OK Geometry Basic

Part II

Reference for OK Geometry Sketch Editor (v. 17)

Zlatan Magajna

June 2019

Contents

1. Sketch Editor of OK Geometry

This document considers editing constructions in OK Geometry. Readers who are familiar with dynamic geometry programs Geogebra, Cabri, Sketchometry, Cinderella, C.a.R. or JGEX may draw constructions in these programs and import them into OK Geometry. Making constructions in OK Geometry is, in general, similar to making them in other dynamic geometry software. OK Geometry allows many operations commonly found in dynamic geometry programs (e.g. dragging points, defining macros). Yet there are differences due to specific aims of OK Geometry. Dynamic geometry programs, above all, promote conceptual understanding. Thus, only very simple construction commands are available, for students should understand how to work out a other construction from basic operations. Furthermore, a lot of attention is put on specific visual representations that enable explorations and demonstrations. On the other hand, **the aim of OK Geometry is to promote hypothetising, deductive reasoning and proving**. Consequently, commands of OK Geometry Sketch editor allow quick and efficient design of geometric configurations. Besides direct non-trivial constructions (e.g. to construct a circle touching three given circles) Sketch editor allows also implicit constructions and constructions based on optimisation. Such constructions are obtained by imposing additional descriptive or optimisation requirements to an existing construction. For example, in a construction we want to achieve that a triangle is equilateral or that its area is minimal. Using specific tools (described in general help file of Ok Geometry) the student analyses the designed configuration, studies its properties, finds how to construct it with compass and ruler, and, possibly, also proves some property of the designed configuration.

Note that the Sketch editor is not available in Simple mode of OK Geometry.

1.1. The interface

The access to the Sketch mode of OK Geometry, i.e. the Sketch editor, is via the **Sketch** button in the main menu bar. When in Edit mode the **Sketch** button is sunken. To exit the Edit mode click the **Sketch** button again or some other button in the main menu bar.

The left pane of the interface (the information pane) contains various sections that are optionally shrunk or expanded (Figure 1). In the **Task section** you can write or edit the description of a task. The **Transformations & Parameters section** contains the lists of the transformations and parameters/expressions used or set in a construction. Finally, the **Treatment section** contains information to be used in the analysis (outside the Sketch editor). You can expand or shrink the sections by clicking on the triangle button on the title line of the section (right click on these buttons for a full expansion). The **Help section** contains the explanation of the used commands. Be aware of the **expansions signs** on the left side of the sections: click them to expand/shrink the sections, right-click them to fully expand the sections.

The right pane (visualisation pane) contains a drawing of the current construction. Above the drawing is the **editor's menu line**. Below the menu line is a very important (red coloured) **information line**. Keep an eye on it – it tells you what is going on and what you are expected to do. Additional help on how to use the commands is provided in the **Help section** (left pane) if it is expanded. On the right of the drawing pane there is a tool bar with some buttons for often used commands.

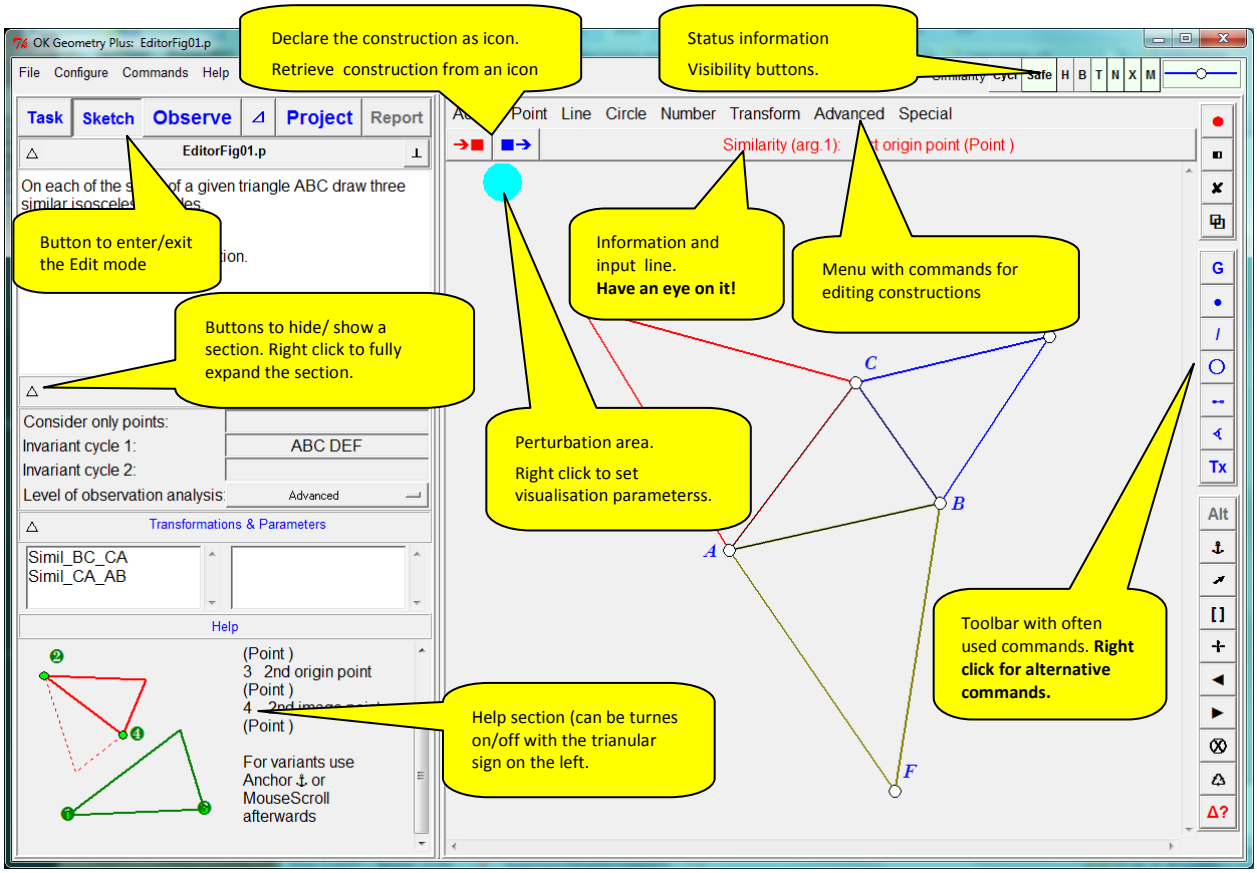


Figure 1

1.2. A first example

The following example will give you an idea how to make constructions in OK Geometry. We shall 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 right angle, and then the third vertex. The position of the third vertex will be automatically corrected so that the triangle will be right.
4. Label the vertices of the triangle. A simple way (but not the quickest) is to click the *Autolabel* button in the editor's toolbar (on the right of the information line, click the button with a letter on it). Then click the vertices in the desired order. The first vertex will be labelled A, the second B, etc. Alternatively, right-click somewhere on the visualisation pane. Select the *Labels* subcommand and then choose an appropriate labelling method, for example *Label all.*
5. To draw the inscribed circle, select in the editor's menu the command *Circle|Circle 3obj*. 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) – just click on the main menu button **Observe**. Among other properties the analysis will spot 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).

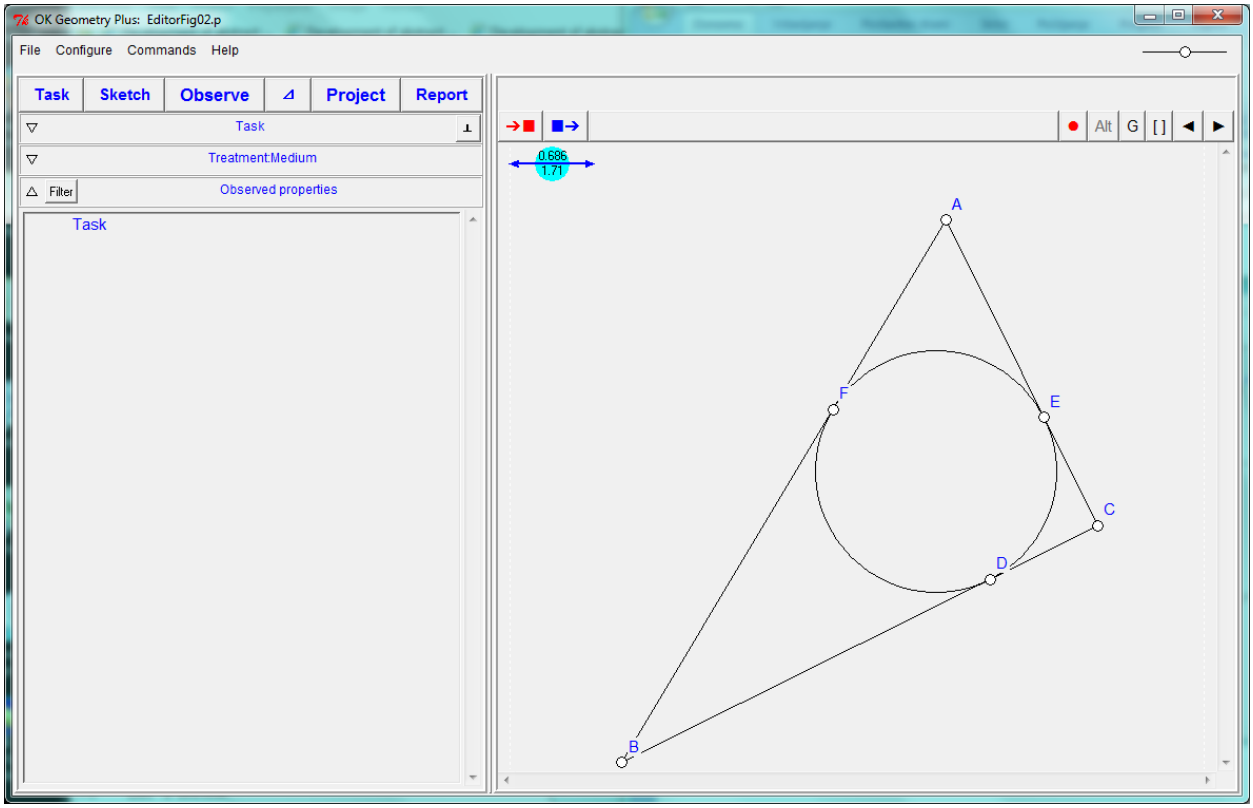


Figure 2

2. General guidelines

Most commands of the OK Geometry Sketch editor are rather straightforward and there is no reason to study them in detail at first reading. However, *we strongly suggest to read the general guidelines below for specific properties of OK Geometry Sketch editor.*

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

2.1. Command first, then parameters

Editor's action are started by activation the appropriate command (the involved objects are chosen later). The information line tells you what you are expected to do when a command is active. 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 Esc is pressed. For example: To draw some points first click 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 the command *Action|Drag Point* and then drag one or more points.
The execution of any command can be cancelled any time by pressing **Escape key** (Esc).

2.2. Only labels of points count

The label may consist of a single letter eventually followed by a numeral or apostrophes. You can thus use labels like: A, A2, A',k3,u1''. Label consisting of more than one character are admitted, OK Geometry will, where necessary, write the label in parenthesis, (AE) for AE. Usually you will label only the points that are potentially important for the analysis. Labels are case sensitive. The characters x,y,z are not admitted in labels.
Note. You can label also other objects (lines, circles, etc.) – either by writing the name immediately after the object is generated or you can do it later as textual information (see Mark|Text command). However, *only labels of points are considered in the analysis of the construction*, all other labels are ignored
Note. If a command results in a construction of a single point, this point is usually automatically labelled. It is possible to write the label of an object immediately after it is constructed. The position of the label can be modified with mouse wheel. Obviously, the label and the position of the label can be modified later with appropriate commands.

2.3. Alternative solutions

Use **Alt** button on the editor's toolbar[1] (possibly together with mouse wheel) for alternative results of operations. Some constructions admit two or more solutions in this case a red coloured **Alt** button appears on the editor's toolbar. Only one solution is shown at time. By repeatedly pressing Alt button alternative solutions can be accessed. Note that some alternatives may be 'empty' or duplicated. For example, the task of constructing a circle that is tangent to three circles has usually several solutions.

