse to an object Declare a glide similarity transformation and apply the transformation or its inverse to an object	Select: 1. the first origin point; 2. the image of first origin point; 3. the second origin point; 4. the image of the second origin point. **Note.** Press the **Alt** button at this point if you want to declare a glide similarity. Then pick the object you want to apply to the (glide) similarity. **Note.** Press the **Alt** button at this point to apply the inverse transformation.
Projectivity	Declare a projectivity that maps four given points to four given points	Select an origin point and then its image point. Repeat this for the remaining three origin and image points. Then pick the object you want to apply to the projectivity. **Note.** Press the **Alt** button at this point to apply the inverse transformation.
Inversion wrt. circle	Invert a point, line or circle wrt. a circle	Pick: 1. a circle; 2. the object (point, line, circle). The inversion of the object wrt. the selected circle is constructed.
Compose transformations	Define a new transformation as the composition of two previously defined transformations	
Inverse transformation	Define a new transformation as the inverse of a previously defined transformation	

Transform object	Apply a previously declared transformation or its inverse to an object	Selected a transformation from the list of previously defined transformations. Press OK in the information line (upper right of the display) to confirm the selection. Then select the object to be transformed. **Another way to transform objects** is to right click on the transformation and use the command *Transform object* (to transform one object) or *Transform object+*(to transform several objects) . **Note.** Press the **Alt** button at this point to apply the inverse transformation.
Other | Multiply object by grid	Position in various ways copies of a given object along a grid of points	This command places copies of a given object O along the variable point S of a given grid, one copy of O for each point of the grid. The way of placing copies of the object O depends on two points related to it: the guide point G and the reference point R. For each point S on the grid a copy of the transformed object O is generated under the composition of: an optional dilatation with centre G and factor |GS|/|GR|; an optional rotation that carries the line RG to line RS; an optional translation that carries G to S. To execute the command select: 1. the object O to position along the grid; 2. the guide point G; 3. the reference R; 4. any grid-point (setPoint) on the grid.

Multiply along polyline	Position geometrically similar copies of a given object along each segment of a polyline	This command positions similarity copies of an object along the sides of a polyline. The similarity transformation brings two given reference points of the object to the endpoints of respective sides of the polyline. Select: 1. the object to position along the grid; 2. the 1st reference point of the object (a point); 3. the 2nd reference point of the object (a point); 4. the polyline along which to position the object.
Repeat transformation	Apply recursively a number of times a transformation to an object	Select: 1. the transformation; 2. the number of repetitions; 3. the object to which to apply to recursively the transformation. A sequence of object will appear, each object is transformed from the previous one with the given transformation.

4.8.   Advanced commands

Command	Purpose	Comments
Shapes	Construction of various commonly used shapes (isosceles triangle, rectangle, regular n-gon and many others)	This command allows you to easily construct frequently used dynamic shapes. In the form that appears, first select the type of shape (triangle, quadrilateral, other) and then the specific shape. Then follow the instructions on the information line. **Note.** The input vertices of the shape should **follow a positive orientation** (for some shapes this is irrelevant). Not all vertices of the constructed shape are displayed. Make them accessible with the command *Point|Vertices*. By default the vertices of the constructed shapes are not labelled. You can label them with the commands *Action|Labels|Auto label* or *Action|Labels|Label all*. **Triangle shapes** are listed with their descriptive names (e.g., Isosceles triangle, Kepler triangle), self-explanatory names (e.g.,

		Triangle 3-4-5, Triangle 10-60-90) or with descriptive properties involving quantities shown below.
		
		In all cases **it is required to enter two base vertices** of the triangle, here named as ① (vertex A) and ② (vertex B) - and sometimes some additional data. The additional data may involve the sides *a, b, c* or angles A, B, C.
		
		Examples:
		
		  C=90 – You get a right triangle, the third vertex (C) is free.
		
		  a:b=2 - The third vertex (C) can be moved along the Apollonius' circle.
		
		  A=60 & *a-b* : *c* = 1 : 2 – You get the specifies triangle.
		
		Quadrilateral shapes are all listed with their descriptive names (e.g. Square, Equidiagonal). In all cases you first enter the first two vertices of the quadrilateral – and possibly one or two additional vertices. You always obtain a dynamic shape in which the vertices and/or some control point can be moved.
		
		Other shapes consist of regular polygons and conics.

Check property	A collection of tests on geometric objects (collinearity of points, congruence of triangles and many others).	This collection of commands contains checks for a variety of geometric properties. In the form that appears when the command is clicked, first select the type of property you want to check (position, equivalence, shape). Then select a property from the displayed list. Afterwards, follow the instructions in the information line. Besides the obvious use, these checks are important for the command *Advanced|Implicit construction*, which tries to modify a given construction so that a previously defined check is fulfilled.

Locus	Create the locus of a constructed point as another point moves along an object.	Select: 1. a constructed point to be traced (the point should depend on the point (2); 2. the point to be moved along a path; 3. the object (circle, arc, line, line segment, polyline) along which (2) moves. The resulting object is a curve, which represents the trail of (1) as (2) moves along (3). **Note.** It is *not* required that the point (2) lies on the object (3). **Note.** If the resulting locus appears to be (part of) an underlying common object (line, circle or conic, cubic), that object can be created too.
Implicit locus	Obtain a hint for the locus of points for which a construction-related parameter is fixed	The command attempts to suggest a possible locus of a constructed point in the construction, so that a construction-related parameter has a desired value. Only points, lines, circles, conics, and cubics are eventually suggested as a possible locus. **Note.** At best, the command provides just hint for the locus. The hint should always be critically evaluated. **Note.** This command reduces the reliability of observational results.
Implicit construction	Find the position of a point so that a condition is satisfied Obtain a hint for the locus of points for which a given condition is satisfied Modify up to three objects in the construction so that condition is satisfied	There are two versions for this command. In both cases the program attempts to modify one or more objects in a construction so that a given condition is fulfilled, i.e. so that a checked property is true. In the **simple version of the command,** the program attempts to find the position of a given free point so that a target (previously defined) condition is fulfilled. The positioned free point can be attached to a line or circle or completely free. In case that several points on the plane fulfil the given condition, OK Geometry occasionally suggests a hint for the locus of such points. Use the **simple version** of the command as follows: Create the initial construction, which satisfies all conditions except one (the target condition). You want to position a variable free point so that the target condition is satisfied. Using the command *Advanced|Check property* find whether the target condition is satisfied (e.g., whether two objects coincide, whether three points are collinear). At this point, obviously, the target condition is not yet satisfied. Call the command *Advanced|Implicit construction.* A form (for simple version of the command) appears. Choose one of the

		three options for implicit construction. The first two options deal with situations where we expect the solution in form of a single point (either on an object or on the plane). The last options deals with situations where we expect the solution in form of a locus of points (a line, a circle, a conic, a cubic). When you fill the form, click OK and pick the variable point. The variable point attains a new position. Check whether the desired position of the moved point has been found, i.e. whether the target condition is true.
		The **advanced version of this command** allows the modification of up to three objects (points, lines, circles) or numeric parameters. Furthermore you can:
		Define a restriction for each object. If the positions of the objects to be modified are almost correct, then select 'local optimisation'. **Note. Implicit construction reduces the reliability of observational results.**
Optimisation	Modify one or more objects in a construction so that the value of a parameter is optimised	Optimisation procedure is similar to implicit construction. Instead of a condition to be fulfilled, there is a numerical parameter to optimise. The scalar value is optimised by automatically changing the position of one or more objects.
		Make the initial construction. Compute (as a numerical parameter) the value to be optimised. Proceed as in the case of *Advanced|Implicit objects*. **Note. Optimisation procedures reduce the reliability of observational results.**
Make macro	Define a sequence of commands as a new command Save macros to be used in other constructions.	First we have to carefully make a construction, in which some (dependent) objects are constructed from some initial objects. Then use the command *Advanced|Make macro* and proceed as follows:
		Fill out the form that describes the macro. In particular, choose the types of the input object(s) and the type of the output object(s). Next to the selected types of input objects you can write comments on how to select objects. Press the Continue button. Select the input and the output objects in the appropriate order. When the macro is successfully created you can save it to a file (to use it in other occasions). In any case you can use the generated macro in the current session with the command *Advanced|Execute macro*.

