E1-$\mathcal{CG}$: Introducing Cabri Geometry II plus[1]

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Introduction:

Cabri Geometry II plus (an enhanced version of *Cabri Geometry II*) enables computer construction of geometric figures as well as elementary transformations of these figures. To get more detailed information about obtaining and using *Cabri*, see the Cabrilog website at http://www.cabrilog.com/en/.

This document gives step-by-step directions for carrying out some of the constructions possible with *Cabri*. As you carry out the constructions described below, note any questions you have about specific features of the program. If this is your first exposure to a computer drawing program, you will find that the beginning exercises will take considerably longer for you than for others who have some familiarity with such programs. However, your initial patience and persistence will soon pay off and you too will soon be a "pro."

How To Begin:

You will need to open the *Cabri* program by *double clicking* on the appropriate icon. This should bring up an initial credit screen. Click on it to remove the credits and bring up a screen entitled "Figure #1." As in other drawing programs, you carry out commands by moving the cursor around the screen using the mouse and clicking on the item you wish to select. In some cases, you can select several objects at once by holding down the shift key while clicking on the objects one at a time. If you want to deselect all your selected objects, move the cursor to an empty portion of the screen and click. To deselect just one of a collection of selected objects, continue holding down the shift key and click on the object to be deselected.

General Procedures:

- **Constructions:** New *Cabri* users should activate *Help* in the **Help** menu to create a window at the bottom of the screen where a list of objects required for a construction will appear once a tool is selected. The construction tools are "contained" in the toolbox in the toolbar at the top of the screen. To see which tools are in a particular toolbox, move the cursor to the toolbox button and click and hold down the mouse button. The toolbox button will become lighter. As you move the cursor over a tool name, the icon for that tool will appear and the name of the tool will appear at the bottom of the screen. Move the cursor (whose shape may now have changed) to an appropriate location on the screen. If the construction requires specific points, e.g., endpoints for a segment, you will need to click on the locations of those points to perform the construction. You can continue performing this same construction as long as the appropriate tool is selected. If you wish to perform the construction represented by the visible icon after other intermediate operations, merely click on the icon again to activate the tool.

- **Moving Objects:** To move an object to a new location on the screen, you must select the *Pointer* (found in the left-hand most toolbox) and then move the cursor to the object and wait for the pointer message "This [named object]" to appear. If instead, the message "Which Object?" appears, click to generate a popup menu that names the possible objects and select the one desired. Once the appropriate name appears, click the mouse to change the cursor to a curled hand. Hold the mouse button down while moving the cursor and the object to a new location.

- **Erasing:** To undo or erase a construction or transformation just completed, merely choose **Undo** under the **Edit** menu. If you want to redo the previously undone operation, choose **Redo**. To delete a small number of objects, select the objects to be deleted and hit the "Delete" key. Note that any objects whose construction was dependent on the deleted objects will also disappear.

[1] Designed to supplement Chapter 1 in *A Course in Modern Geometries, 2nd Ed.*; revised by JNC Jan. 3, 2007. Source File: My Documents\Text.dir\Web-exp.dir\e1cg+07.tex

- **Changing Attributes:** To activate the attributes bar, select *Show Attributes* in the **Options** menu. Tools in this bar enable changes in attributes of color, style, size, etc. To use a new color, thickness, etc., for objects yet to be constructed, choose the construction tool, then select the attribute from the icons in the attributes bar and then construct the object. To change the appearance of an object already constructed, select the appropriate tool from the **Draw** toolbox and then "paint" your object with the tool.

Exploration Activities:

With this quick introduction, you should be able to carry out the elementary Euclidean constructions described below. These activities illustrate the use of a variety of tools in the *Cabri* toolboxes (indicated in boldface).