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

Only one is drawn at time. By repeatedly pressing Alt button one obtains the desired solution. For convenience Alt button executes also analogies of some commands (e.g. parallel/perpendicular line). Figure 3 shows a simple example (line tangent to two circles) with several possible solutions including the radical axis. Using **Alt** it is possible to select the desired solution.

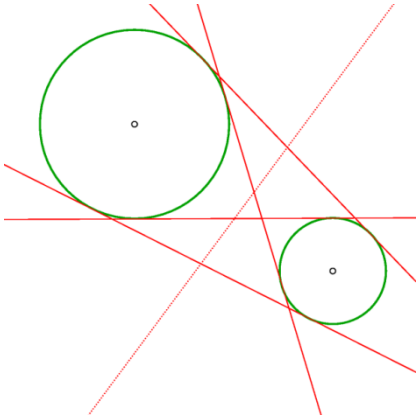
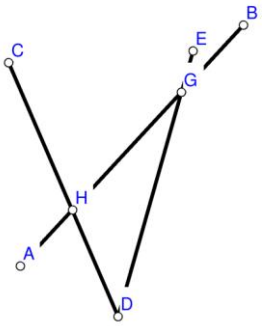
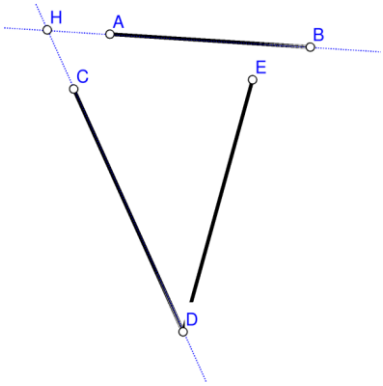


Figure 3

2.4. Safe points

Safe points is a feature that determines the behaviour of a point that is positioned on an object, e.g. line segment, segment of polyline, circular arc. Safe points feature can be turned ON or OFF. If Safe points is ON then line segments (segments of a polyline, circular arcs) in a construction of a point are treated as respective base objects. For example, a free point on a line segment is treated as a point on the baseline of the line segment, thus it 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 respective baselines. We illustrate this feature with two examples (Figure 4).

Construction of points	Behaviour of the construction
	
G was defined as intersection of segments with Safe points OFF. H was defined as 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 under Safe points ON, H is positioned at the intersection of the respective base-lines of the segments AB and CD. (*Note. The dotted lines are displayed here only for evidence.*)

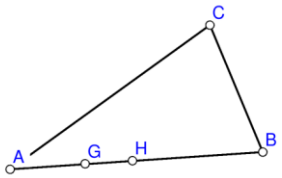
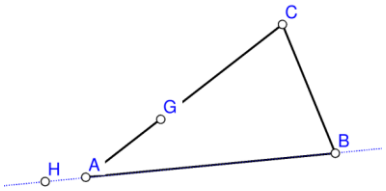
	
G was defined as a point on the polyline ABCA with Safe points OFF. H was defined as a point on the polyline ABCA with Safe points N.	As G is dragged around, it remains on the polyline, since it was constructed under Safe point OFF. The point H was constructed under Safe points ON, thus it was positioned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

Figure 4

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

2.5. Geometric transformations and numeric parameters

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

The used numeric parameters and transformations are displayed on the left hand side of the display. The numeric parameters may be assigned a desired value or may be the result of a measurement.

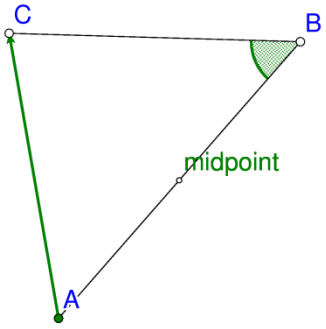
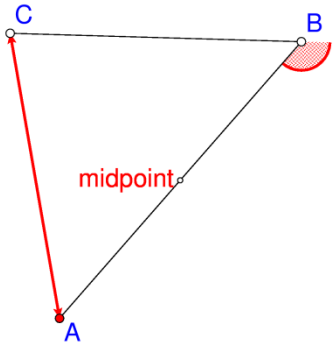
2.6. Commands on polylines

Commands that apply to line segments usually 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 to the polyline as a whole. For example: The command Midpoint when applied to a polyline has three version:

- you can generate the midpoint of the segment you pointed to,
- you can generate the set of midpoints of each segment of a polyline,
- you can generate the midpoint of a polyline as a whole (i.e. at the point that splits the polyline into two parts of equal length).

2.7. The anchor command

The **Anchor** command and button  modifies a relevant element of various object. The table explains and illustrates, which element are modified in various types of objects. The command is used repeatedly until the desired effect is achieved – a quicker way is to use the scroll button on the mouse.

Object	Effect	Example before	Example after (possibly repeated) anchor
Point (label)	Changes the position of the label wrt. the point.		
Angle	Sets a different angle with the same base-lines as the original.		
Arrowed segment	Modifies the position of the arrows.		
Text/marker	Changes the position of the text/marker wrt. the reference point.		
Polyline	Changes the *fill state* of the polygon defined by the polyline.		

2.8. Emphasized, bleached, and transparent objects

Important objects, e.g. those intended to represent some geometric property, can be declared as **emphasized**. In Sketch editor it is possible to control the emphasizing level with the **Shift+Up/Down** keys , with **Shift+mouse wheel**, or with the **Scenes** command; elsewhere the emphasizing level is controlled with sliders. The emphasizing level in icons can be changed at any time with sliders.

Objects that are relevant but may cause unwanted confusion can be declared as **bleached**. In this way they become less visible. In Sketch editor the degree of visibility (bleaching level) can be adjusted with **Alt+Up/Down** keys, with **Alt + mouse wheel**, or with the **Scenes** command.

Objects can be also declared as **transparent.** Such objects behave similarly as hidden objects. However, transparent objects are , contrary to hidden objects, considered in the observational analysis. Transparent objects are mostly used in scenes. A complete construction is presented as several scenes, scenes differ among them only in the appearance of the objects: an object can be transparent in one

scene and non-transparent in another, or can be emphasized in one scene and non-emphasized in other etc.

There are several commands for setting the relation-emphasis and bleaching status of objects. The usual way is to use the buttons for toggling the emphasis/bleaching status of objects.

Figure 5 dispays a triangle ABC with bleached incircle and three relation-emphasized line segments. The three variations show different bleaching and emphasizing effects.

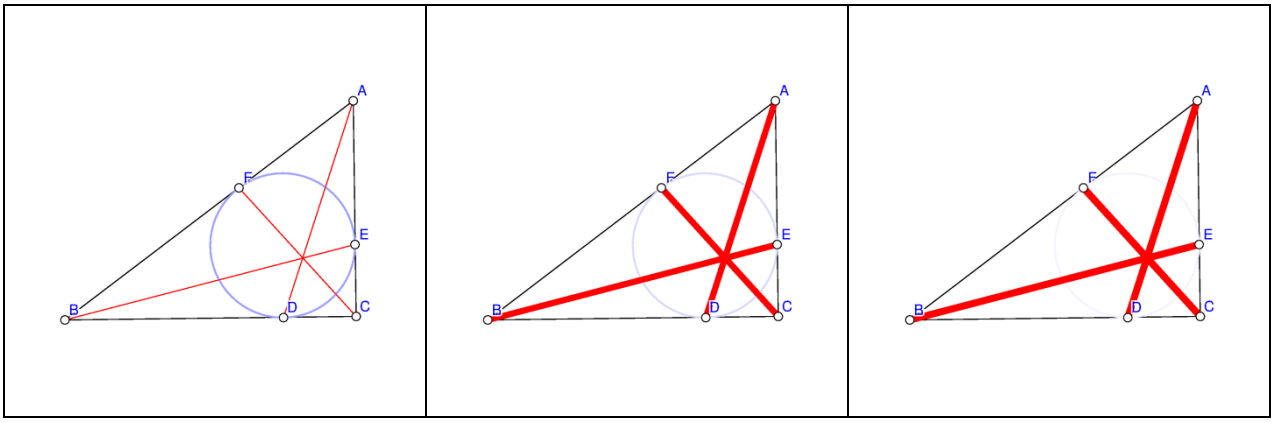


Figure 5

2.9. Scenes

A construction may consist of several scenes, which share a common underlying construction. The scenes of a construction vary only in selection of objects that are emphasised, transparent, and bleached. The scenes are visible (can be displayed) only in Project mode with big icons. The aim of the scenes is to catch the attention of different specific configurations in the construction.

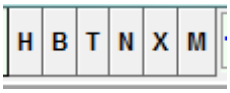
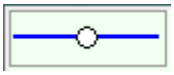
The scenes of a construction are managed with the **Scenes** command and the self explaining forms that is displayed when the command is active.

3. Toolboxes

3.1. Visibility and current style information

On the upper right of the editor window there is a small toolbox setting the style (colour, widths, shape of lines/points, etc.) of the drawn objects. The toolbox contains also some visualisation related commands and indicators of mode of work.

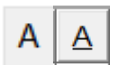
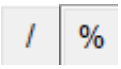
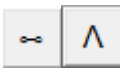
Button	Command	See cmd
Cycl	**Cyclic mode ON/OFF switch and indicator** (*Only in Plus mode*). When the cyclic mode is ON, the program performs cyclic constructions on triangles. (See OK Geometry Plus documentation for details.)	
Safe	**Safe point button ON/OFF switch and indicator.** See Section2.4.	

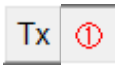
	**Visibility ON/OFF switches and indicators.** When the switch **H** (hidden) is ON, all hidden objects are displayed as if they were not hidden. When the switch **B** (bleach) is ON, bleached objects are displayed as if they were not bleached, i.e. the objects are well visible. When the switch **T** (text) is ON, the texts on the construction are displayed. Note that labels of points of objects are always visible, regardless this switch. When the switch **X** is ON, the auxiliary lines of angles are displayed. When the switch **M** is ON, all markers in the construction are displayed.	
	The rightmost indicator displays the style of new objects to be created in Sketch editor. To change the style of new objects, click on the indicator and set the styles in the form that appears.	

3.2. Sketch editor toolbox

The editor's tool bar contains the more frequently used commands. When two buttons are shown together, a right click on the button switches between them.

Button	Command	See cmd
	**Restyle objects**. This command is used to modify the style (i.e. colour, width or size, shape) of displayed objects. After a click, a form for setting styles appears. Then click on the objects to be modified.	43
	**Manage the visibility status of objects.** The hidden objects are displayed in red colour. A click on an object changes its status from hidden to visible and vice-versa.	13
	**Delete objects**	14
	**Scenes.** With this command it is possible to add several scenes to the ground construction. The scenes share a common (ground) construction, however objects in scenes may be differently emphasised, bleached, made transparent. After clicking the leftmost button, a form appears that enables the setting of scenes on the current (ground) construction. The other three buttons toggle the status of objects on the current (ground) construction.	
	Toggle emphasize status.	