Get macro	Read one or more macros saved in from previous sessions.	
Execute macro	Execute a macro	Select a macro and execute it as any other command.

The Sketch Editor of OK Geometry Plus contains two additional groups of commands: Special and Generic. The first group is a collection of commands on various triangle objects. The second group is dedicated to generic constructions. Both groups of commands are described in the OK Geometry Plus Reference manual.
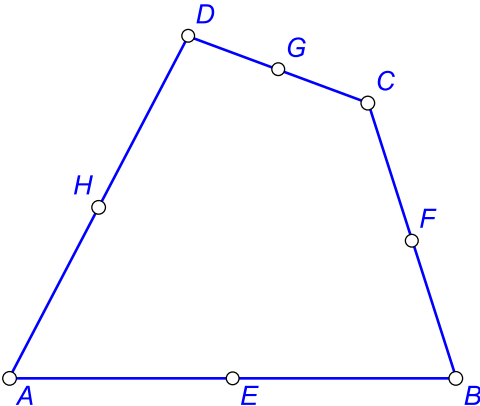
5. Examples

The examples in this section illustrate the use of some of the commands of OK Geometry Sketch Editor. The main purpose of the Sketch Editor is to allow fast and effective construction of geometric configurations, which are then analysed in OK Geometry. The analysis and the observed properties are the focus of the work.

Usually there are many ways to complete a construction task in OK Geometry Sketch Editor. In the following examples we show only one way – to illustrate a command or a construction strategy.

5.1.   Predefined shapes. Commands on a polyline

Example. Midpoints in a quadrilateral

Operations on line segments (e.g., midpoint) can be applied in different ways to polylines (see Section 2.9).
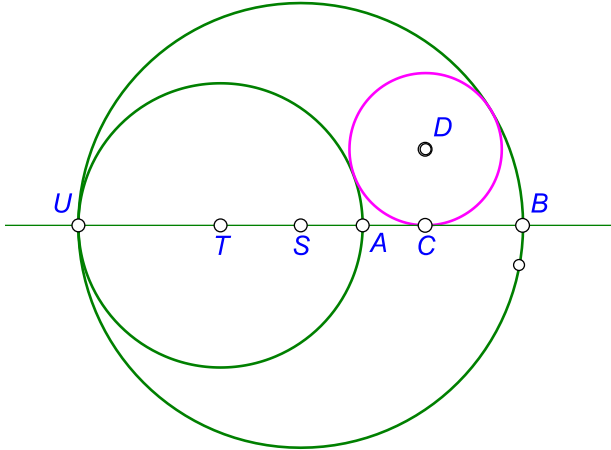
Task:	In an arbitrary quadrilateral ABCD, mark the midpoints E,F,G,H of the four sides. What interesting properties of the obtained configuration can you spot?	
File:	OKExamples\OKG_SketchEditor\OkEditEx_1.p OKExamples\OKG_SketchEditor\OkEditEx_1a.pro OKExamples\OKG_SketchEditor\OkEditEx_1b.pro	
Strategy:	Draw the quadrilateral as a predefined shape. Use the Midpoint command on all sides of the polyline at once.	

Procedure/Step	Sketch Editor command	Comment
1	Shapes|Quadrilateral	Pick 4 vertices. You obtain an unlabelled

		quadrilateral.
2	Point|Midpoint or ▢ button	Point to the quadrilateral (at one of the edges). In the form that appears, select 'On each segment' to obtain at once the midpoints of all sides.
3	Action|Labels|Label all	Label all created points. The order of the labels follows the order of construction of the points.
Suggestions for the analysis	According to the construction, we are interested in properties that are invariant under the cyclic permutation of vertices: ABCD EFGH. (See OkEditEx1a.pro for an elaboration.) What can you say about the shape of the quadrilateral EFGH? (See OkEditEx1a.pro for an elaboration.) How is the area of EFGH related to the area of ABCD? (See OkEditEx1b.pro for an elaboration.)	

5.2.   Complex construction operations

This example demonstrates how complex construction commands help to analyse a construction.

Example. Construct a circle that touches three given objects

Task:	A circle is inscribed into another circle. Construct a circle that touches the two circles and the line through the centres of the two given circles.	
File:	OKExamples\OKG_SketchEditor\OkEditEx_2.p	
Strategy:	Draw the configuration using complex commands (e.g. construct a circle tangent to three other circles/lines/points). A study of the construction will reveal how to work out the construction with Euclidean construction tools.	

Procedure /Step	Sketch Editor command	Comment
1	Circle|CircleCentre+point or [○] button	Draw the outmost circle with centre S. (See the labels on the figure above. Until Step 6 do not bother about the labels on your display.)
2	Circle|CircleCentre+object or [①] button	Construct a circle tangent (from inside) to the outmost circle. Pick the centre (T). Pick the outer circle. Click on Alt button until the shown new circle is the desired one.
3	Line|Line 2 points or [/] button	Construct the line through the points S and T.
4	Circle|Circle 3 objects or [③] button	Construct the circle tangent to the three drawn objects: Pick the outer circle, the inner circle, and the drawn line (any order of picking them will do). Click repeatedly on the Alt key until the new circle is the desired one.
5	Point|Centre of circle Point	Pick the recently constructed circle to obtain its centre.
6	Action|Labels|Clear all labels Action|Labels|Label vertex Action|Labels|Label auto	After you set the label A skip to Label auto. Then pick the points in the desired order to obtain labels A,B,C,D. Work in a similar way for labels S,T,U.
7	Action|Restyle objects	Select first the desired colour, width and line style; then select the line or circle to be modified. Repeat this step as desired.
Suggestions for the analysis	• How to do the construction with Euclidean tools only? The analysis reveals lots of properties of the configuration. We want to know the position of the point C on line AB and the position of D right above the point C. • To obtain the position of C use the [?•] button and select the point C. To inquire on the segment CD, click on the [?••] button and select point C and D.	

- Perhaps you can hypthetise the beautiful 3-square constuction shown below. (First draw the squares that determine the red dotted line and the point C. Then draw the square that determines the blue dotted line and the point D. See OkEditEx_2a.p .)
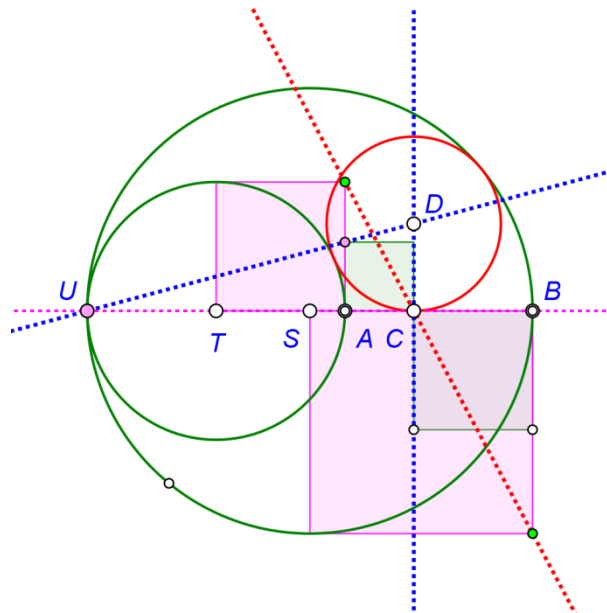
How to prove the correctness of this solution? A possible way to find the relations between the radii of the three circles and the distance AC is by considering right triangles related to the mentioned quantities. In fact, using Pytagoras' theorem on triangles TCD and SCD and a bit of algebra, you can prove the correctness of the construction.