1.1.1 Triangle Construction and Measurement:

1. In the **Lines** toolbox select *Triangle*. Then click the mouse consecutively at three vertex locations.
2. To label the vertices as A, B, and C, select *Label* from the **Display** toolbox. Move your cursor to each vertex; wait for the pointer message "This Point," click to make an edit box appear, and then type the desired label. To change or delete a label with the *Label* tool, click on the label. Once the edit box appears you can make the desired changes. Later, with the *Pointer* selected, you can change a label without invoking the *Label* tool, by double clicking the *Pointer* on the label to invoke the editor. Labels can be moved using the *Pointer* but most will stay near the object they name.
3. Select *Distance or Length* from the **Measure** toolbox. Move the cursor to a side of the triangle and click. Note that the measure of the perimeter (in cm) appears. Immediately type a label for this measurement to indicate that it is the perimeter.
4. With the *Distance or Length* tool still selected, measure the sides by moving the cursor to a vertex of the triangle. Wait for the pointer message "Distance from this point" to appear. Then click the mouse and move to the second vertex. Once the message "to that point" appears, click again. When the distance appears, label it appropriately. You may want to move the distance measurements away from the triangle by using the *Pointer* to drag them (They will move after an initial hesitation.).
5. Use the *Pointer*[2] to select and move individual vertices of your triangle until the screen recorded measurements of the lengths of the sides of ΔABC indicate that you have an equilateral triangle (or a close approximation).
6. With the *Angle* tool from the **Measure** toolbox selected, click consecutively on the three vertices to measure $\angle ABC$. Label your measure. Then find and label the other two angle measures. Do your angle measurements verify that ΔABC is an equilateral triangle?
7. Drag point A until the screen recorded measurement indicates that ΔABC is a right triangle, with right angle at C. To verify that you have a right triangle, follow the procedure below to have *Cabri* carry out the computation: $\sqrt{d^2(A,C) + d^2(B,C)}$
   (a) Select *Calculate* from the **Measure** toolbox to make a calculator appear on screen.
   (b) First click on the *sqrt* "key".
   (c) Then click on the numerical value of $d(A,C)$ and notice that a "variable" representing this quantity appears in the calculator window. Complete entering the expression above by clicking on the appropriate "calculator keys" and the other measurements and entering numbers for exponents from the keyboard. Then click on the "=" sign to get your result.

[2]Since the *Pointer* is used frequently, a *Cabri* shortcut allows you to access the *Pointer* by clicking the mouse key anywhere in the gray area of the Toolbar.

(d) What should the answer be? Did you get that result?

(e) To record your result on-screen, right click on the numerical answer in the calculator to copy the result. Then paste the result at the desired position. Use *Text* from the **Display** toolbox to label your result.

8. Select the entire triangle.[3] With the triangle selected, place the *Pointer* on any part of the triangle and drag the triangle to a new position on the screen. Do your measurements change?

9. Use the following procedure to save your figure:

   - In the (L:) Class Shared Student Folder, create a folder titled "E1-∗∗∗∗∗∗" where the 6 ∗'s are replaced by first and last initials of each of you in your group.
   - Select **Save As** under the **File** menu. Then enter the name "RtTriang." Note that some computers automatically add the ".fig" extension so the name becomes "RtTri.fig." If yours does not, add the ".fig"
   - Then click on **Save**.

Comments:

As the previous exercises demonstrated, the triangle you constructed was non-rigid, i.e., the lengths of its sides and the measure of its angles change if a vertex is dragged. There are times when it is important to generate objects that maintain certain properties when any part is dragged. The following exercises lead you through the construction of several such polygons.

1.1.2 Equilateral Triangles, Squares and Rectangles:

1. Equilateral Triangle Construction via Euclid[4]:

   (a) **Open** a new drawing window (see **File** menu). Select the *Segment* tool. To construct and label the first endpoint, first click at the desired location and then type the letter A. Move the cursor to the second endpoint of your segment, click and type the letter B.[5]

   (b) Select *Circle* in the **Curves** toolbox. Move the cursor towards point A until the pointer message "This center point" appears. Click once; then move the cursor towards B and click again once the message "This radius point" appears. Construct a second circle with center at B and radius point A.

   (c) Use the *Intersection Point* tool in the **Points** toolbox to construct one of the points of intersection of these circles. Label this point C.

   (d) Complete the triangle by constructing the segments AC and BC. Then use the **Hide** tool in the **Display** toolbox to select the two circles.

   (e) Measure each of the sides of your triangle to verify that it is an equilateral triangle.

   (f) Try dragging each vertex in turn and note whether the vertex can be moved. Once you have determined which vertices can be moved, move the cursor to an unoccupied space and press and hold the mouse key for several seconds until objects begin flashing. How do the flashing objects relate to your determination?

   (g) Watch the measurements to verify that the shape of the triangle remains the same as you increase or decrease the length of a side.

   (h) Save your figure as "EquTri.fig"

2. Square Construction via *Cabri's Regular Polygon Tool*:

[3] To do this efficiently, click in a blank area above and to the left of the triangle. Then while holding down the mouse button, drag the cursor down and to the right to create a rectangular area of selection surrounding the triangle. When the area of selection surrounds the triangle, release the mouse button.

[4] This construction was used by Euclid to prove the first proposition in *The Elements*.

[5] This way you can label objects as you create them without changing to the *Label* tool.

(a) **Open** a new drawing window (see **File** menu).

(b) Select *Regular Polygon* from the **Lines** toolbox.

(c) Move your cursor and click at a location for the center of your square. Then move the cursor away from the center and click at a location for a vertex.

(d) A regular polygon[6] with a large number of sides will appear (The number is indicated in the center of the polygon.) To reduce the number of sides to 4, click on an endpoint of your original segment and move the cursor clockwise. You might find it interesting to note what happens if you move the cursor the other way.