	Toggle bleach status	
	Toggle transparency status	
	**Auto label indicated points.** Label a point with the letter that is on the button. If the point is already labelled the label is cleared. To set the label on the button press **Alt+S** key.	16
	Label points with a specified label	17
	**Point.** Declare a point as a free point, a point on an object or an intersection point (depending on the position of the point).	52
	Point as intersection of two objects	54
	Midpoint of segments, centre of circles.	
	**Line through 2 points**	73
	Line touching 2 objects. Depending on the input objects, the constructed line passes through points, is tangent to circle(s), or is parallel or perpendicular to a given line, also line bisector and radical axis of two circles. Use the **Alt button** to select alternatives.	80
	**Circle with given centre and a point on the circumference**	81
	Circle touching 3 objects. Constructs a circle touching three given objects (points, lines, circles). Use the **Alt button** to select among alternative solutions.	88
	Circle with given centre and touching a given object	
	Compass. Constructs a circle, which radius is a line segment or the radius of a circle and a given centre.	
	**Line segment**	74
	Polyline. Constructs a polyline with pointed vertices.	75
	**Angle.** Select a point on the ray, the vertex, and a point on the other ray. Angles are positively oriented. Use the anchor command to change the angle to other angles with the same vertex and base lines.	?
	Congruence. A click on an object puts a congruence mark (with 1,2,3,or 0) lines. Use the anchor command to change the angle to other angles with the same vertex and base lines.	
	Mark area. Fills the area of a polygon or circle. The colour of the area	

	matches the colour of the border.	
	Mark arrow. Adds an arrow to the displayed line segment. Use the anchor command to change position and size of the arrow.	
	**Text.** For displaying simple text within construction. Texts can be attached to objects. Texts are not geometric object but in many respects they behave as labelled points.	30
	Marker. Markers (1-10) are simple marks, with optional information in balloons, which are intended for easier explanation of constructions or similar purposes. Markers are not geometric object but in many respects they behave as labelled points.	27
	**Alternative results.** Press repeatedly for alternative results of (certain) commands (or use the **mouse wheel**). This is understood in rather broad sense. Alternatives may be different solutions or analogous commands (e.g. parallel and perpendicular lines).	2.3
	**Anchor.** Can be pressed several times in succession (or use the *mouse wheel*). Changes the position of the *label of a labelled point*. Changes the *selection of angle* between intersecting lines. Changes the *direction of arrow* in an arrowed segment. Changes the *position of a text* wrt. its reference point. Changes *fill state of a polygon* (defined by a polyline).	19
	**Drag.** Dynamically changes the construction as a selected *point* is dragged or a selected *parameter* is changed. The command is reset after each dragging.	11
	**Zoom fit**. Press repeatedly for various zooming options: view all objects; view all displayed points; view all labelled points; user (saved) view.	
	**Pan.** Move the whole configuration.	
	**Undo.** Undoes the last command. Can be pressed several times in succession.	44
	**Redo.** Redoes the last undone command. Can be pressed several times in succession.	45
	**Redefine object.** Pick the object to be redefined and the set the new construction of the object.	15
	**Set cyclic objects**. (*Only in Plus* mode) Declare 3 pointed objects as cyclic with respect to the reference triangle.	

Some examples of geometric constructions are described in detail in Section 5. All commands are explained in detail in Chapter3.

4. Description of the menu commands

4.1. Sketch editor: organisation of the menu

1. Action commands	The group contains commands for manipulating geometric objects: dragging points or parameters, labelling vertices, hiding and deleting objects, undoing commands, and zooming.
2. Point commands	Here are various commands for positioning and constructing points and sets of points.
3. Line commands	Here are various commands for constructing lines, line segments, and polylines. Note that OK Geometry does not explicitly use rays and vectors.
4. Circle commands	Here are various commands for constructing circles, circular arcs, and conics.
5. Number commands	This group contains commands for measuring geometric quantities, defining numeric values (as parameters), for calculating expressions, and for composing logical conditions.
6. Transformation commands	Here are the commands for defining transformations and commands for applying transformations to objects. A transformation is treated as an explicit object. Once it is defined it can be applied later to various objects.
7. Advanced commands	Here you can find commands for complex operations: for constructing commonly used shapes, for constructing a locus, for checking conditions, for fulfilling conditions (implicit constructions), for constructions based on optimisation.
8. (Special commands)	This group of commands is available only in Plus mode. Here you can find a wide range of commands and constructions related to triangle geometry. Useful only for specialist in triangle geometry.

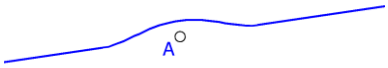
4.2. Action commands

Command	Meaning	Comments
9. New project	Clear the current project and the current construction.	

10. New construction	Clear the current construction.	**Note**. The project (ie. all icons) remains unchanged.
11. Drag Point/Parameter (available also in editor's tool bar)	Move points Dynamically change the value of a parameter	Only free (non-constructed) points can be dragged. It is possible to 'drag' numeric parameters – but only parameters that were explicitly set as constant numbers (and not 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 and click **Apply interval**. Change the value of the parameter with the slider.
12. Hide	Hide objects	Click the object you want to hide. See *Action|Show hidden* do unhide objects. Note that parameters and transformations cannot be hidden.
13. Show hidden (available also in editor's tool bar)	Unhide/hide objects	All objects (displayed and hidden) are shown. The hidden ones are of red colour. By clicking the objects you change their status from hidden to displayed and vice versa.
14. Delete	Delete an object together with all objects that depend on it	
15. Redefine object	Redefine an object. All objects that depend on the redefined object are modified accordingly.	1. Pick the object to be redefined. 2. Define a new object. *Example. Suppose you draw a line AB. After several construction steps you find out the line should be AC. To correct the situation redefine the line:* *1. Select the command Redefine object* *2. Click the line AB. The line turns blue and dotted.* *3. Select the command Line 2pts* *4. Click the points A and C. The situation is corrected.*

16. Labels|Auto label (available also in editor's tool bar)	Auto label selected points Label/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 **Alt-S ir** use the command *Actions*|*Labels*|*Label* vertex.
17. Labels|Label vertex	Label selected points with specified labels	Click 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).
18. Labels|Clear label	Delete the label of selected points.	Click the point to be unlabelled.
19. Labels| Anchor label/angle/text	Select from various possibilities of positioning labels and text Select another angle with same baselines as a given one Change congruence mark Change arrows Change fill state of a polygon region	**Anchor.** Can be pressed several times in succession (or use the *mouse wheel*). Changes the position of the *label of a labelled point*. Changes the *selection of angle* between intersecting lines. Changes the *direction of arrow* in an arrowed segment. Changes the *position of a text* wrt. its reference point. Changes *fill state of a polygon* (defined by a polyline.
20. Labels|Set next label	Set new label for auto-labelling	See *Labels*|*Auto label*
21. Labels|Label all	Auto label all shown points	All displayed unlabelled points are labelled in the same order as they were defined. Each displayed point is named by the first available label.
22. Labels|Clear all labels	Clear all labels	The labels of all points are deleted.

23. Mark|Mark angle	Mark an angle	Pick: 1. a point on the ray, 2. the vertex of the angle, 3. a point on the other ray. The described (positively oriented) angle is marked. **Note.** The size and the type of the arc denoting the arc in Sketch editor are set automatically. It is possible to set both, the size and the type, but only in the *Configuration|General options|Sketch.* **Note.** Use **Anchor** command to mark other angles related to the marked angle.
24. Mark|Mark area	Mark the interior of a polygon	The colour of the interior is determined by the colour of the edging polyline. **Note.** Polylines need not to be closed in order to be (area) filled. **Note.** You may also use the **Anchor** command to mark/unmark the area of a polygon.
25. Mark|Mark arrow	Mark one or two arrows on a line segment	Apply repeatedly for various arrow modes. Adding arrows affects a line segment only visually, not functionally (i.e. arrowed segment does not represent a vector). **Note.** You may also use the **Anchor** command to vary the type of arrow of a segment.
26. Mark/Mark congruence	Mark various congruence marks on segments and angle marks	Apply repeatedly for various congruence marks. **Note.** You may also use the **Anchor** command to vary the type of congruence mark.
27. Mark|Marker	Draw a marker with a ballooned comment	Markers are encircled numbers 1-10 with optional comments or predefined symbols like !, ?, *. **Note.** You may also use the **Anchor** command to vary the position of the marker wrt. its reference point.

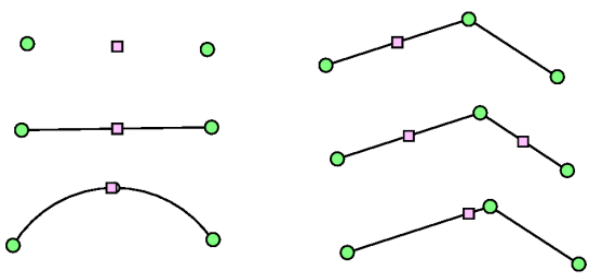
28. Mark|Detour point	Make an object visually avoid a given point	If a point lies on an object (e.g. a line or circle) it is possible to detour the object so that it avoids the point. Such may be useful when presenting hypothetical situations ("Assume that the line does not pass through A...") or facts 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 and then (2) pick the point to be avoided.
29. Mark|Detour segment	Make an object visually avoid a given point along a segment	This command serves the same function as Detour point, only the presentation is a bit different.  In order to detour an object along a segment (1) pick the object, then (2) pick the beginning of the detour, and (3) end of detour. The points (2) and (3) become hidden.
30. Mark|Text	Include a simple text in the construction	**Note.** You may also use the **Anchor** command to vary the position of the text wrt. its reference point.
31. Background	Set (import/copy) the background of the construction and related icon.	This is **not intended** to be the background of a construction since the constructed points are usually not fixed. The background is rather intended to be a self-standing imported image to be displayed as icon.
32. Scenes...	Manage the scenes of the current construction	Set various emphasise/highlight/bleach attributes of the objects of the current construction as scenes. The command opens a self-explaining form to manage the scenes. Note that scenes can be displayed only in Project mode with big icons.
33. Bleach/Emphasis| Togle bleach	Toggle the bleach status of object	**Note.** A bleached object is displayed as less visible (fainted). See Section 2.8.
34. Bleach/Emphasis| All bleach	Bleach all objects	
35. Bleach/Emphasis| Unmark all bleach	Un-bleach all objects	

36. Bleach/Emphasis|Toggle emphasis	Toggle the emphasis status of object	**Note.** An emphasised object is displayed in a way to be well visible in a controlled way. See Section 2.8.
37. Bleach/Emphasis|Unmark all emphasis		
38. Bleach/Emphasis|Toggle transparent	Toggle the transparency status of object	**Note.** A transparent object is considered in observation but is not visible. This feature is used when a construction is presented in several scenes. See Section 2.8.
39. Bleach/Emphasis|Unmartk all transparent		
40. Bleach/Emphasis|Make everything transparent		
41. Bleach/Emphasize		
42. Bleach/Emphasis|Use current attributes of object in all scenes		When a construction is shown in various scenes, then each object has in each scene a desired state of transparency, emphasis or bleach. This command copies the status of one or more objects from the ground construction to all scenes.
43. Restyle objects (available also in editor's tool bar)	Set the visual appearance of the objects.	In the form that appears select the width, colour, and shape of line/point. Then click on the objects you want to apply the selected appearance.
44. Undo command (available also in editor's tool bar)	Undo the last command	The command can be repeated several times.
45. Redo command (available also in editor's tool bar)	Undo the last undo command	The command can be repeated several times.
46. Zoom|Zoom in [Ctrl+Plus]	Zoom in with respect to the centre of the displayed area	
47. Zoom|Zoom out [Ctrl+Minus]	Zoom out with respect to the centre of the displayed area	

48. Zoom|Pan view		Drag the view area to the desired position.
49. Zoom|Zoom view		Define (by dragging) the rectangle, which becomes the new view area.
50. 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.
51. Zoom|Fit points/objects [Ctrl+Home] (available also in editor's tool bar)	Zoom to show all points/objects	Sets the viewed area so that all visible points are displayed. If repeated, then the viewed area contains in turn: - All labelled points, - All visible points, - All visible objects, - the user-saved view area. **Note.** In general, OK geometry manages alone the viewed area by displaying all drawn points.

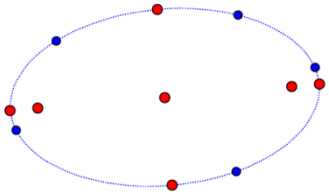
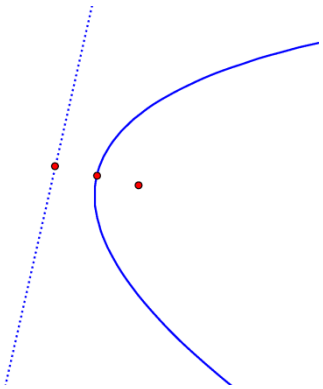
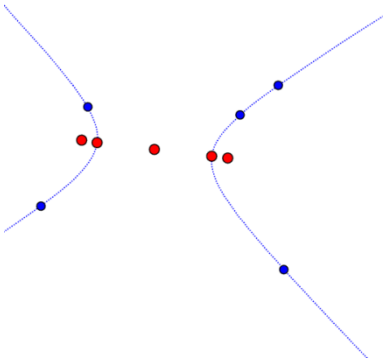
4.3. Point commands

Command	Meaning	Comments
52. Point	Draw a point Draw a point on an object Draw an intersection point	Click on an 'empty' region to draw a 'free' point. If clicked on an object (e.g. line or circle) the drawn point is attached to that object. If clicked near the intersection of two objects the intersection point is constructed. (See also ***Intersections*** for the set of all intersections of two objects.) If clicked near the intersection of three or more objects, you are asked to sequentially select two of the objects – the new point is the intersection of these two objects.
53. Point on object	Draw a point that is linked to an object	Click on an object (e.g. line or circle). The new point will be linked to that object.
54. Intersection	Construct an intersection point	Click in sequence on two objects (e.g. line, circle, polyline). The intersection of the two objects (the nearest intersection point to the clicked position) will be constructed.