5.1.   Transformations

The following example demonstrates how to define and apply a transformation.

Example. Isosceles triangles on top of a triangle

Task:	On each side of a given triangle ABC draw three similar isosceles triangles. Study the obtained configuration.	
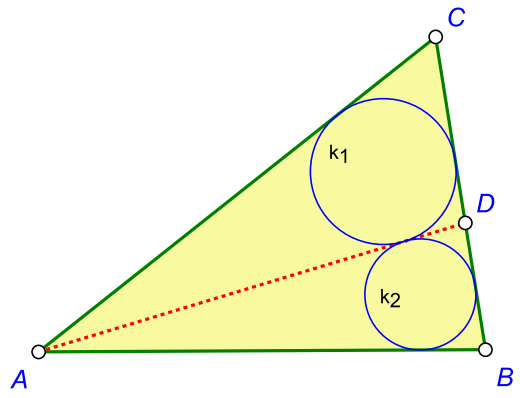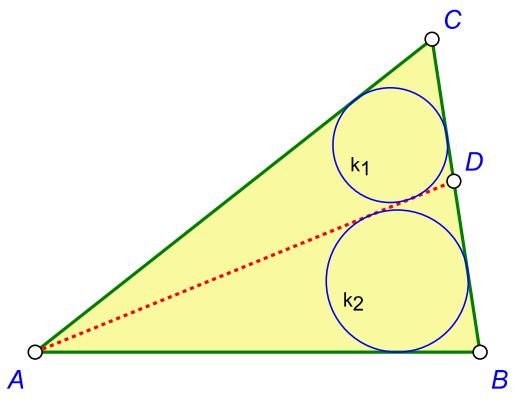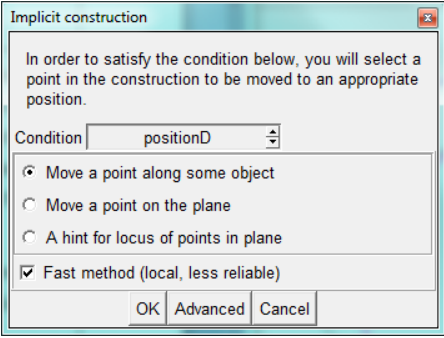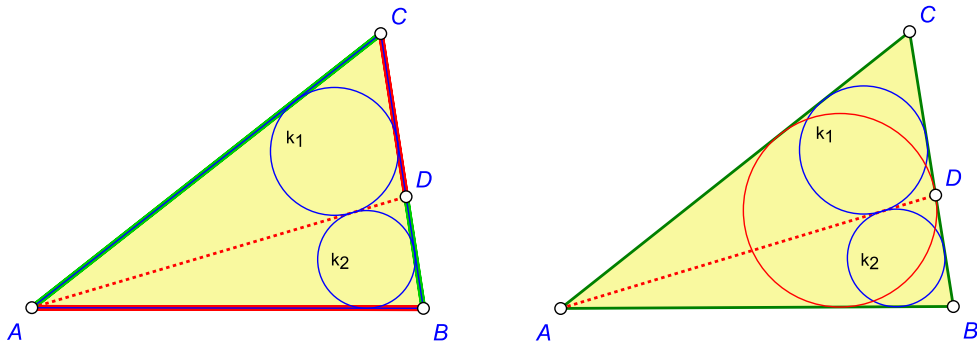
File:	OKExamples\OKG_SketchEditor\OkEditEx_3.p
Strategy:	Draw a triangle ABC. On one of the sides place an isosceles triangle. Using the similitude transformation construct copies of the isosceles triangles on the other two sides.

Procedure /Step	Sketch Editor command	Comment
1	Shape|Triangle Action|Labels|Label all	Draw a triangle. Label all the vertices, they are labelled as A,B,C.
2	Shape|Isosceles Action| Labels|Label all	On the side BC draw an isosceles triangle: Point to C, to B and then approximately where you want D to be.
3	Transform|Similarity	First we define a similarity that maps BC to CA. We immediately apply this similarity to the isosceles triangle and to the point D. Select the point B, then C (the desired image of B). Select the point C, then A (the desired image of C). The created transformationis automatically given the name Sim_BCCA. Immediately apply the transformation to the isosceles triangle (click on it). Set the new vertex as point E. Analogously construct a triangle on the side AB.
4	Action|Auto label Action|Colours and styles	Label properly the vertices. Apply the desired attributes to lines and points.
Suggestions for the analysis	According to the construction, we are interested in properties that are invariant under the cyclic permutation of vertices: ABC DEF. The configuration has some very interesting properties. Find them with the command Observe.

5.2.   Implicit constructions

The following is an example of an implicit construction of a point.

Example. Where to position a point?
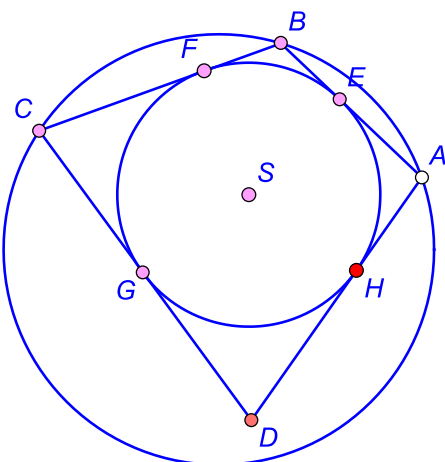
Task:	Given is a triangle ABC. Construct a point D on the side BC so that the incircle *k1* of the triangle ABD and the incircle *k2* of the triangle ADC touch each other.	
File:	OKExamples\OKG_SketchEditor\OkEditEx_4.p	
Strategy:	We create a construction as required by the task, except that circles k1 and k2 do not touch each other. We obtain the tangency requirement with and implicit construction, by moving the point D along BC, so that the tangency requirement is fulfilled. An analysis of the resulting configuration (hopefully) provides a hypothesis how to obtain the point D in a simple way-.	

Procedure/ Step	Sketch Editor command	Comment
1	Shape|Triangle Action|Labels|Label all	Draw a triangle. Label all the vertices, they are labelled as A,B,C.
2	Point | Point on object	Draw the point D on the side BC.
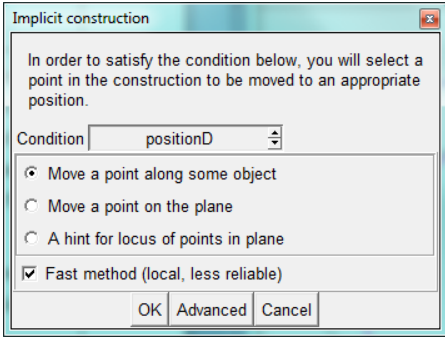
	Line | Segment	Draw the line segment AD.
3	Circle|Circle 3 objects or ③ button	Construct the circle tangent to the three drawn objects: Pick one by one the three sides of ABD. Click repeatedly on the Alt key until the new circle is the incircle of ABD. In the same way obtain the incircle of ADC..
4	Advanced|Check pro*perty* | Position | Tangent	Pick the two incirles. A condition is declared, its default name is Tange_xx'. The condition Tange_xx appears (as False) in the list of parameters. (In the next step we instruct OK Geometry to move the **point D along the BC** so that the condition **Tange_xx becomes True**.)
6	Advanced|Implicit construction **Implicit construction** In order to satisfy the condition below, you will select a point in the construction to be moved to an appropriate position. Condition positionD ⊙ Move a point along some object ○ Move a point on the plane ○ A hint for locus of points in plane ☑ Fast method (local, less reliable) OK Advanced Cancel	In the form that appears check the option *Move a point along some object,* since we want to position D on the side BC of our triangle so that the conditionTange_xx will be met. Leave the other options as suggested. Click on the OK button in the form. Pick the point to be modified, i.e. the point D. Finally, pick the constraint object, i.e. the side BC, along which D will be positioned. (Now D should appear in a desired position.)
Suggestions for the analysis		

The observation of the obtained configuration shows that |AB| + |CD| = |AC| + |BD|, a fact that can be easily proven. This is a well known property of the point of contact of the

	incircle of ABC with the side BC. Thus, we hipothetise that this is the position of the point D. **Note. The presence of implicitly constructed objects reduces the reliability of observational results.**

The following is an example of an implicit construction of a point.