(e) Check the "rigidity" of your square by trying to drag each vertex. Which of the vertices can be moved? What happens when you move them?

(f) Save your figure as "Squ.fig"

3. Rectangle Construction:

(a) Open a new drawing window and construct a segment AB. Label the endpoints.

(b) Select *Perpendicular Line* in the **Construct** toolbox. Click on B, then on segment AB to obtain a line perpendicular to AB at B.

(c) Use *Point on Object* to locate a point on this perpendicular; immediately type C to label it.

(d) Construct segment BC and hide the perpendicular line.

(e) Select *Parallel Line* in the **Construct** toolbox and construct a line through C parallel to AB and another line through A parallel to BC.

(f) Use *Intersection Point* to locate point D, the last vertex of your rectangle.

(g) To check that AD is perpendicular to AB, select *Perpendicular* from the **Check Property** toolbox. Then move the cursor to first one of the lines, then the other. Move the marquee box that appears to a convenient location. A comment indicating whether or not your lines are perpendicular should appear.

(h) Construct segments AD and CD and hide the corresponding lines.

(i) Measure each of the segments and one of the angles to verify that you have a rectangle. Check that quadrilateral ABCD remains a rectangle as you drag its vertices. Determine how dragging each vertex affects the rectangle.

(j) Select *Text* from the **Display** toolbox and move the cursor to an empty region of your screen. In the edit box that appears, type a description of the effect on the rectangle of moving each vertex. To change the shape of your edit box, move the cursor to the lower righthand corner of the box until an double arrow appears. Then click and drag the corner to change the box dimensions.

(k) Save your figure as "Rect.fig"

4. Square Construction from an Initial Side:

(a) Open a new drawing window. In it construct a segment and label its endpoints A and B.

(b) To rotate point B through 90^o about A...

- In the **Display Toolbox** select *Numerical Edit* and click someplace on the screen. Type 90 in the box that appears. To record the units as degrees, press the $CTRL$ and U keys to display the popup unit menu.
- In the **Transform** Toolbox select *Rotation*, and click successively on points B, A and the angle value. Label the new point D and construct segment AD.

(c) Now construct and label the square's remaining sides, BC and CD.

(d) Try dragging each vertex of your square and record what happens using the *Text* tool.

(e) Save your construction as "Side-squ.fig"

[6] A *regular polygon* is a polygon with all its sides equal and all its angles equal.

1.1.3 Creating Macros:

Cabri's **Macro** toolbox (identified with the **X**→ icon) allows you to create your own tailor-made tool by carrying out the construction and then identifying first the initial objects and second the final objects. The created macro then enables you to duplicate the construction by merely setting up the required initial objects. The following exercises will lead you through the creation of a macro for Euclid's construction of an equilateral triangle.

1. A Macro for Equilateral Triangles:
   (a) Reopen your file "Equ-triangle.fig," or reconstruct an equilateral triangle as outlined in 1.2.2. Recall that you only have one initial object (the object on which everything else depends), namely, the first segment you constructed.
   (b) Select *Initial Objects* from the **Macro** toolbox and then select this first segment.
   (c) Select *Final Objects* from the same toolbox and then select the remaining two sides of your triangle.
   (d) Finally, select *Define Macro* in the **Macro** toolbox. A "Define Macro" window should appear. In it enter a name for your macro and check the *Save to File* box. Your macro name will appear temporarily in the **Macro** toolbox.
   (e) The "Define Macro" window also creates (or allows you to create) an icon button for your macro. To create your own, choose a color and select pixels to be colored. Also enter the name of the final object and a help message. The latter should explain what needs to be selected as the initial objects.
   (f) Save your macro as "EquTri.mac"[7]"
   (g) Your new macro should now appear in the **Macro** toolbox.
   (h) To try out the macro, construct the initial object (here a segment). Select your new macro from the **Macro** toolbox and then select the segment. An equilateral triangle should appear.
   (i) Construct a new initial segment by reversing the cursor direction you used for the previous initial segment (If you constructed the first segment from left to right, this time move from right to left.). Apply your macro to this new segment. What happens?
   (j) Try applying your macro to the sides of your new triangle.
2. Create a macro that creates a square from an initial side. Save it as "SideSqu.mac"
3. (Optional) Create a macro that creates a regular hexagon from an initial side. Save it as RegHex.mac"

Report:

Your folder E1-****** should contain the files below. Submit your work by placing a copy of this folder in the Class Drop Box.

1. Figures:
(a) RtTri.fig
(b) EquTri.fig
(c) Squ.fig
(d) Rec.fig
(e) SideSqu.fig

2. Macros:
(a) EquTri.mac
(b) Squ.mac
(c) RegHex.mac (optional)

[7] Your computer may automatically attach this extension.