55. PointXY	Declare a point with fixed coordinates	Such point cannot be dragged. It is considered as a fixed point also in observation analysis.
56. Safe points	Modality of treatment of line segments and arcs. (See 2.4.)	If Safe intersection is ON then line segments, segments of polylines, and circular arcs objects are interpreted as base-lines or base-circles in intersection operation and in dragging operations. When the Safe intersection option is ON, the Point button in editor's toolbox assumes the cyan colour. *If a point is defined as the intersection of two segments (with Safe intersection ON), then the point is defined as the intersection of the respective base-lines. Such intersection point exists even if the two segments (when dragged) do not intersect each other.* *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.* If Safe intersection is OFF then intersections and dragging behave as intuitively expected. When the Safe intersection option is OFF, the Point button in editor's toolbox is not coloured. The ON option is more robust. It may be preferred in far-away dragging, in implicit constructions.
57. Midpoint	Construct the midpoint of a segment Construct midpoints of segments of an object (See 2.6)	With this command you can construct: - the midpoint between two points; - the midpoint of a line segment or a circular arc; - the midpoint of a segment of a polyline; - the midpoints of all segments of a polyline; - The point at half length of a polyline. 

58. Divide ratio	Construct the point(s) that divide(s) an object in a given ratio Construct points on object that divide the segments of an object in a given ratio (See 2.6)	Works like ***Midpoint***, the only difference is that you have to enter the desired ratio of the length of the obtained segments. The ratio *a/b* or *a*:*b* divides a segment in ratio *a*:*b*. Thus dividing the segment AB with ratio 1:2 we obtain a point C that lies at 1/3 of distance from A to B.
59. Centre of circle	Construct the centre of a circle (circular arc)	
60. Inversion wrt. circle	Invert a point wrt. a circle	Pick (1) a circle and then (2) a point. The inversion of the point wrt. the selected circle is constructed.
61. Nearest point	Construct the point on a given object that is nearest to a given point (See 2.6)	Select (1) an object (line, line segment, polyline, arc), (2) a point. The point on the object (1) that is nearest to the point (2) is constructed. If the selected object (1) is a polyline, then 2.6 applies, i.e. you can obtain the nearest point on the shown segment, on each segment, or on the whole polyline.

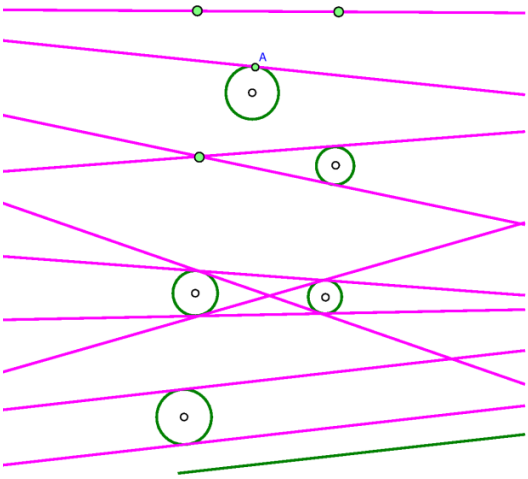
62. At length	Construct a point on the object at a given arc length (See 2.6)	Select (1) an object (line segment, polyline, arc), (2) a positive number. The point on the object (1) is constructed so that the arc length from the beginning of the object to the constructed point is equal to (2). You may prefer to determine previously the desired arc length as a parameter (see 4.6), and select the number (2) as a previously defined parameter. In this way you can dynamically change the value (2). If the selected object (1) is a polyline, then 2.6applies, i.e. you can obtain points at a given length on the shown segment, on each segment, or on the whole polyline.
63. Triangle centres	Construct the classical triangle centres	In the form that appears, select the type of triangle centre. Then, either pick a triangle (as a polyline) or the three triangle's vertices.
64. Special constructions	Various constructions of points (only in Plus mode)	The following constructions are currently available: Harmonic conjugate (of a triplet of points) Insimilicentre (of two circles) Exsimilicentre (of two circles) Centre of similitude (of two similar triangles).
65. Vertices	Treat all vertices of a polyline as points. (See 2.6)	Some commands produce a polyline with no marked vertices on it. Use this command to obtain all vertices of such polylines.
66. Conics points	Construct the characteristic points of a conic that is given by 5 points on it.	After you select 5 points that determine the considered conic a set of points is constructed. The number and meaning of the constructed points depends on the type of the considered conic. If the conic is an ellipse then the centre, the two focuses and the endpoints of both axes are constructed.

		 If the conic is a parabola then the focus and the intersection of the axis with the directrix is constructed.  If the conic is a hyperbola then the focuses, the centre and the two intersections of the parabola with the axis are constructed.  **Note.** Conic as curve (given by 5 points) can be displayed with the editor's command *Circle|Conic5pts*.
67. Intersections| Intersections	Construct **all** intersection points of two objects	Select two objects (circles, lines, arcs, polylines). The command constructs all intersection points of the two objects.

68. Intersections/ Nearest	Among the intersection points select the one that is nearest to a given point	Select two objects (circles, lines, arcs, polylines) and a point.
69. Intersections/ Farthest	Among the intersection points select the one that is farthest from a given point	Select two objects (circles, lines, arcs, polylines) and a point.
70. Grids/Uniform divide	Construct a pattern of equally spaced points along an object (See 2.6)	Select (1) two points or a line segment, arc, or polyline, and (2) the number of segments(not points) to generate. A pattern of the specified number (2) of points is constructed along the object (1). If the selected object (1) is a polyline, then 2.6 applies. Using this command you can divide a line segment into a specified number of pieces.
71. Grids/Recangular grid	Construct a grid of points in the form of a parallelogram	Enter (1) the lower left corner of the grid, (2) the lower right corner, (3) the upper left corner, (4) number of points in the horizontal direction, (5) number of points in the vertical direction.
72. 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.

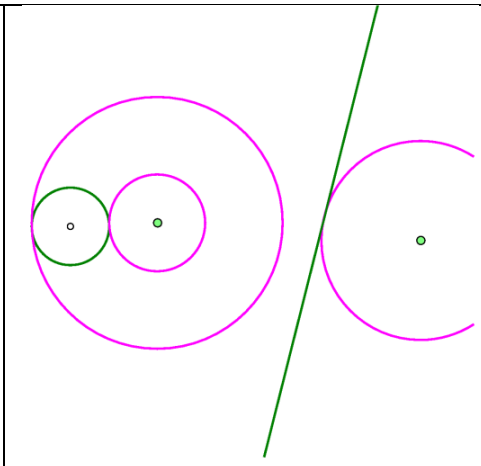
4.4. Line commands

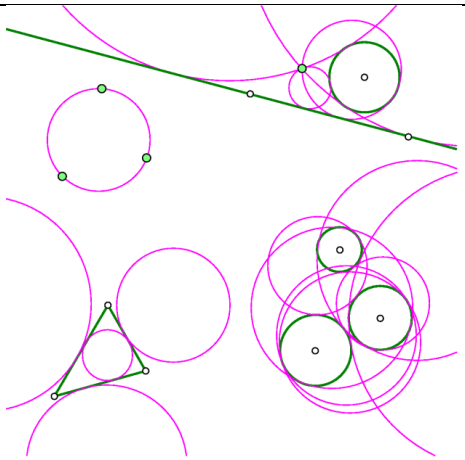
Command	Meaning	Comments
73. Line	Construct a line through two points	Point to two points. You can point either to an existent or nonexistent point – in the later case a new point (free or linked) is implicitly defined.
74. Segment	Construct a line segment given its endpoints	Point to the two edges of a line segment to be constructed. You can point either to existent or nonexistent point – in the later case a new point (free or linked) is implicitly defined.
75. Polyline	Construct a polygonal line given its vertices	Click sequentially to the vertices of the polygonal line. You can point either to existent or nonexistent points – in the later case new points (free or linked) are implicitly defined. To draw a new polygon line, click again the command Polyline. To draw a closed polygon just end at the start 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.
76. Parallel line	Through a given point construct the line parallel to a given line	Select a line and a point or vice versa. **Note.** To obtain a perpendicular line press ***Alt*** button in editor's toolbar.
77. Perpendicular line	Through a given point draws the line that is perpendicular to a given line	Select a line and a point or vice versa. **Note.** To obtain a parallel line click the ***Alt*** button in editor's toolbar.
78. Bisector	Construct the bisector of a line segment	Pick the endpoints of a segment or pick a line segment.

79. 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 clicks the ***Alt*** button in editor's toolbar. Or, pick (1) a point on a ray, then (2) the vertex of the angle, and (3) a point on the second ray.
80. Line 2 objects	Construct a line determined by two selected objects: - a line through 2 points, - a line tangent to 2 circles, - a tangent to a circle through a point, - a line that is parallel to a given line and touches a given circle, - the radical axis of two circles, - a line through a point, tangent to a conic. See 2.3.	Select two objects (points, lines, circles). A line that touches the two objects is drawn. **Note.** This command comprises most of the lines commands. The resulting line is determined by two objects and the relations 'passing through', 'parallel with', 'tangent to'. Usually there are two or more alternative solutions. To obtain them click the ***Alt*** button in editor's toolbar or use the mouse wheel.  Note. **Alt** gives rise also to other lines related to the two selected objects.

4.5. Circle commands

Command	Meaning	Comments
81. CircleC	Construct a circle given its centre and a radial point.	Point to (1) the centre of the circle, (2) a point on the circumference. You can point either to an existent or nonexistent point – in the later case a new point (free or linked) is implicitly defined.
82. CircleR	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 or picking a previously set parameter or point to a circle.
83. 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 a circle; (2) the centre of the circle.
84. Apollonius circle	Given two points construct the locus of points X with a given ratio of 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. Any point X on the resulting Apollonius circle has the property that the ratio of distance from X and (1) and from X and (3) is the same as the ratio of distance from (2) and (1) and from (2) and (3).
85. CircleC obj	Construct a circle given its centre and a 'touching object' (circle, line or point). See 2.3	Pick (1) the centre of the circle, (2) the object that touches the circle. The object can be a circle, a line or a point. Usually there are two or more alternative solutions. To obtain them click the ***Alt*** button in editor's toolbar.

		
86. CircleR 2obj	Construct a circle with a given radius that 'touches' two given objects (circles, lines or points). See 2.3.	(1) Pick the first tangency object, (2) pick the second tangency object, (3) write the numeric value of the radius of the circle (on the information line, click OK to confirm). You may prefer to determine previously the radius as a parameter (see 4.6), and select the radius as a previously defined parameter. In this way you can dynamically change the radius. Usually there are several alternative solutions. To obtain them click repeatedly the ***Alt*** button in editor's toolbar.
87. CircleA 2obj	Construct a circle that 'touches' two given objects (circles, lines or points) so that the circle radiuses to the touch-points form a desired angle.	(1) Pick the first tangency object, (2) pick the second tangency object, (3) set the angle between the radiuses to the touch-points (on the information line, click OK to confirm). Usually there are several alternative solutions. To obtain them click repeatedly the ***Alt*** button in editor's toolbar.
88. Circle 3obj	Construct a circle that 'touches' to three given objects (circles, lines or points). See 2.3	Pick the three objects that the circle is supposed to touch. Each of the three objects can be a point, a line or a circle. Usually there are several alternative solutions. To obtain them click repeatedly the ***Alt*** button in editor's toolbar. With this command you can 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 ...

		
89. 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.
90. Arc centre	Construct a circular arc given its centre and two endpoints	Pick (1) the centre of the arc, then (2) the first endpoint of the arc (considering the positive orientation of the arc), and (3) the second endpoint of the arc (considering the positive orientation of the arc).
91. Indicate arc	Construct an arc indicating a circle	Pick (1) the centre of the arc, then (2) the approximate centre of the indicated arc .
92. Conic 5 pts	Draw a conic given 5 points on it.	Pick 5 points on the conic to be drawn. **Note.** Other constructions of conics are available in menu Advanced| Shapes|Other.