Example. A cyclic tangential quadrilateral

Task:	Construct a quadrilateral that is both cyclic (i.e. its vertices lay on a circle) and tangential (i.e. all sides are tangent to a circle). Study the obtained quadrilateral. Given the inscribed circle and the points E,F,G, how to construct the point H, so that the resulting quadrilateral ABCD is cyclic?	
File:	OKExamples\OKG_SketchEditor\OkEditEx_4a.p	
Strategy:	Starting from an (in)circle we pick 4 points, E,F,G,H on it and draw the tangent lines to the circles at these points. The resulting quadrilateral ABCD is tangential but, in general, not cyclic. In fact, we draw the (out)circle through A,B,C and observe that D does not lay on it. Using the implicit construction command of OK Geometry we position H on the (in)circle so that the point D lays on the outer circle. ABCD is then be cyclic and tangential. An analysis of the resulting configuration (hopefully) provides a hypothesis how to construct the point H given the (in)circle and the points E,F,G.	
Procedure/ Step	Sketch Editor command	Comment
1	Circle|Centre+point Point|Point	Draw the incircle. Position the points E,F,G,H on it.
2	Line|Line 2objects	To draw the tangent line to the incircle at E pick the point E and the incircle. In the same way

		construct the tangents to the incircle at F,G, and H.
3	Point|Point Action|Hide Line|Polyline	Construct the intersection points A,B,C,D. Hide the four tangent lines. Draw the quadrilateral ABCD.
4	Circle|Circle 3obj	Pick the points A, B, C. The outcircle through A, B, and C appears.
5	Advanced|Check property|Position|PointOnObject	Pick the point D and then the outer circle. Name the resulting condition 'positionD'. The condition positionD appears (as False) in the list of parameters. (In the next step we instruct OK Geometry to move the **point H along the incircle** so that the condition **positionD becomes True**.)
6	Advanced|Implicit construction 	In the form that appears, check the option *Move a point along some object,* since we want to position H on the 'incircle' (object) so that the condition positionD (that D lays on the 'outcircle') will be met. Leave the other options as suggested. Click on the OK button in the form. Pick the point to be modified, i.e. the point H. Finally, pick the constraint object, i.e. the 'incircle', along which H will be positioned. (Now H and D should appear in a desired position.)

Suggestions for the analysis	We are interested in properties that are invariant under cyclic permutation of vertices: ABCD EFGH. The analysis will provide additional evidence if a second cyclic permutation AB CD FH is specified.
	The cyclic tangential quadrilaterals have many indeed interesting properties. Study them with the **Observe** command.
	How to construct the point H in Euclidean steps? Note that the incircle and the points S,E,F,G,B and C can be taken as given. Among the properties listed by OK Geometry, we are looking for some property that relates the given objects to the point H.
	One of these relations is shown here. It is easy to show that the two emphasized triangles are similar isosceles triangles. If you use this fact, the construction of the point H is fairly obvious.
	Note. Another way to obtain H is to consider that EG is perpendiculat to FH.
	Note. Quadrilaterals that are tangential and cyclic are called bycentric. With OK Geometry you can draw a bycentric quadrilateral with the Advanced|Shapes|Quadrilaterals|Bycentric command.
	Note. The presence of implicitly constructed objects reduces the reliability of observational results.
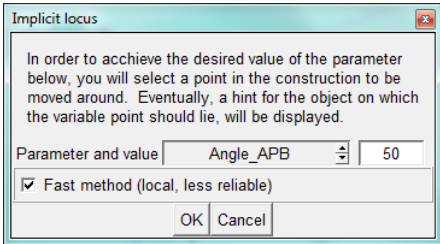
5.3.   Implicit objects by measuring

The following trivial example demonstrates the implicit construction of the locus of points.

Example. The angular size of a line segment

Task:	Given a line segment AB, we want to find instances of points P, from which the segment AB is visible at a given angle, say 50°. In other words, we look for the locus of points P, for which the angle APB is constant.	

File:	OKExamples\OKG_SketchEditor\OkEditEx_5.p
Strategy:	Given the segment AB we pick an arbitrary point P and measure the angle APB. Then we ask OK Geometry to find some instances of positions of point P, for which the angle APB has the desired value.

Procedure /Step	Sketch Editor command	Comment
1	Point Action|Label vertex Number|Angle	Draw the vertices A,B and the point P. Then measure the angle APB. Name the measured value as AngleAPB.
2	Advanced|Implicit locus **Implicit locus** In order to acchieve the desired value of the parameter below, you will select a point in the construction to be moved around. Eventually, a hint for the object on which the variable point should lie, will be displayed. Parameter and value Angle_APB 50 ☑ Fast method (local, less reliable) OK Cancel	Fill in the form as shown on the left: Since we are looking for the locus for P where a parameter (i.e. AngleAPB) is specified, fill on the form as shown on the left and click OK. After the form is filled out, pick the point P (the variable object). OK Geometry gives a hint that the sought locus for P is a circle (see Figure 8). The hint is not the correct solution, but is not far from it.
	Important note. As can be seen from this trivial example, OK Geometry may only provide a hint for the sought locus of points. In our example, the correct locus is the arc BPA (since it refers to the size of the *oriented angle*), and not the whole circle. Depending on the situation, OK Geometry may miss the locus, provide an 'extended' locus or even gives a misleading hint. It is only a hint that requires additional checks.	
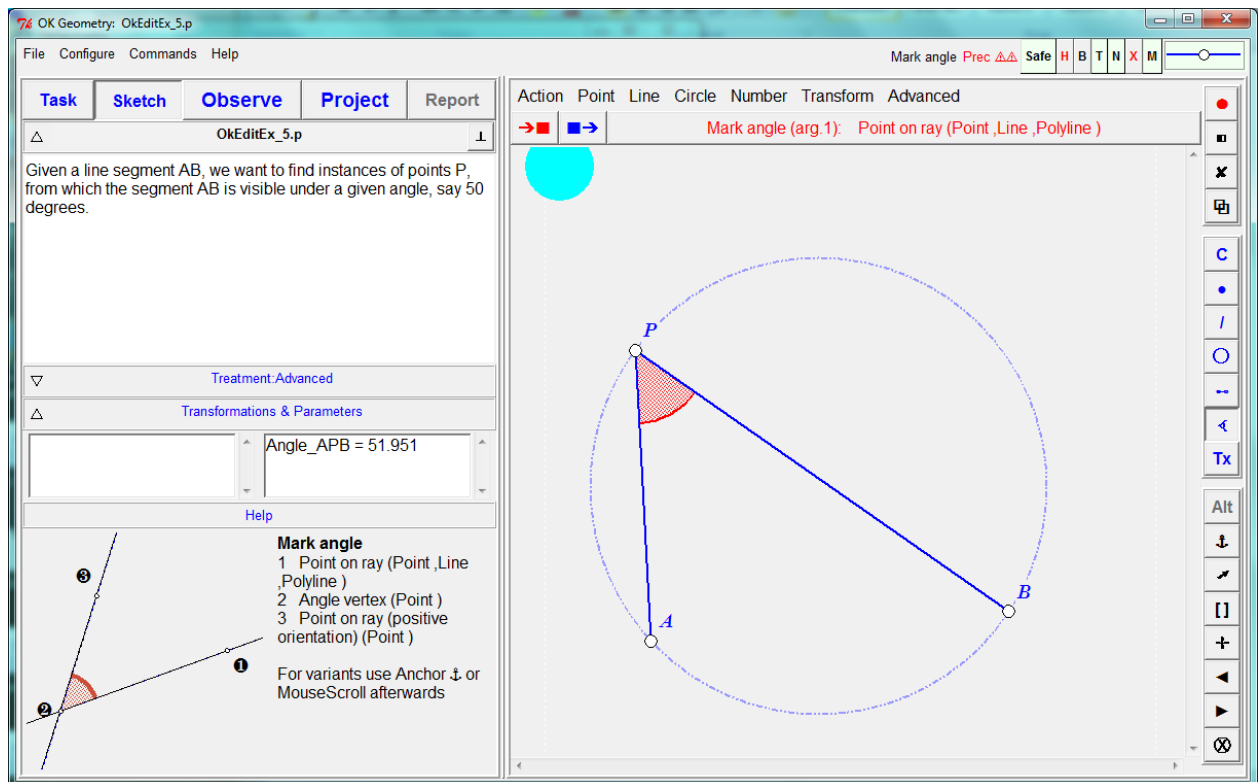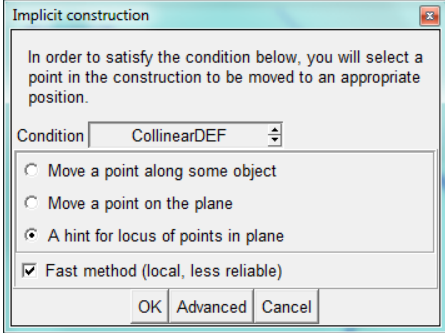
Figure 8