4.6. Number commands

Command	Meaning	Comments
93. Distance to object	The distance from a point to an object (another point, a line, a circle) is set as a numeric parameter.	(1) Pick the point from where the distance is measured. (2) Pick the object to which the distance is measured (can be a point, a line or a circle). (3) Write the name of the parameter that will contain the measured value.

94. Radius of circle	The radius of a circle or circular arc is set as a numeric parameter.	(1) Pick a circle. (2) Write the name of the parameter that will contain the radius of the circle.
95. Angle	The size of an angle is set as a numeric parameter. The angles are always expressed in degrees.	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) Write the name of the parameter that will contain the size of the angle. The measured size of the angle can be positive or negative, depending on the orientation of the angle. Second option: (1) Pick a base line of a ray. (2) Pick the base line of the other ray. (3) Write the name of the parameter that will contain the size of the angle between base lines. *The measured angle between baselines is always smaller or equal to the right angle.*
96. Length, circumference	Set a numeric parameter, the value of which is: the circumference of a circle, the length of a line segment or circular arc, the length of a polyline, the length of a segment of a polyline.	(1) Point to a circle, a line segment or a polyline. If you select a polyline you need to specify whether you the length refers to the pointed segment or to the whole polyline. (2) Write the name of the parameter that will contain the length/circumference.
97. Area	The area of a given circle is set as a numeric parameter. The area enclosed in a polyline is set as a numeric parameter.	(1) Select a circle or a polyline. (2) Write the name of the parameter that will contain the measured area. **Note.** The polyline should be closed and without self-intersections, otherwise the resulting area is not valid.
98. Ratio of segments	The ratio of the lengths of two line segments is set as a numeric parameter.	Either select two existing line segments (they can be a part of a polyline) or pick the 4 endpoints of the line segments. Then write the name of the parameter that will contain the ratio of the lengths of the segments.

99. Value, Expression	A user defined numeric value or the value of an arithmetic expression is set as the value of a numeric parameter.	Note the box that appears in the information line and the OK button. In the box write a numeric value for a parameter. Then write the name of the parameter (variable). Such 'free' numerical parameters can be dynamically changed (see the command *Action*|*Drag Parameter*). In the box you can write as well an arithmetic expression, which may contain mathematical functions and previously defined numeric parameters. Expressions are not 'free' and thus cannot be 'dragged'. To insert in expression a numeric parameter just click on the parameter in the Transformations & Parameters section (on the left pane). Expressions should comply with the usual syntax rules. Expressions may contain mathematical functions (see the list below). For the power sign you can use either ^ or **.
100. Compose conditions	Compose conditions	There are several commands for setting geometric conditions (e.g. whether three points are collinear), see the command Check property *in section 4.8*. Sometimes it is necessary to compose previously set geometric conditions. The only two allowed operations are logical conjunction (and) and logical disjunction (or). Conditions are composed in the box that appears in the information line. To insert a previously set condition just click on the condition. As mentioned, in the expression may contain only: conditions, and, or, parentheses.
101. Triangle expression	Calculate triangle related numeric expression (Only in Plus mode)	*In the calculation the well-known triangle-related parameters may be used, e.g. triangle sides, triangle angles, Brocard angles, Conway parameters, etc.* ***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
ACOS(x)	arcus cosines of x (degrees)
ASIN(x)	arcus sinus of x, in degrees
ATAN(y,x)	arcus tangens of y/x, in degrees
ATANG(x)	arcus tangens of x, in degrees
CEIL(x)	smallest integer that is bigger or equal to x
COS(x)	cosine of x (degrees)

DEG(x)	express radians in degrees
EXP(x)	exponent function
FLOOR(x)	largest integer that is smaller or equal to x
FROUND(x)	round x to the nearest integer
GCD(x,y)	greatest common divisor of x and y
HYPOT(x,y)	length of hypotenuse in right triangle with sides x and y
IFIX(x)	integer part of x

LCM(x,y)	least common multiple of x and y
LOG(x)	natural logarithm of x
MAX(x,y)	the biggest of x and y
MIN(x,y)	the smallest of x and y
PI	the constant pi
RAD(x)	x degrees expressed in radians
RAND(x,y)	a random number between x and

	y
REM(x,y)	remainder of x when divided by y
RND	random number between 0 and 1
SIGN(x)	sign of x, can be -1, 0 or 1
SIN(x)	sine of x (degrees)
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 you define it, 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 generated and can be immediately applied to an object. The transformation is 'visible' in Transformation & Parameters list. It is possible to change the default name of the transformation. You can refer to and apply the transformation later using the command *Transform|Transform object*.

Command	**Meaning**	**Comments**
102. Translation	Define a translation	Pick (1) the origin (a point), and (2) the point where you want the origin to be translated.
103. Reflection	Define a reflection (wrt. a line) or a skew (glide) reflection	Pick a line or two points of the line of reflection.
104. Rotation symmetry	Define a rotation symmetry	Pick the centre of rotation symmetry.
105. Rotation	Define a rotation around a given point	Select (1) the centre of rotation, and (2) the numerical value of the rotation angle (in degrees). You may prefer to previously set the rotation angle as a parameter (see 4.6). In this way the rotation angle can be dynamically changed.

106. Dilatation	Define a dilatation	(1) Pick the centre of dilatation. (2) Input the dilatation factor. You may prefer to previously set the dilatation factor as a parameter (see 4.6). In this way the dilatation factor can be dynamically changed.
107. Similarity	Define a similarity transformation that maps two given origin points to two given target points.	Select (1) the first origin point, (2) the first image, i.e. the image of (1), (3) the second origin point, (4) the second image, i.e. the image of (3). If at the end you choose a skew variant, the transformation will be composed with reflection along the line through the target points.
108. Projectivity	Define a projectivity that maps four given points to four given points	
109. Compose	Define a new transformation by composing two previously defined transformations.	
110. Inverse transformation	Define a new transformation as the inverse of a previously defined transformation.	
111. Transform object	Apply a transformation to an object.	Selected a transformation from the list of previously defined transformations. Select the object to be transformed by (1). Repeat step 2 as many times as necessary.

112. Other | Multiply by grid	Position copies of a given object along a grid of points.	This command positions along a grid copies of an object to be multiplied. For each point on the grid a copy of the object to be multiplied is generated. The copies are rotated, dilatated and/or translated according the transformation reference object and selected options. Select (1) the object to position along the grid (to be multiplied), (2) the guide point of the object to be multiplied, (3) the transformation reference object, (4) any grid-point (setPoint) on the grid.
113. Other | Multiply along a polyline	Geometrically similar copies of a given object are positioned the sides 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.
114. Repeat transformation	Sequentially apply a number of times a transformation to an object	Select (1) the transformation, (2) the object to which to apply the transformation, (3) the number of repetitions. A sequence of object will appear, each transformed from the previous one with the given transformation.

4.8. Advanced commands

Command	Meaning	Comments
115. Shapes	Commands for a quick construction of various commonly used shapes (isosceles triangle, rectangle, regular n-gon and many others)	With this command you can easily construct commonly used shapes by positioning or approximately positioning some vertices of the shape to be constructed. In the form that appears first choose the type of shape (triangle, quadrilateral, other) and then the specific shape. Then follow the instructions on the information line. **Note that**: The input vertices of the shape should **follow a positive orientation** (for some shapes this is immaterial). Not all vertices of the constructed shape are shown. Make them accessible with the command *Point|Vertices*. By default the vertices of the constructed shapes are not labelled. You can label them with commands *Action|Labels|Auto label* or *Action|Labels|Label all*.
116. Check property	The command comprises a series of test of geometric objects (collinearity of points, congruence of triangles and many others).	This set of commands contains checks for a wide range of geometric properties. The main use of these checks is related to the command *Advanced|Implicit construction*. Using implicit construction it may be possible to modify a given construction so that a geometric property becomes fulfilled. In the form that appears when the command is clicked first choose the type of property you want to check (position, equivalence, shape). And select a property from the displayed list. Then follow the instructions on the information line.

117. Locus	Displays the locus of a constructed point as another point moves along an object.	Select (1) the constructed point to be followed (should depend on the position o f point (2), (2) the point to be moved, (3) the object (circle, arc, line, line segment, polyline) along which (2) is supposed to move. 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).
118. Implicit locus	Give a hint for the locus of points for which a given construction-related parameter is fixed.	The command tries to suggest a possible locus of a specified variable point in the construction, so that a specified construction-related parameter has a desired value. Only points, lines, circles, and conics are eventually suggested as locuses. **Note. With this command it is, eventually, possible to obtain just a hint for the sought locus. The hint should be always critically evaluated.** **Note. The presence of implicitly constructed locus reduces the reliability of observational results.**
119. Implicit construction	Implicit construction of one or more objects Find the position of a point so that a condition is satisfied. Give a hint for the locus of points for which a given condition is satisfied. Modify up to three objects so that condition is satisfied.	There are two versions for this command. In both cases the program tries to modify one or more objects in a construction so that a condition is fulfilled, i.e. so that one or more properties hold. In the **simple version of the command** the program tries to find the position of a given point so that a previously set condition is fulfilled. The position of a point may be arbitrary or the point may be linked to an object. In case that several points on the plane fulfil a given condition, OK Geometry may provide a hint for the locus of such points. Make the initial construction. Using the command *Advanced*|*Check property* find whether the target condition is satisfied (e.g. whether two objects coincide, whether three points are collinear). If it is false and you would like to make it true by moving a point in a construction, proceed with the find command. 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 line, circle, conic. After you fill the form, click OK and pick the point to be moved. If you have check-marked the constraint option for the variable point (i.e. an object on which to restrict the search), click the object to which the moving point is linked. Check whether the desired position of the moved point has been found, i.e. whether the sought condition is true. The **advanced version of this command** allows modifying 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. The presence of implicitly constructed objects reduces the reliability of observational results.**
120. Optimisation	Modifies 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 fulfil the aim is to optimise a scalar value. We optimise the scalar value by automatically changing the position of one or more objects. Make the initial construction. Compute (as a numeric parameter the value to be optimised. Proceed as in the case of *Advanced*|*Implicit objects*. **Note. The presence of optimisation procedures reduces the reliability of observational results.**
121. Make macro	Define a sequence of commands as a new command. Macros can be stored and used in other constructions.	First we need to carefully make a construction in which some (dependent) objects are generated from some initial objects. Then click the command *Advanced*|*Make macro* and proceed as follows: Fill the form that describes the macro. In particular, choose the types of the input object(s) and the type of output object(s). Adjacent to the selected types of input objects you may write comments on how to select objects. Press the Continue button.

		Pick the input and the output objects in the appropriate order. If the macro is successfully constructed you can save it to a file (to be used in other occasions). In any case you can use the generated macro in the current session with the command *Advanced*|*Execute macro*.
122. Get macro	Reads one or more macros saved in from previous sessions.	
123. Execute macro		Select a macro and execute it as any other command.

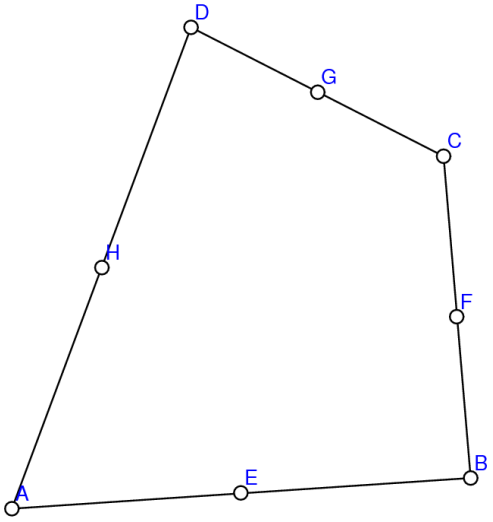
5. Examples

The examples in this section illustrate the use of some commands of OK Geometry Sketch editor. The Sketch editor differs from common programs of dynamic geometry. Its main aim is to enable quick and effective constructions of geometric configurations to be submitted for further analysis in OK Geometry. In this way the user is focused on analysing and proving properties.

Usually there are many ways how to work out a construction task in OK Geometry Sketch editor. In examples below we show just one way – in order to illustrate a command or a construction strategy.

5.1. Midpoints in a quadrilateral

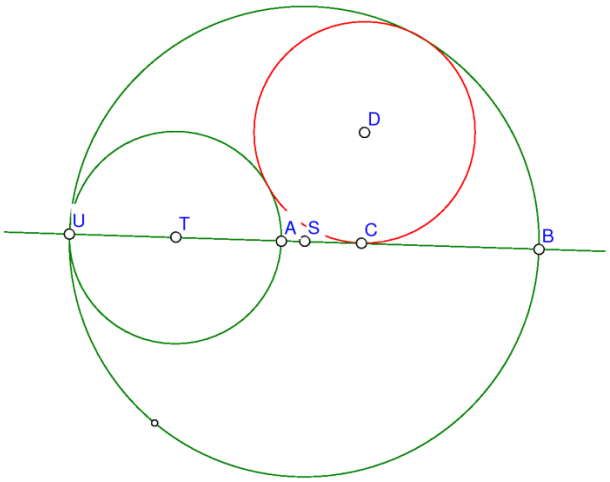
This example demonstrates how certain commands are applied in different ways to a polyline.

<table>
<tr><td>Task:</td><td>In an arbitrary quadrilateral ABCD mark the midpoints E,F,G,H of the four sides. Which interesting properties of the obtained configuration can you spot?</td><td> 
</td></tr>
<tr><td>File:</td><td>OkEditEx_1.p</td><td></td></tr>
<tr><td>Strategy:</td><td colspan="2">Draw the quadrilateral as a shape.
Draw the midpoints using the Midpoint command</td></tr>
<tr><td>Procedure/Step</td><td>Sketch editor command</td><td>Comment</td></tr>
<tr><td>1</td><td>Shapes|Quadrilateral</td><td>Pick 4 vertices. You obtain an unlabelled quadrilateral.</td></tr>
<tr><td>2</td><td>Point|Midpoint</td><td>Point to the quadrilateral (on one of the edges). In the form that appears and select the option ‘On each segment’ to obtain all midpoints at once.</td></tr>
</table>

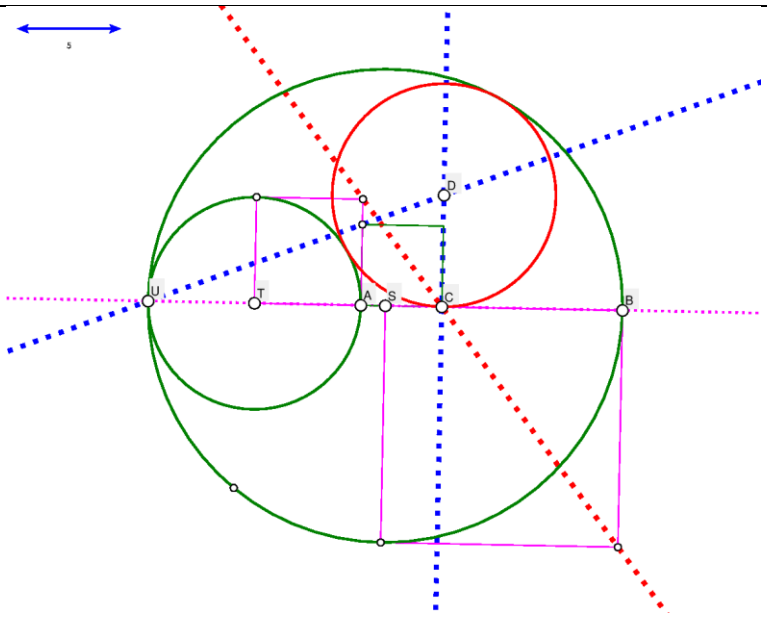
3	Action|Labels|Label all	Label all generated points. The order of labels follows the order of construction of points.
Suggestions for the analysis	According to the construction we are interested in properties that are invariant under the cyclic permutation of vertices: ABCD EFGH. (See OkEditEx1a.pro for an elaboration.) What can you say about the shape of the quadrilateral EFGH? How does the its area relate to the area of ABCD? (See OkEditEx1b.pro for an elaboration.)	

5.2. Inscribing a circle

This example demonstrates the use of complex construction commands to produce configurations to be analysed.

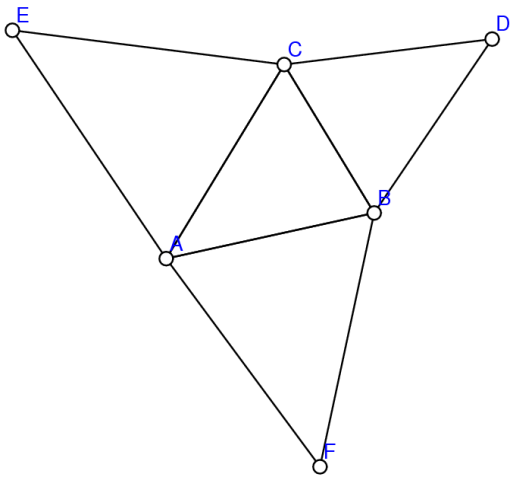
Task:	A circle is inscribed into another circle. Construct a circle that touches the two circles and the line through the centres of the two given circles.	
File:	OkEditEx_2.p	
Strategy:	Draw the configuration using complex commands (e.g. construct a circle tangent to three other circles/lines). A study of the construction will reveal how to work out the construction using only standard construction steps.	
Procedure/ Step	Sketch editor command	Comment
1	Circle|CircleC	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|CircleC obj	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	Circle|Line 2 pts	Construct the line through the points S and T.
4	Circle|Line 3 obj	Construct the circle tangent to the three drawn objects: Pick the outer circle, the inner circle, and the drawn line (any order of picking will do). Click the Alt key until the new shown circle is the desired one.
5	Point|Centre of circle Point	Pick the newly constructed circle to obtain its centre. Point to the position of the relevant points.
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|Colours and styles	Select first the desired colour, width and line style and then select the line or circle to be modified. Repeat this step as desired.
Suggestions for the analysis	• How would one do the construction using Euclidean tools? The analysis reveals lots of properties, but 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 Filter search and look for ratios AC and BC (in the Filter search write: AC && BC). • To obtain the radius CD look for ratios of distances containing CD. Using such data you will perhaps come to a 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 ratios you will (hopefully) find among the relations? A possible way to find out the relations between the radiusses 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 doing a bit of algebra we can prove the correctness of the construction.

5.3. Isosceles triangles on top of a triangle

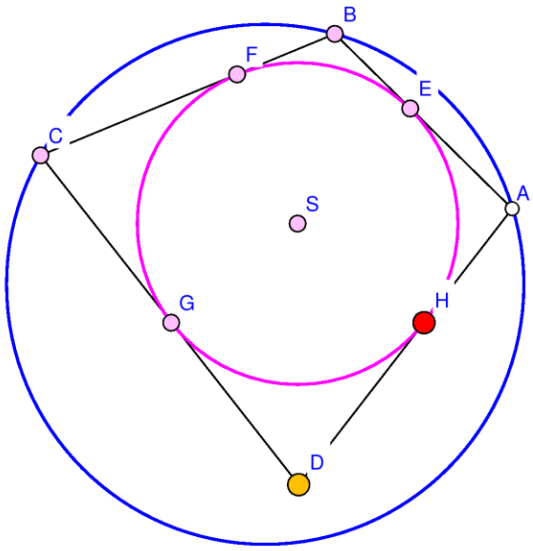
This example demonstrates how to define and apply a transformation.

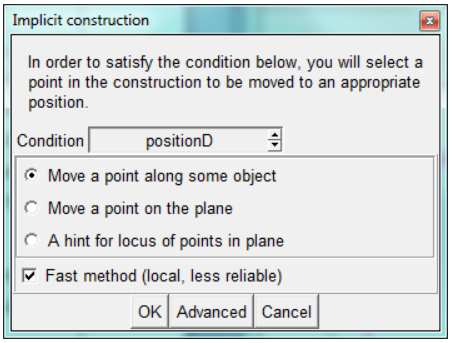
Task:	On each of the sides of a given triangle ABC draw three similar isosceles triangles. Study the obtained configuration.	
File:	OkEditEx_3.p	

Strategy:	Draw a triangle ABC. On one of the sides place an isosceles triangle. Using similitude transformations construct copies of the isosceles triangles on the two other 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 shall define a similarity that maps BC to CA. We shall apply this similarity immediately to the isosceles triangle and to the point D. Pick the point B, then to C (the desired image of B). Select the point C, then to A (the desired image of C). Name the obtained transformation as Simil_BC_CA. Since we shall immediately apply it, click Transform. Immediately apply the transformation to the isosceles triangle (point on it), and to point D (point it). 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. Detect them with the command Observe.	

5.4. A cyclic tangential quadrilateral

The following example demonstrates the usage of implicit construction of a point.

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:	OkEditEx_4.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, as we draw the (out)circle through A,B,C and observe that D does not lay on it. Using implicit construction command of OK Geometry we position H on the (in)circle so that the point D will lay on the outer circle, ABCD will then be cyclic and tangential. An analysis of the resulting configuration will (hopefully) provide 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|Circle Point|Point	Draw the incircle. Position the points E,F,G,H on it.
2	Line|Line 2obj	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	Construct the intersection points A,B,C,D. Hide the four tangent lines.

	Line|Polyline	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 outcircle. Name the resulting condition 'positionD'. The condition positionD appears (as False) in the list of parameters. (In the next step we shall 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 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	According to the construction we are interested in properties that are invariant under the cyclic permutation of vertices: ABCD EFGH. The analysis will gain additional evidence an additional cyclic permutation AB CD FH is specified. The cyclic tangential quadrilateral 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 may be considered as given. Among the properties listed by OK Geometry we look for some property that relates the given objects with the point H. One of such relations is shown on Figure 6. It is easy to show that the two emphasized triangles are similar isosceles triangles. Making use of this fact the construction of the point H is rather obvious. **Note. The presence of implicitly constructed objects reduces the reliability of observational results.**	

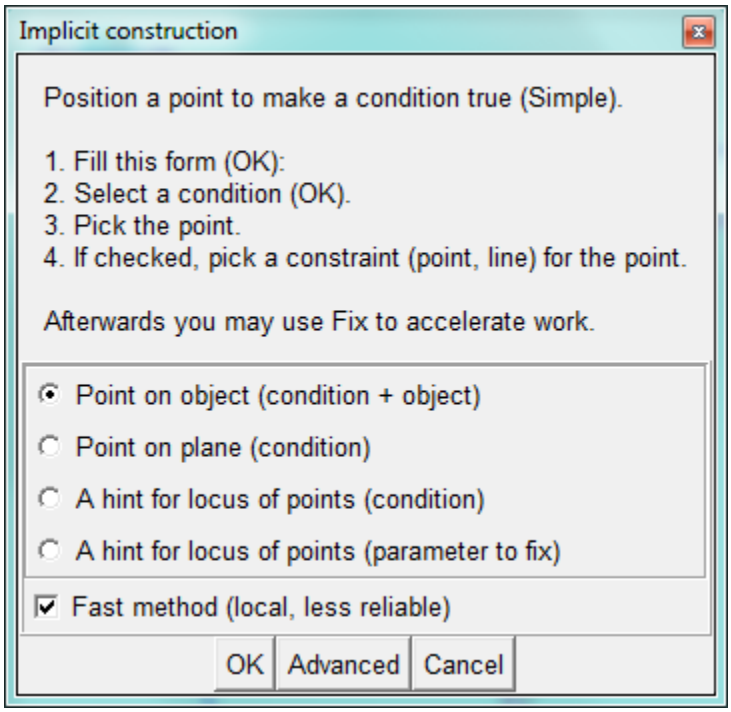
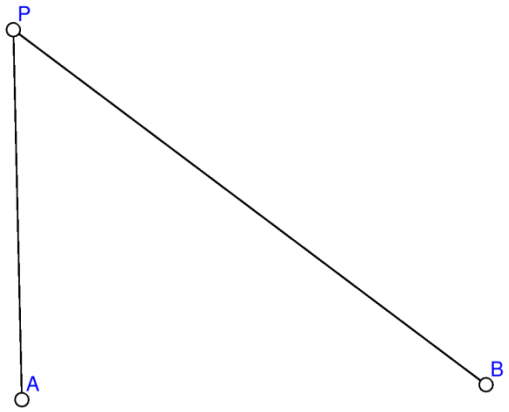
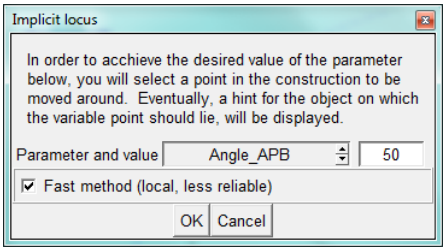


Figure 6

5.5. The angular size of a line segment

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

Task:	Given a line segment AB, we want to find instances of points P, from which the segment AB is visible under an angle of a fixed size. In other words, we are looking for the locus of points for P where the angle APB is constant.	
File:	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 in 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 	Fill the form as shown on the left: Since we are looking for the locus for P where a parameter (i.e. AngleAPB) is fixed, fill the form as shown on the left and click OK. After the form is filled pick the point P (to variable object). (A circle – the circumcircle of APB appears, see Figure 7.)
	Important note. As is evident from this trivial example, OK Geometry possibly provides only 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 it may happen that OK Geometry misses the locus, provides an 'extended' locus or even gives a deceiving hint. It is just a hint that requires additional checks.	