5.4.   Implicit objects by construction

The following example shows the use of implicit construction command.

Example. The pedal points. Simson's line

Task:	The orthogonal projections of a point P onto the baselines of the three sides of a triangle ABC are called the pedal points of P wrt. the triangle ABC. The pedal points are the vertices of the pedal triangle of the point P wrt. the triangle ABC. Is there some point P, for which the corresponding pedal points D, E, F are collinear? What can be said about such point P ?	
File:	OKExamples\OKG_SketchEditor\OkEditEx_6.p	

Strategy:	Given a triangle ABC and an arbitrary point P ,we construct the pedal points D,E,F.
	With the command Implicit objects we find several instances of points P that satisfy the condition that its pedal points D, E, F are collinear.

Procedure/ Step	Sketch Editor command	Comment
1	Point|Point Line|Line 2points Line|Polyline	Draw the vertices A,B,C, and the point P. Construct the lines AB, BC, CA. For reference draw the triangle ABC as a polyline. Note: We need the lines since we project P to the base lines of the triangle's sides.
2	Line|Perpendicular segment Action|Label|Label vertex	Draw perpendicular segments connecting P to the baselines of the triangle ABC. Label the points D, E, F.For each base line (!) find the projection of P to the line as nearest line to P.
3	Advanced|Check property|Position|CollinearP	Check whether D, E, and F are collinear. Name the condition as CollinearDEF.
4	Advanced|Implicit construction 	Since we are looking for the locus of points of P that satisfy a given condition (i.e. CollinearDEF), fill the form as shown of the left. Then click OK, and pick the point P (to be moved around). (The sought locus appears, see Figure 8.)
	Important note. OK Geometry may provide only a hint for the sought locus of points. In our example the found locus happens to be indeed (by Simson's theorem). However, depending on the situation, it can happen that OK Geometry misses the locus, provides an 'extended' locus or even gives a deceiving hint. The result thus always requires additional checks.	
Suggestions for the analysis	Once you obtain a hint, you can check in a more reliable way that the points on the suggested locus satisfy the considered condition. You can use OK Geometry to prove the theorem (start with a new construction where P lies on the circumcircle of ABC and analyse the situation. The proof is not trivial. Try also to investigate, where should P lie in order that the pedal triangle has a fixed area (proceed as in example 5.3).	
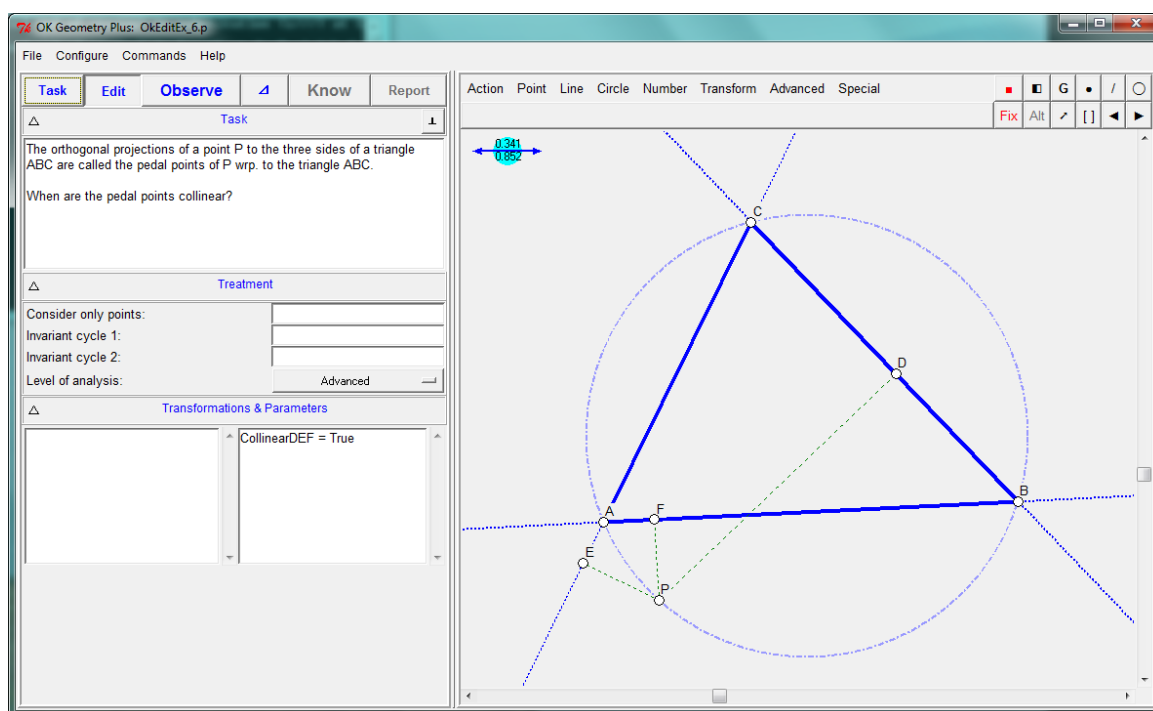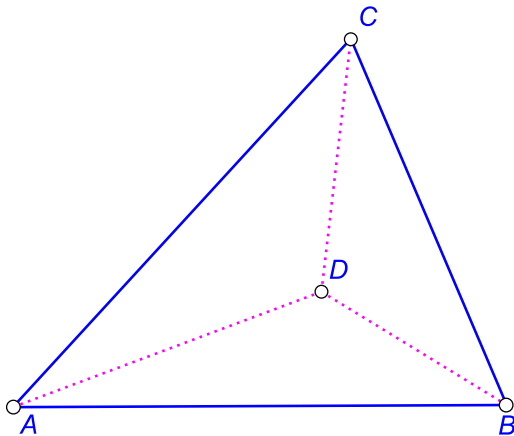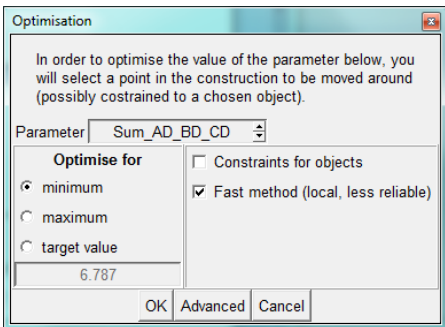
Figure 9

5.5.   Constructions by optimisation

This example shows how to generate a hypothesis for the solution of an optimisation tasks.