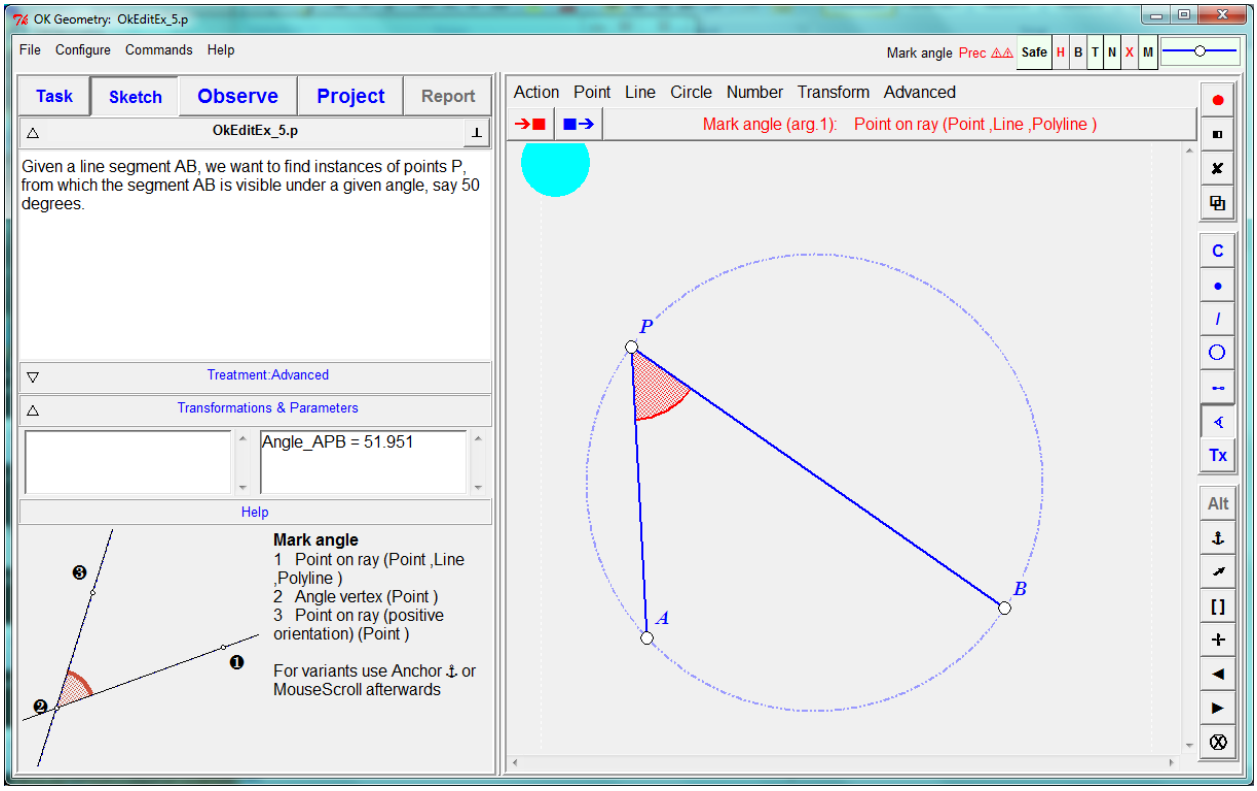
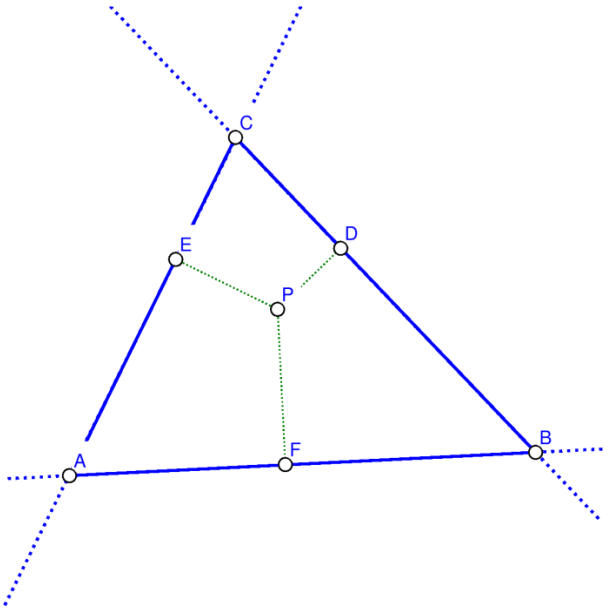
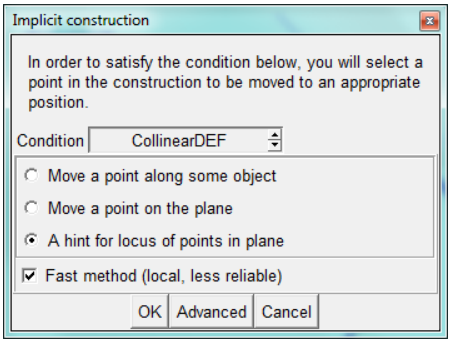


Figure 7

5.6. The pedal points

The following example demonstrates the usage of implicit construction.

Task:	The orthogonal projections of a point P to the base lines 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 point P wrt. the triangle ABC. Does it happen that the pedal points are collinear? When?	
File:	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 their pedal points D, E, F are collinear.	
Procedure/ Step	Sketch editor command	Comment
1	Point|Point Line|Line 2pts 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 polyline. Note: We need the lines since we project P to the base lines of the triangle's sides.
2	Point|Nearest point	For each base line (!) find the projection of P to the line as nearest line to P. The easiest way is to determine D as the point on the baseline BC that is nearest to P. In the same way construct the points E and F. Note. The line segments PD,PE,PF are shown only for reference.

3	Advanced|Check property|Position|CollinearP	Check whether D, E, and F are collinear. Name the result 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 7.)
	Important note. OK Geometry possibly provides only a hint for the sought locus of points. In our example the found locus is indeed correct (by Simson's theorem). However, depending on the situation it may happen that OK Geometry misses the locus, provides an 'extended' locus or even gives a deceiving hint. The result this always requires additional checks.	
Suggestions for the analysis	Given the obtained hint, it is easy to provide a more reliable check 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 5.5).	

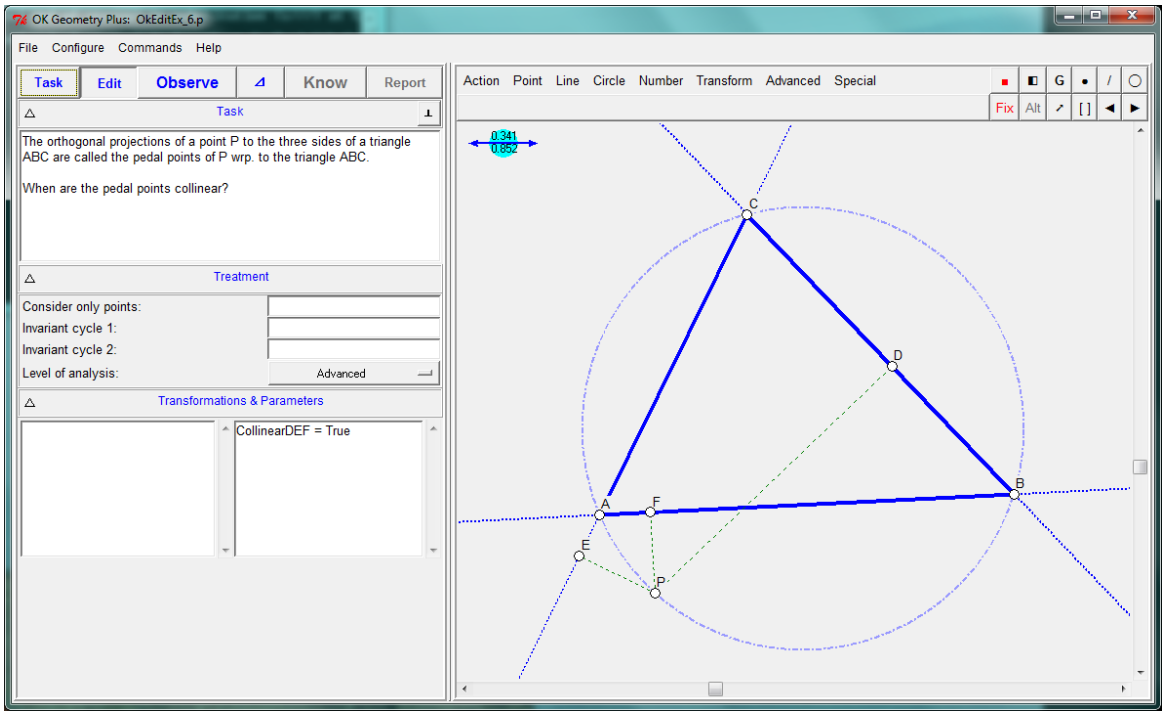
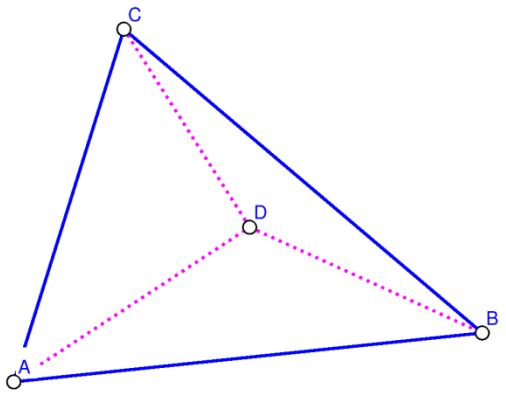
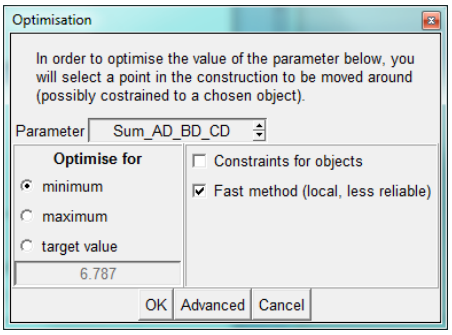


Figure 8

5.7. The Fermat point of a triangle

This example will demonstrate how to generate a hypothesis for the solution of geometric optimisation tasks.

Task:	For a given triangle ABC find the point D for which the sum of the distances from the vertices A, B, C is minimal.	
File:	OkEditEx_7.p	
Strategy:	Given a triangle ABC and an arbitrary point D we measure the lengths of AD, BD, and CD and calculate the sum of these distances. Then we let OK Geometry to move the point D around to a position where the sum of distances to the vertices is minimal.	
Procedure/ Step	Sketch editor command	Comment
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 the + key on the

		keyboard. Click on the DistanceBD. Repeat this also for DistanceCD In the information row appears [DistanceAD] + [DistanceBD] +[DistanceCD]. Click 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 the minimum option (Optimise for), uncheck the *Constraints* option, since D is not restricted to any 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 9). 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. The presence of optimisation methods reduces the reliability of observational results.	