Example. Fermat point of a triangle

Task:	For a given triangle ABC find the point D for which the sum of the distances from the vertices A, B, C to D is minimal.	
File:	OkExamples\OKG_SketchEditor\OkEditEx_7.p	
Strategy:	Given a triangle ABC and an arbitrary point D we measure the lengths of AD, BD, and CD. Then we calculate the sum of these distances. We let OK Geometry to move the point D	

Procedure /Step	Sketch Editor command	Comment
	around to a position where the sum of distances to the vertices is minimal.	
1	Shape|Triangle Action|Label all Point[Point	Draw a triangle. Label the vertices A,B,C. Draw and arbitrary point D.
2	Number|Distance to object	Measure the distance from D to A. Point to the two points. Name the parameter DistanceAD. In the same way measure DistanceBD and DistanceCD. In the next step we shall calculate the sum of the three measured distances.
3	Number|Value,expr	Click first on DistanceAD. In the information row appears [DistanceAD]. Then click on the + key on the keyboard. Click on the DistanceBD. Repeat this also for DistanceCD In the information row appears [DistanceAD] + [DistanceBD] +[DistanceCD]. Click on the red coloured OK to enter this expression. Name the result Sum_AD_BD_CD. In the next step we let OK Geometry move around the point D so that Sum_AD_BD_CD attains a minimal value.
4	Advanced|Optimisation 	In the form that appears: Select minimum (Optimise for), Uncheck the *Constraints* option, since D is not restricted to an object (line, circle, conic). Prefer the *Fast method*. In case the results are not as expected try with the option unchecked. Select the parameter to be optimised, i.e. Sum_AD_BD_CD . Then click OK in the information line. Pick the point to be moved around (D). The point D is appears on new position (Figure 10). Note, if one of the angles is bigger than 120 deg. the point D is positioned behind one of the

	vertices.
Suggestions for the analysis	The point D assumes the position of the Fermat point (if all the interior angles are less than 120 degrees). Use Observe to find the characteristic property of Fermat's point. Note that the property should be invariant under the cyclic permutation of labels ABC.
	Note. Optimisation reduces the reliability of observational results.
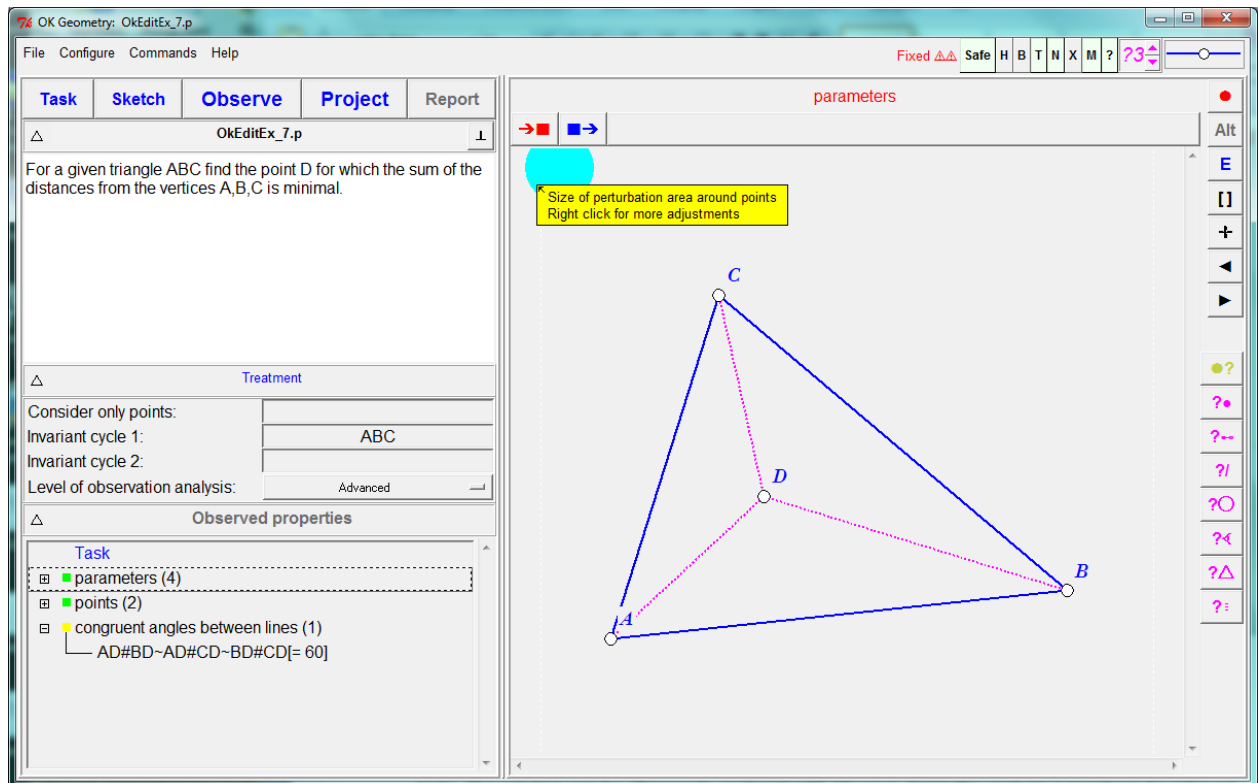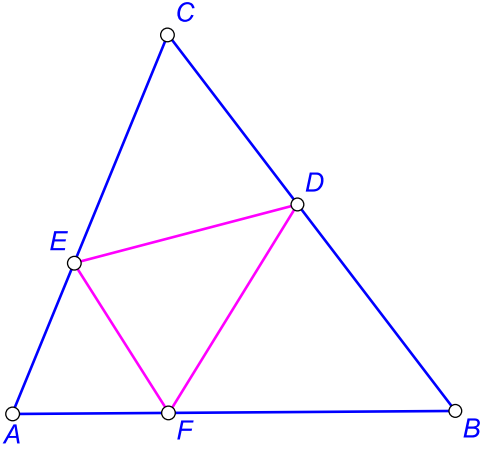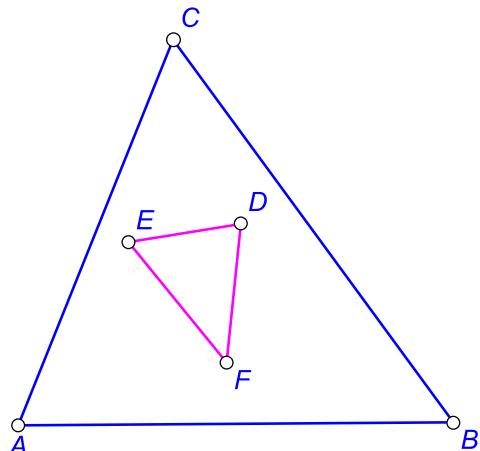
Figure 10

This example will show how to generate hypothesis for the solution of a complex optimisation tasks. The solution can be afterwards analysed with Observe. From the analysis a proof can be inferred.