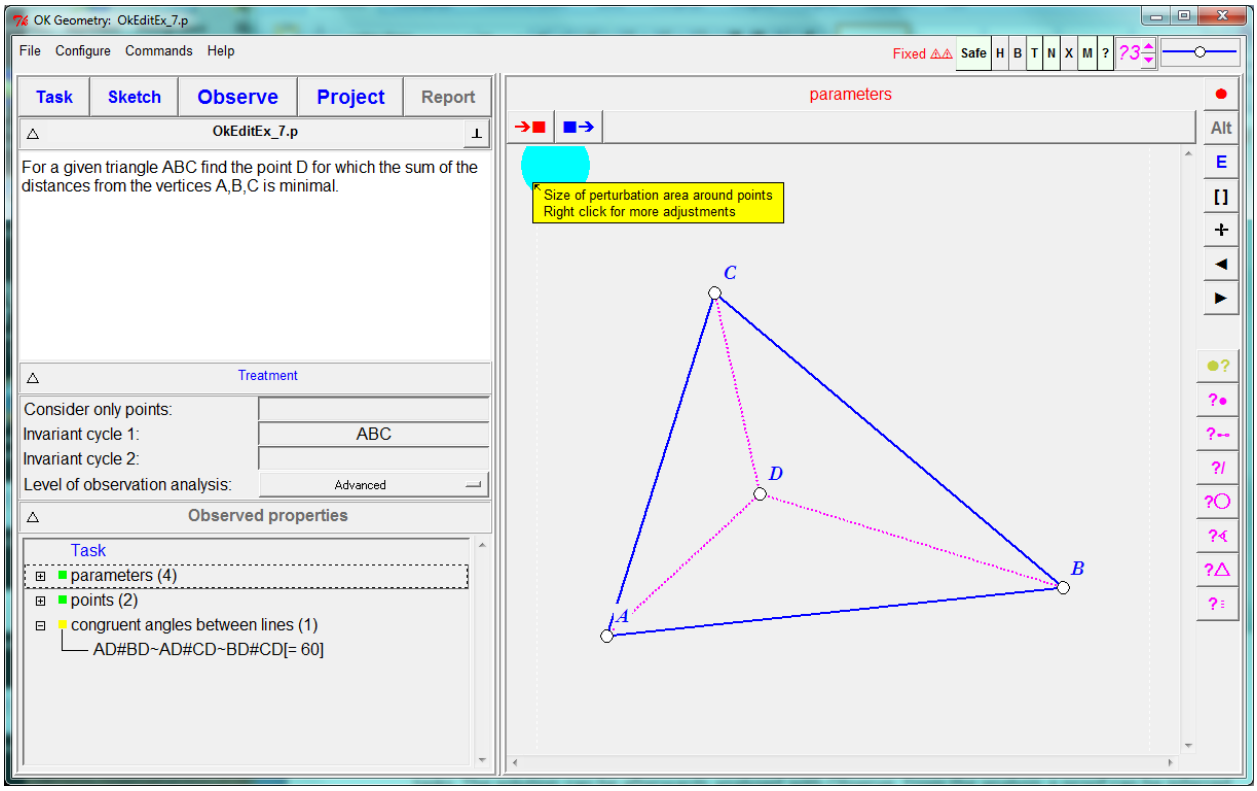
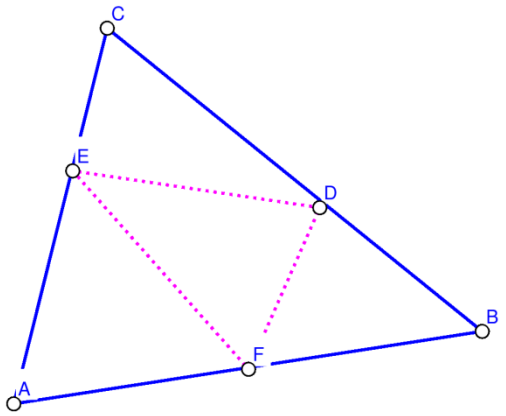
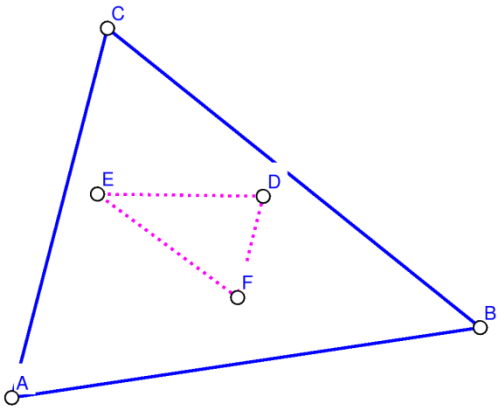


Figure 9

5.8. A minimal triangle

This example will demonstrate 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.

Task:	In a given triangle ABC inscribe the triangle DEF with minimal perimeter.	
File:	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 respective sides of the triangle ABC OK Geometry will adjust 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 may 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 may place these vertices along the sides of BC, CA, AB, but this is not necessary.
2	Number|Length,circumference	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 10. 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 the point E, then the restriction (the pointed

		segment CA of ABC). Click the point F, then the restriction (the pointed segment AB of ABC). The point D,E,F are given the calculated optimal position.
Suggestions for the analysis	In the Treatment section set the Invariant cycle to ABC DEF. Inspect the properties of the found solution. The properties may lead you to a proper construction and also to the proof of the correctness of your construction.	

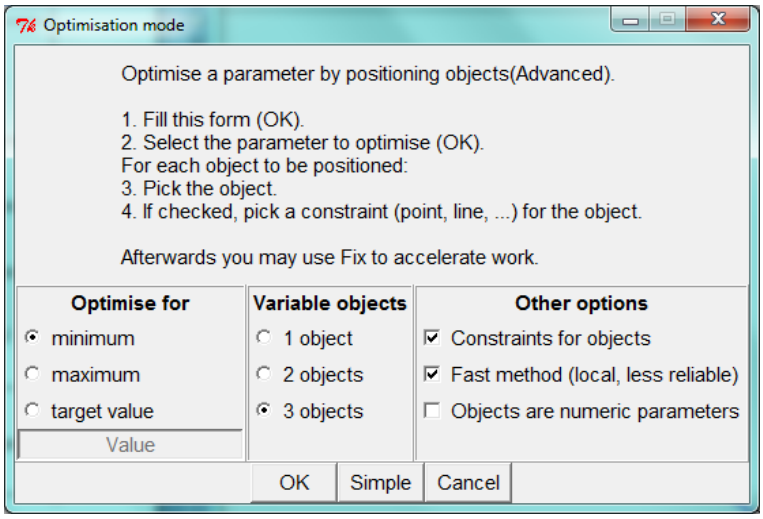


Figure 10

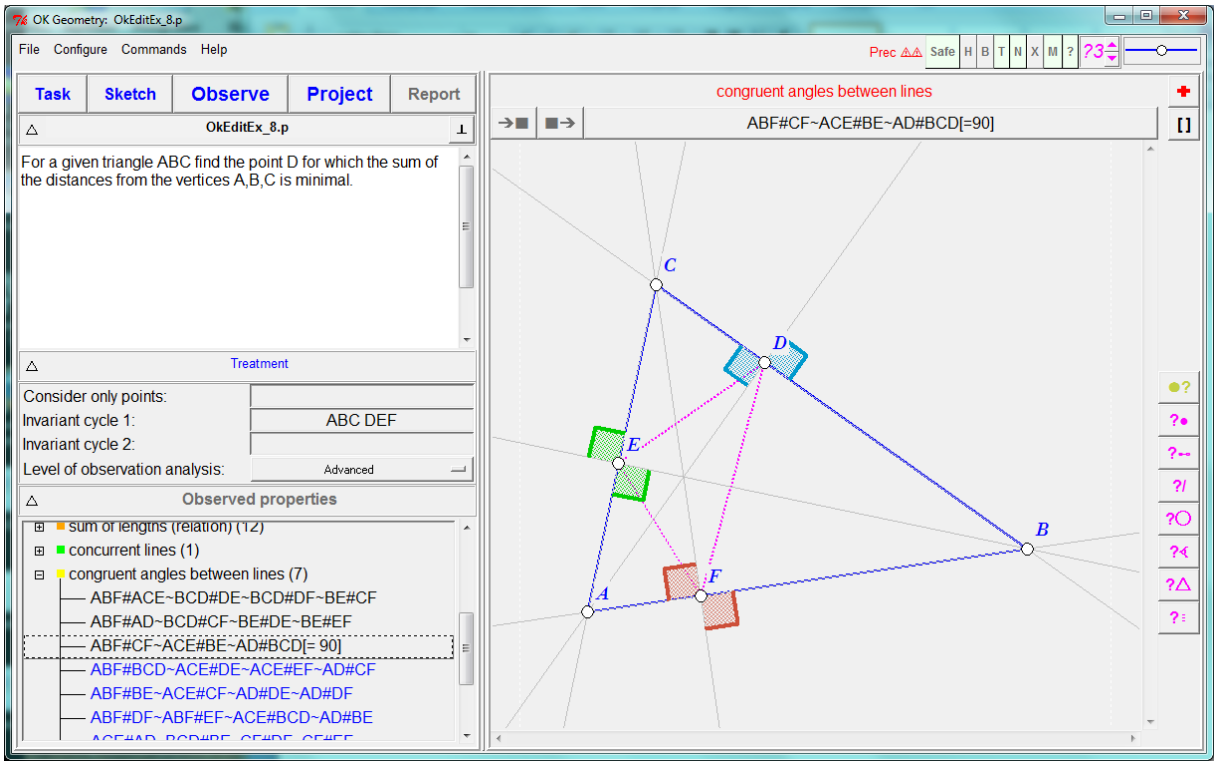
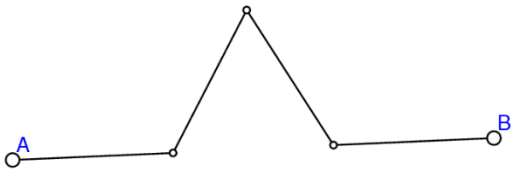


Figure 11

5.9. Making a macro

This simple example will demonstrate how to make a macro.

Task:	Given two points A,B we would like to construct a 'left bulged' path between them like shown right. All the involved segments should measure one third of the distance between A and B. The angles between segments should measure 120 and 60 degrees. Since we need to connect several points in this way we shall make a macro.	
File:	OkEditEx_9.p	
Strategy:	Given the points A,B we shall first draw points at each third between them. Then we shall draw and equilateral triangle on the middle part and draw the desired path as a polyline. At this point we shall define the macro. It is very important to think in advance what will be 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 generated points in the middle part of the segment..
2	Action|Label all Line|Polyline	It is important to label the points to be part of the output. Draw the polyline for output by clicking the vertices in appropriate order.

3	Macros|Make macro	Fill the form as shown in Figure 12. After you click OK Geometry you need to point the input and then the output objects in the same order as specified in the form. In the final form that appears you may choose to use the constructed macro only with this file or to store it separately and use it 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 separately and read it separately with Advanced|Get macro command.
	Advanced|Execute macro	The constructed macro is a new command available in the form that appears.

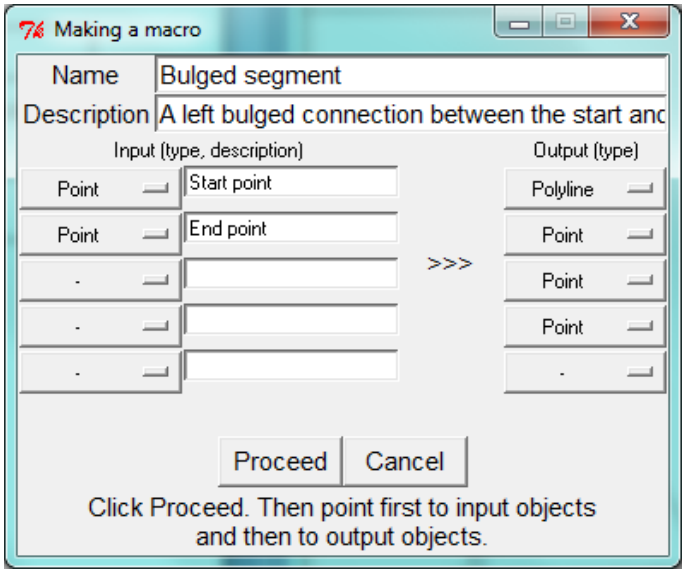


Figure 12