Example. A minimal triangle

Task:	In a given triangle ABC inscribe the triangle DEF with minimal perimeter.	
File:	OKExamples\OKG_SketchEditor\OkEditEx_8.p	
Strategy:	Given is a triangle ABC. We draw another triangle DEF – not necessary inscribed in ABC - and measure its perimeter. Then, by (automatically) moving the points D,E,F along the corresponding sides of the triangle ABC, OK Geometry will position the points D,E,F to obtain the triangle with minimal perimeter. A subsequent analysis will reveal the properties of the optimised triangle DEF. From the observed properties a proof can be inferred.	
Procedure/ Step	Sketch Editor command	Comment
1	Advanced|Shapes|Triangle|Triangle Action|Label all	Draw a triangle. Label the vertices A,B,C. Draw also another triangle, label the vertices D,E,F. You can place these vertices along the sides of BC, CA, AB, but this is not necessary.
2	Number|Length,perimeter	Measure the perimeter of triangle DEF. Name the value as PerimDEF.

		Note. In the next step we shall move D,E,F along BC,CA,AB so that PerimDEF will attain a minimal value.
3	Advanced|Optimisation	In the form that appears choose the Advanced button. Check the entries as shown in Figure 11.
		In particular:
		Select the parameter to minimise (PerimDEF). Select the *minimum* option. Select 3 variable objects since we shall move three points: D,E,F. Check the *Constraints* option since the three points shall move along the sides of the triangle ABC. Use *Fast method*, if possible.
		To confirm the options click OK in the form.
		Click on the point E, then the restriction (the pointed segment CA of ABC).
		Click on the point F, then the restriction (the pointed segment AB of ABC).
		The point D,E,F are given the calculated optimal position.
		Click on OK button.
Suggestions for the analysis	In the Treatment section set the Invariant cycle to ABC DEF. Inspect the properties of the found solution. The properties can lead you to a proper construction and also to the proof of the correctness of your construction.	

Figure 11

Figure 12

5.6. Locus of points

This simple example will show how to create a locus of points.

Example
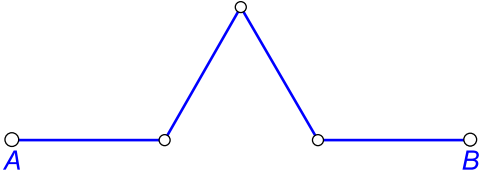
Task:	Let H be the orthocentre of the triangle ABC. If the position of C changes (with A and B fixed), the position of H changes accordingly.	
	What is the locus of point H as C takes the place of points on a line that is parallel to AB?	
	What is the locus of point H as C takes the place of points on a circle through A and B?	
File:	OKExamples\OKG_SketchEditor\OkEditEx_11.p	

Strategy:	We draw a triangle ABC, a line, parallel to AB, and a circle through A and B.
	Then we use twice the command Locus for the point H: first when C moves along the line, then when C moves along the circle.

Procedure /Step	**Sketch Editor command**	**Comment**
1	Shape|Triangle	Draw a triangle.
	Action|Label all	Label the vertices A,B,C.
	Point[Triangle 4 centres|Orthocentre	Obtain the orthocentre of ABC.
2	Line|Parallel	Draw a parallel to AB through an arbitrary point.
	Circle|Circle 3 obj	Draw a circle through A, B, and an arbitrary point.
3	Advanced|Locus	Click first on the point H, then on point C, then on the line that is parallel to AB.
		OK Geometry observes that the locus appears to be a parabola. OK Geometry can draw a recognised object, the locus (as a polyline), or both.
4	Advanced|Locus	Click first on the point H, then on point C, then on the line circle through A, B.
		OK Geometry observes that the locus appears to be a circle. OK Geometry can draw a recognised object, the locus (as a polyline), or both.
Suggestions for the analysis		If a locus is a recognised object you can analyse its position and hypothetise how to obtain it by construction.
		Note that the recognised objects are obtained by observation. This calls for additional checks and, obviously, a proof.

5.7.   Macros

This simple example will show how to create a macro.

Example

Task:	We want to create a macro for the construction of a 'bulge' for given pair of points A, B. Each segment of a bulge measures one third of the distance between A and B. The angles between segments should measure 120 and 60 degrees.	
File:	OKExamples\OKG_SketchEditor\OkEditEx_9.p	
Strategy:	Given the points A,B we first draw points at each third of the distance between them. Then we draw and equilateral triangle on the middle part and draw the desired path as a polyline.	
	At this point we define the macro. It is very important to think in advance what are the input data and what exactly the output data. In our case the input data are the points A and B. We want the output data to be the resulting polyline and the three points on the way.	
Procedure /Step	**Sketch Editor command**	**Comment**
1	Point|Uniform divide Shape|Equilateral triangle	Divide a line segment in three equal parts. Click on points A, B, and write 3 (the number of parts) in the information line. Confirm by clicking OK in the information line. Construct an equilateral triangle using the two points in the middle part of the segment.
2	Line|Polyline	Draw the polyline for output by clicking the vertices in appropriate order.
3	Macros|Make macro	Fill in the form as shown in Figure 13 and click

		Proceed.
		Then you need to click on the objects on the configuration, one by one, as they are stated in the input and in the output list.
		In the final form that appears, you can choose to use the constructed macro only within the current session or to store it and use also elsewhere (with the Get macro command).
		Note. The macro is not part of the construction. The next time you open the construction the macro will not be available unless you store it retrieve it with the Advanced|Get macro command.
4	Advanced|Execute macro	The constructed macro is a new command available in the form that appears.
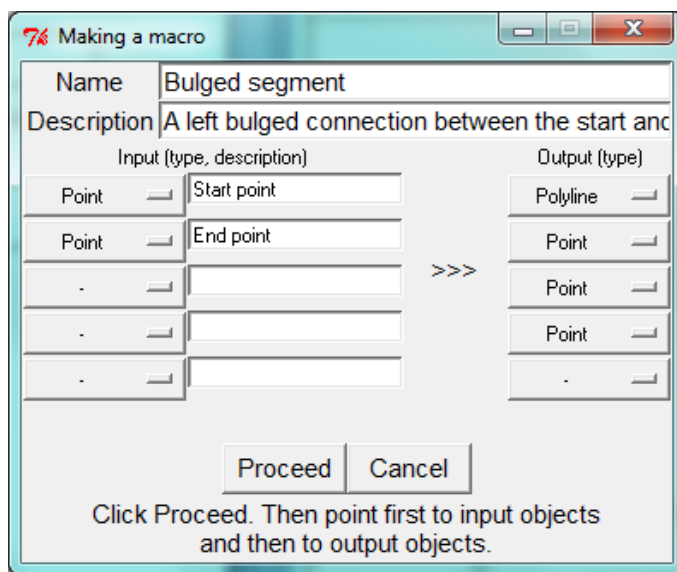
Figure 13

6. An overview of representation of objects

Objects in OK Geometry can have some **functional attributes** (used mainly for creating scenes of a construction):

- Objects can be **hidden** (although they are part of the construction, such objects are not visible and are not considered in the analysis).
- Objects can be **transparent** (objects are not visible, but are taken into account in the analysis).
- Objects can be **bleached** (such objects can be more or less visible and are taken into account in the analysis; the degree of visibility can be controlled with **Alt+mouse-scroll**, sometimes also with sliders).
- Objects can be **emphasised** (the degree of highlighting can be controlled with **Shift+mouse-scroll**).

Functional attributes are explained in ???

In this section we present an overview of the **representational attributes** of standard geometry objects (points, lines, line segments, circles, arcs, conics, triangle cubics). Such attributes are not considered by OK Geometry but can make the construction easy to understand and in concordance to the users' aesthetics.

Some representational attributes are standard and convey relevant information, e.g., congruence sign, arrow on a line segment. Note that additional information to any objects can be added with the Marker command (such information appears only when the mouse is on the object, see ???).

Some common representational attributes, e.g. colour, width, style of objects, font, are usually intended to make constructions easy to interpret.
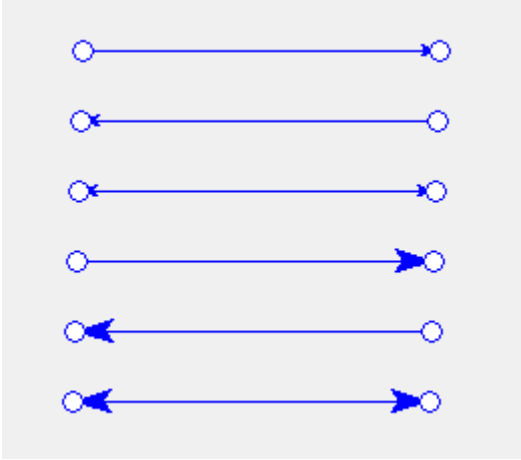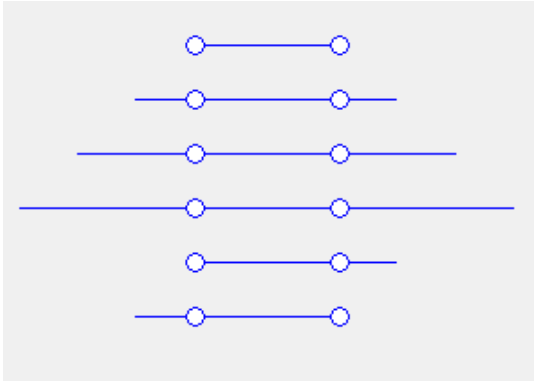
Finally, some objects of the same type can be represented in different ways for clarity. For example, a line may be represented as line segment from edge to edge of the display, or as a segment connecting all declared points on the line, or as a segment extending slightly beyond the declared points on the line, and so on.
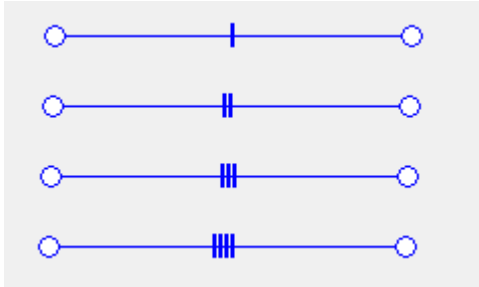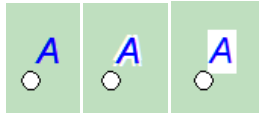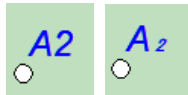
The following table shows how the representational attributes of objects can be handled. You will notice that the **usual way to choose among various representational options is to usethe Anchor command**
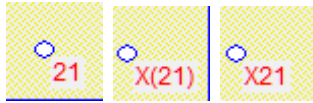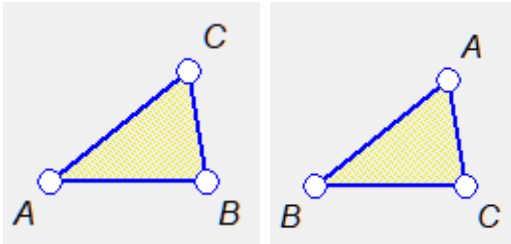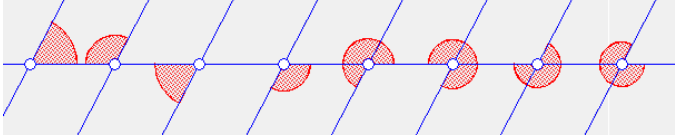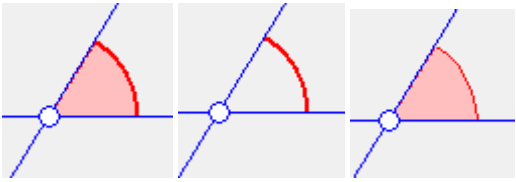
 repeatedly, possibly followed by scrolling the mouse middle button.

Effect		Command	Applies to	
Linear objects	Set width	*Action|Restyle objects* Note. Line width can be additionally set for - display in construction view (*Configure|General options|Sketch|Lines width %*), - export construction and reports (*Configure|General*	Line Line segment Circle Arc	

75		*options|Report|Lines width %*).	(Angle arc) Polyline Conic Cubic	
	Set shape	● *Action|Restyle objects*		
	Set colour	● *Action|Restyle objects*		
Arrows	Toggle arrow	→ *Action|Mark arrow*	Line segment	
	Choose arrows mode	⚓ *Action|Anchor*		
Extension	Choose representation mode	⚓ *Action|Anchor* Note. Extensions of lines behave in a different way.	Line Line segment Arc	(1)
	Extensions size	Note. The size of extensions can be set in *Configure|General options|Sketch|Extensions of lines.*	Line Line segment Arc	

Congruence sign	Set congruence sign	♯ *Action|Mark|Mark congruence*	Line segment Arc Angle (arc)	
	Choose congruence sign	⚓ *Action|Anchor*		
Label/Texts	Choose position wrt. reference point	⚓ *Action|Anchor* Note: Labels can also be moved with the ↗ command.	Label Text Marker	
	Label distance (report)	Note. The distance of the label from the respective points **in exported constructions and reports** can be set in *Configure|General options|Report|Distance of labels (%).*		
	Background of labels	*Configure|General options|Sketch|Point labels – background* Note. The 'halo' option (figure in the centre) is displayed only in the project view. Only the 'transparent' and 'white' option is used in construction view and when exporting figures.	Label (Text)	(2)
	Subscripts mode	*Configure|General options|Sketch|Point labels – subscripts (figures, texts)*		

	Triangle centres notation	*Configure|General options|Sketch|Triangle centre notation* Note. The option also sets the way of labelling the initial reference triangle.		
	Labels font	*Configure|General options|Sketch|Point labels - font*		
	Labels colour	*Configure|General options|Sketch|Point labels - colour*		
	Texts font	*Configure|General options|Sketch|Text on sketch - font*		
	Text colour	🔴 *Action|Restyle objects* Use the colour for colouring points.	Text Marker	
Point attributes	Set point size	🔴 *Action|Restyle objects* Note. The size of points can be iadditionally adjusted for - display in the construction view (*Configure|General options|Sketch|Point size (%)*), - export construction and reports (*Configure|General options|Report|Point size (%)*).	Point	
	Set point shape	🔴 *Action|Restyle objects*		
	Set point colour	🔴 *Action|Restyle objects*		

Angle	Display angle	*Action | Mark angle*	Angle	
	Choose angle between lines	*Action|Anchor*	Angle	
	Angles representation mode	*Configure| General options|Sketch|Angle – display mode*		
	Max. display angle	*Configure| General options|Sketch|Angle – display mode* Displayed angles can measure 0°-90°, 0°-180° or 0°-360°.		
	Angle colour , arc width	*Action|Restyle objects*		
	Angles arc radius	*Configure|General options|Sketch|Angle – approx. arc radius*		
	Auxiliary lines on/off	Angle guides can be toggled with the sign in the upper right corner of the display.		
Filled circles, polygons	Toggle fill	*Action|Mark|Mark fil l(area)*		
	Fill colour	*Action|Restyle objects* Be sure to select the line colour and to **activate the** **button**.		
	Fill mode	*Configure|General options|Sketch|Hatch mode of filled areas* You can choose between different dither modes,		

79		random mode and solid mode. Note that some modes do not export well to some graphics formats.		
	Fill density	*Configure|General options|Sketch|Hatch (fill area) density* Density applies only to random and solid fill modes.		
	Fill level	*Action|Anchor* The filled polygons/circles are transparent unless the fill mode is **solid**. If the fill is solid, each filled object will hide the filled objects below it. In order to control the overlap you can set the fill level of a filled object. The fill levels range from 1 (at the top) to 5.		